

**Code\_Aster** ®

*Version*

6.4

*Titrate:*

*Guide reading of the documentation of Use*

*Date*

:

13/06/03

*Author (S):*

**COURTEOUS Mr., Mr. BOIN, J.M. PROIX Key**

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*Organization (S): EDF-R & D /AMA*

***Instruction manual***

***U0.00 booklet: General***

***Document: U0.00.01***

***Guide reading of the documentation of Use***

***Summary:***

*This document has as an ambition to propose an assistance to a first access to the contents of documentation of Aster use.*

*One describes, initially, the principles which govern the organization space time of documentation Aster in general and the parts of this documentation which concern the user in particular. In fact, one will see that the user (not developer) will not draw only his documentary resources in the Handbook of Use.*

*One suggests a guide (way) of reading while trying to put itself in the state of mind of an initial user as well for the handling of the code as for navigation in its documentation.*

*Finally one formulates in the questions and answers mode of the considerations on the questionings of which is the object documentation Aster, by locating them in the problems of the documentary cover of a large product software.*

*The reader wishing to go directly to the active part of this document will go to [§2] and [§3].*  
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*1 Documentation*

*Code\_Aster: organization and access*

*Before beginning navigation as a whole from the documentation of Code\_Aster, the user must to have well at the head the organization space time of the documentary territory in which it will*

*evolve/move and*

*the aspects Quality assurance of the documentary objects Aster. The code grows rich, changes all weeks, its documentation, unfortunately, not. Nevertheless, a good apprehension of structuring of the documentary ground, of the nature even of the objects that one meets there and the laws of*

*their evolution in time should make it possible the user not to be exceeded by the sum and the scatter of required knowledge, has minimum, to launch its first Aster calculation.*

**1.1**

*A logical cutting in Handbooks: the ARDUV*

*The technical documentation of Code\_Aster comprises:*

- five handbooks,*
- a whole of other documentary objects which come in complement from documentation basic technique Ci above.*

*Instruction manual*

**U**

*Instructions of the orders, structures of data*

*users, examples of use*

*Handbook of Reference*

**R**

*Formulation of the modelled phenomena, methods of analysis, algorithms numerical*

*Data-processing handbook of Description D*

*Structures of data, algorithms, architecture, environment*

*Handbook of Validation*

**V**

*Elementary test probes in all the fields of modeling*

*Handbook of Administration*

**With**

*Quality plan, procedures of development and of maintenance, engagements of services, versionnement*

*The other documentary objects consist of a series of articles, presentations of functionalities code (for example, the collection of the newspaper ASTER echoes, plate of presentation of fields of modeling of the code, transparencies of conferences on functionalities of the code, presentations of industrial studies, etc). These objects, whose documentary vocation is not precisely directed towards the technique of use of Code\_Aster are accessible in various headings of Internet site of Code\_Aster.*

*The basic handbooks of the Aster user are the Instruction manual, the Handbook of Reference and it Handbook of Validation. The Instruction manual frequently returns to the Handbook of Reference. Data-processing handbook of Description is reserved for the developers, in theory it does not relate to them users; it is the same for the Handbook for Administration. An exception of size for it the last: the user has access to the Cards Quality and Cards Followed Quality which indicate to him for poured exploitation and of development of the code which are the evolutions, identified errors corrected or not and solutions of skirting.*

*The handbook is subdivided in ten named parts (numbered from 0 to 9), the parts in booklets also named (00 to 99), booklets in documents (00 to 99).*

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*1.1.1 The documentary key Aster*

*A document is located in the documentary space of the handbooks by a documentary key:*

*Manuel\_Partie.Numéro\_du\_fascicule.Numéro\_du\_document-Indice*

*Example of a documentary key: U1.02.00-B*

*Naturally, one indicates a document by his documentary key. For reasons of convenience two classes of documents are as indicated by the Aster function as it document:*

- *documents of the instructions of the orders (Instruction manual) indicated by name of the documented order,*
- *documents of description of the elementary cases test dedicated to the validation of the code (Handbook of Validation) indicated by the code of the case test.*

### *Examples:*

*U4.43.01-F documents order DEFI\_MATERIAU, one will say document DEFI\_MATERIAU.  
V7.90.04-A documents the case test of thermomechanics HNSV100: Thermoplasticity in traction simple, document HNSV100 will be said*

*Other documentary objects that those contained in the handbooks are not affected key it has just been question.*

### *1.1.2 Version of the code versus index of the document*

*Each technical document of the handbooks increases in heading a certain number of indications bibliometric (names of the handbooks and booklets of membership, titrates, the name of () the author, key, summary, version of the code). Among those, three deserve a detailed attention because they touch with the Quality assurance of the code and the update of the documents:*

- *the Version of the code concerned with the document,*
- *the index of the document,*
- *the date carried by the document.*

### *1.1.3 With which version of the code applies the document?*

*In top and on the right the top of page of the document the n° of version appears and, possibly, of under version of the code for which the document applies. For example:*

- *5.0 documentation valid for all version 5 (and the following ones if there is no setting with day),*
- *6.3 valid documentation starting from under-version 6.3 and for the following ones; documents which carry former numbers (6.0, 6.1, 6.2) are not updated at the time of the introduction of a under-version.*

*There is always, at least, 2 versions of the code available. The version known as of Exploitation, currently version 6, validated and qualified (thus under AQ). It is the version of exploitation which must be used for the studies under AQ. The version of Development (currently version 7), provided with last innovations, not yet validated version nor qualified. The Aster user must constantly*

*to know which are officially the version of exploitation and the version of development. These versions evolve/move every 2 years (increment of the number of version). With each startup of a version and of under versions of exploitation or development, are brought into service a Card Quality and Cards Followed Quality. These documents index, for a version or under version given, the list fields (functionalities) qualified and remarks and restrictions on the qualified fields. These cards (which are documents resulting from the File of Administration) are available on the waiter in the heading Use/Quality.*

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#### *1.1.4 What represents the index of a document?*

*It traces the evolution of the document in time and known as if the document is under AQ or not. In theory, with*

*each update of a document, this one follows an internal circuit of validation which qualifies the document*

*within the meaning of the quality assurance of the code. The indices of the documents under AQ are literal (A, B, C, D, etc).*

*For example, in the version of exploitation of the code at a given time, the document of use of order DEF1\_MATERIAU carries key U4.43.01-F, the code letter F indicates that the document is under AQ and which it was updated under AQ five times. At the same time, document U4.43.01-G1 is also published; it corresponds to an update not AQ and applies to the version of development.*

### ***1.1.5 Date from the document***

***It is the date of qualification of the document. It will be noted, for example, that the most up to date documents***

***relate to the use of the orders of the version of current exploitation, as well as modelings and structures of data of the result type of this version. It is documentary leading policy of the code which wants that the release of a version of exploitation is immediately followed edition of the documents of which it has just been question.***

### ***1.2***

***To reach the documentation of use of Code\_Aster***

***The technical documentation of Use of Code\_Aster is a subset of its documentation general.***

#### ***1.2.1 It is an entirely electronic documentation....***

***... since the 07/2000. Old documentations paper in the form of white sorters with rings with the A4 format are out-of-date and do not have to be used any more. It was requested from all the users***

***Aster at the time of the introduction of the electronic form to destroy all these sorters.***

***Documentation is published on Internet site of the code to the address:***

***<http://www.code-aster.org/>***

***Periodically (approximately every 15 days), electronic documentation grows rich by new documents or of updates of old documents.***

***Internet site is the subject of a data-processing description [D9.09.01].***

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**1.2.2... Which also exists in form paper**

**Every 2 years (at each release of a new version of exploitation), handbooks paper of pocket documentation of the code are published. Those are a photograph at one time given of electronic documentation. For consultation of these handbooks of pocket, it is necessary to have the reflex of to ensure itself of the n° of version of the code that they document, and the date which they carry.**

**One will order the shape paper of the Reference and instruction manuals (several volumes each one) with code-aster@edf.fr.**

**It is nevertheless possible to print locally the electronic document posted entirely or in part.**

**1.3**

**General presentation of the documentary resources of use**

**In fact the basic user will draw his documentary resources in 3 handbooks, in this order:**

**· Manuel U of which it must have the structuring at the head well**

**Documented functionalities**

**Parts of handbook**

**U4: basic commands**

**Instructions of the orders**

**U7: orders of exchanges of data with other software**

**Structures of user data**

**U5**

**Characteristics of modelings**

**U3**

**Note of use of modelings**

**U2**

**Access to the code**

**U1**



- **Manuel R:** *finite elements, the formulation of modelings of the phenomena*
- **Manuel V:** *the cases test of validation*

## 2

### **Making of contact**

*There is obviously no question exhaustively of reading all the instruction manual. In May 2003, it comprise 310 documents (of which 200 relate to the use itself of the orders) which approximately 2000 physical pages represent. Many documents undoubtedly do not concern the user at the time of his first modeling and its first calculation; he is however absolutely necessary to consult the documents describing the functionalities implementing this first modeling. This for two reasons:*

- *to avoid the errors of use,*
- *but also, to be informed of the possibilities of Code\_Aster close to those which are sought (solutions of skirting) and which could perhaps prove to be useful.*

*It is thus advised to consult the documentation of use according to the step suggested hereafter.*

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### 2.1

**Can Code\_Aster cover subject of my problem?**

*Four documents claim to answer this question. They are presented more synthetic to*

*more complete.*

### ***2.1.1 For a fast answer***

***To consult the pages of the plate of presentation of the fields of modeling of the code, on the site Web section Produced, where the phenomena modélisables by the code are described synthetically.***

### ***2.1.2 For a more excavated answer***

***To consult on the document [U1.02.00] Introduction to Code\_Aster, in particular chapters 1.3 (Phenomena, modelings, finite elements and behaviors) and 1.4 (Several methods of analysis) where the phenomena modélisables by the code are described synthetically.***

### ***2.1.3 For a more up to date answer (taking account of the last developments)***

***To consult transparencies of the last presentation of the new functionalities of the code with annual day of the users of Code\_Aster at the date of publication of this document: section Produced Web site.***

### ***2.1.4 For an answer more developed even...***

***One approaches a field of questioning there where the answer cannot be directly brought any more by objects present on the documentary waiter. For example, the answer can be YES and consist in subtleties of modeling or circumvented ways of modeling. It is addressed, in all state of cause, with already informed users. Service AOM (Assistance with the Optimization of Modeling) of the Experience feedback (REX) Aster makes it possible to submit to the Team of Development***

***Aster (EDA) a problem of modeling particular to implement with average the Aster. It type of tender is carried out by emitting a request for expertise by the REX of the interface graph of access to Code\_Aster astk. A person of the EDA is then charged to help it applicant to carry out his modeling.***

## ***2.2***

***Code\_Aster it already dealt with problem comparable (close) with mien?***

***Two ways are proposed: the way of the elementary cases tests, the way of the industrial applications.***

### ***2.2.1 The elementary cases tests***

***In fact elementary cases tests (known as of school, known as also academic) are used to validate the code***

***and to make sure of the conservation of the precision of the results at the time of its weekly update.***

***The user will thus look at if an elementary case test deals with similar problem: Waiter documentary, heading VALIDATION/Case Test By Names, the list of documentations of the names***

*of  
case tests (classified by applicability) is posted like their titles, or, section  
Use/Examples of the site.*

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### *2.2.2 Industrial studies*

*A certain number of studies (applications) industrial were carried out using Code\_Aster and have fact the object of an article in ASTER echoes (last new of Code\_Aster) or of a presentation at the annual day of the users of Code\_Aster.*

*These documented studies are available on the site, Produit section/Applications. One finds there collection of the cards Studies of the periodical ASTER echoes since its creation (10/91, 39 numbers published*

*to the 01/2003) and a collection of industrial studies in all the fields of modeling of the code presented at the time of the annual days of Code\_Aster.*

*One will find also studies industrial in number 60 of Diagram, Simulation in mechanics of structures, 10/1998, accessible since the section Produced.*

*3  
First use of Code\_Aster*

*To consult the document [U1.01.04] describing the graphic interface of access to Code\_Aster ask.*

*The simplest way to carry out a calculation with Code\_Aster is to start from a nearby example which*

*is most of the time in the elementary cases tests described in the Handbook of Validation. The command files associated with the cases tests described in documentation with validation are located in the repertory astest of the version used. On the waiter of centralized calculation of EDF R & D, they are in /aster/vx/STAx/astest where X is the number of the version in exploitation (6 at the date of writing of this document).*

*This way of proceeding by analogy, appreciated generally well by the community of mechanics, should not replace a constructive step completely but, mistrust, them command files associated with the case-tests (or those written by the colleagues) are not always realized in the most skilful way. Indeed:*

- these files were written at various times of the evolution of the code and do not profit thus not necessarily of the recent contributions allowing to simplify or supplement the study,*
- of many possibilities is generally offered to complete same work which are adapted more or less well to each case.*

*It is thus necessary, to take the practice to consult this handbook of validation to each new need.*

### **3.1** *Great principles and key stages of a calculation*

*One exposes hereafter a read path taking as a starting point the the great obliged stages of a study mechanics with Code\_Aster. In this step, three documents are proposed with the reading.*

#### **3.1.1** *Great principles of Code\_Aster*

*To consult on the document [U1.03.00] the great principles of Code\_Aster, which presents summarily principles of operation and principal rules of use.*

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### **3.1.2 Simple example of use of Code\_Aster**

**To consult on the document [U1.05.00] simple Example of use of Code\_Aster, the orders “impossible to circumvent”, on a calculation of cylindrical reserve mean in hydrostatic pressure, modeling axisymmetric.**

## **3.2 grid**

**The structure of the file of Aster grid is described in the document [U3.01.00] Description of file of grid of Code\_Aster.**

**If the initial grid results from an external maillor with Aster such as for example GMSH, GIBI or I DEAS, interfaces and Aster orders which create starting from the objects produced by these pre processors of the objects of the grid of Aster (which are not a copy of the initial objects; their significance can change, of new objects can be created) are described in the documents:**

**[U3.02.01] Interface of the file of grid GMSH with Aster,  
[U3.03.01] Interface of the file of grid I-DEAS with Aster,  
[U3.04.01] Interface of the file of grid GIBI with Aster,  
[U7.01.01] Procedure PRE\_IDEAS,  
[U7.01.11] Procedure PRE\_GIBI,  
[U7.01.31] Procedure PRE\_GMSH,**

**See also [U7.01.21] Reading of a grid to format MED (Model of Data exchange).**

## **3.3 orders**

**The description of the orders of Code\_Aster are contained in the parts U4 and U7 of the Handbook of Use. It is undoubtedly with these 2 parts of handbook that the Aster user will generally have resort. They are organized in the U4 handbook according to a scenario which follows them logically great stages of a calculation:**

**U4.1-  
Allowance of the resources disc and memory,**

**U4.2-, U7.01. - in U7.03. -**

*Acquisition of the data of grid,*

**U4.3- and U4.4-**

*Modeling (assignment of the finite elements, materials, loadings, etc...),*

**U4.5-**

*Resolution of the system of equations (calculation)*

**U4.6-, U4.7-, U4.8-, U7.03 with U7.05. - Post treatment and examination of the results**

*Finally the document [U4.01.00] **How to read the documentation of the orders**, explains in particular significance of the métacaractères and the typography which one meets in documentation of the syntax of the orders.*

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**3.4**

**Notes of use**

*A certain number of modelings or type of modelings (such as for example under static structuring, the mechanical cushioning, the thin hulls, etc) are the subject of notes of use. The related documents will be available on the waiter in the U2 part of the Handbook of use.*

**3.5**

**Finite elements, modelings of the phenomena**

*From the numerical point of view, the choice of the finite elements for a type of modeling is responsibility for the user. The mathematical description of the modelings supported by finite elements is in the **Handbook of Reference**. The description of the degrees of freedom of these elements like their possibilities of modeling (supported loadings, fields produced, non-linear possibilities, etc...) are in the documents:*

***U3.1-: Mechanical modelings,  
U3.2-: Thermal modelings,  
U3.3-: Acoustic modelings.***

### **3.6**

#### ***Structures of user data of the result type***

*The operators (orders) of Aster calculation create objects of which the structuring of the data that they must be absolutely known users contain. **Part 5 of the Instruction manual** their is entirely devoted.*

*It is advisable to start by reading the two general documents which describe the **generic structure** data of the result type and **accessible fields of sizes**:*

- [U5.01.00] Structure of data result,*
- [U5.01.01] accessible Fields in the Structures of data result,*

*Then, it is advisable to consult the documents which describe the specific organization of the structure data produced by the operator. For example, results of a modal calculation produced by operator `MODE_ITER_SIMULT` have a structure of data which can be of `mode_meca` type described in the document [U5.01.23] **Structure of data mode\_meca and mode\_meca\_c**.*

*Finally and especially, it is imperative of very carefully reading the documents devoted to the orders Aster dedicated to the impression of the results (on listing or files).*

*Initially two generic documents:*

***[U4.91.01] Procedure IMPR\_RESU (FORMAT = “RESULT” and “ASTER”)***

***[U4.33.01] Procedure IMPR\_COURBE.***

*Then five documents of description of the orders which generate files of results to the format `MED`, `GMSH` and `ENSIGHT` and with the formats accepted by the post processors `I-DEAS` and `CASTEM` (Gibi):*

***[U7.05.01] Procedure IMPR\_RESU (FORMAT=' IDEAS'),***

***[U7.05.11] Procedure IMPR\_RESU (FORMAT=' CASTEM'),***

***[U7.05.21] Procedure IMPR\_RESU (FORMAT=' MED'),***

***[U7.05.31] Procedure IMPR\_RESU (FORMAT=' ENSIGHT'),***

***[U7.05.32] Procedure IMPR\_RESU (FORMAT=' GMSH'),***

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## 3.7

### ***Errors in the command file***

*The constitution of a command file Aster is a stage obliged for the user. Currently, the user has the choice between constituting this file with the hand or building it using the interface graph EFICAS “Editor of rather natural use, Command file Aster...”.*

*Moreover, it gives access directly to electronic documentation.*

*If the command file is built with the hand and if Aster detects a syntactic error, grammatical even semantic in this file, of the brief replies to cure the errors met are in [U1.03.01] Supervisory and process control language.*

## 3.8 Assistance telephone

*The Technical aid Telephone Aster for the use is ensured by an external speaker, whose co-ordinates are reproduced on the Web site, heading Services (necessary access Intranet).*

## 4

### ***Questions and answers about the documentation of Code\_Aster***

#### 4.1



### ***I have it the most up to date version of the document?***

*If the document is consulted electronically on the waiter the answer is **YES**. If the document is resulting from a handbook of pocket paper then, on the waiter, to check if this document were not the object one*

*update in its electronic version. It is necessary to take the practice to think that the handbook paper is a photograph at a given moment of electronic documentation (the date of edition of these handbooks appear very obviously on first page).*

*This question occurs at the time of errors met during the execution. It is then necessary to be turned towards the **Monitoring sheet Quality** of the version of the code which one uses (section *Produit/Qualité* of part *Intranet* of the site).*

### ***4.2 Which is the documentation (the whole of the documents) which applies to the current version of exploitation of the code?***

*They are the documents contained in the waiter even if those *Ci* carry a n° of version of code lower than the current version and carry old dates. For each Handbook, the list of these documents (documents valid for the current version) appears in under **Synopsis** heading.*

### ***4.3***

#### ***I have it right to contact the author of the document directly? ...***

*... because I do not include/understand something or that I discovered an error there?*

*It is advised to initially pass by the Telephone Assistance Aster (cf [§3.8]) which will answer majority of the questions.*

*In the event of complex request, it is possible to contact the author of a document by taking care of to trace this intervention by emitting a card of the type AOM (cf [§2.1.4]) in the Experience feedback.*

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#### ***4.4 Then I to contribute to a better quality of documentation Aster?***

***YES, (it is even recommended), errors and suggestions are to be announced by the writing of a Card of Evolution of Documentation in the Experience feedback of the graphic interface of access to Code\_Aster.***

#### **4.5**

***I prefer a documentation paper all the same***

*In ordering from code-aster@edf.fr*

#### ***4.6 I want to perfect my knowledge in the possibilities and the use of Aster***

*The technical documentation of Code\_Aster (more generally all documentary objects Aster present on the documentary waiter) are not the only tools which answer this concern. In addition to the documents of which it was question at the time of the presentation of the read path documentation of use, one will approach the following events:*

- Courses trainings: initiation with Aster, basic training with the use, thermo plasticity, with postprocessings,*
- Aster echoes, quarterly, the last news of Code\_Aster,*
- Quarterly ordinary Séance of the Club of the Users Aster,*
- Grande annual Day of the Users Aster, generally at the beginning of March.*

**Note:**

*The training courses organized by EDF R & D are intended to users EDF and their partners. Users of Free Code\_Aster, consult the Services section for to know the list of the distributors.*

*For these events, information with code-aster@edf.fr*

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## ***Introduction to Code\_Aster***

### **Warning:**

***One proposes to describe here, the philosophy and the applicability of Code\_Aster, without developing in detail methodologies of study usable.***

***This document is a first making of contact with Code\_Aster and was thus written with a concern of concision. It does not have the role to index all modelings or possible types of analysis with Code\_Aster, and is not substituted to in no case with the plate of the Version 7 which draws up a panorama of it exhaustive.***

***All the information, provided here or in the various handbooks, is given to describe, with maximum of precision, contents of Code\_Aster. They do not have as an ambition to deliver a formation with numerical modeling of the behavior of the mechanical structures. Code\_Aster is only the establishment of methods described and shown in various works to which the reader will have to refer, in complement reference material, if necessary. The handbooks of Code\_Aster suppose acquired in addition a formation with the mechanics of the solids and the finite element method.***

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# **1**

## ***The study of the mechanical behavior of the structures***

### **1.1**

#### ***A code general***

*Code\_Aster is a code general for the study of the mechanical behavior of the structures.*

*The priority applicability is that of the mechanics of the deformable solids: that justifies it a number of functionalities attached to the mechanical phenomenon. However, the study of the behavior mechanics of the industrial components requires beforehand the modeling of the requests which they are subjected, or of the physical phenomena which modify the parameters of it behavior (fluid intern or external, temperature, metallurgical phase shift, efforts of electromagnetic origin...). For these reasons, Code\_Aster offers several possibilities of “chaining” of the mechanical phenomenon with the phenomena thermics or accoustics, or with external software, as well as a “kit” of construction of problems thermo-hydro-mechanics coupled.*

*Although Code\_Aster can be used for many problems of structural analysis (code*

general), it was developed in particular to allow the study of the components of materials or of machines used in the field of the electricity production and transmission. Thus the priority was data with the modeling of the isotropic metal structures, géomatériaux and the components of composite material or reinforced concrete structure.

The nonlinear analyses, as well in mechanics in thermics, are in the middle of Code\_Aster: their effective treatment required the development of powerful and relatively simple algorithms of use, even if the goal is not to make them function in “block box”. For the studies complexes, it is thus necessary to include/understand the nature of the operations carried out by the code, so of being able to control them in an optimal way: one refers then to the theoretical notes giving the details the modelings and methods, gathered in the Handbook of Reference.

The setting under Quality assurance to be able to carry out industrial studies justifies several choice:

- existence of a version of fixed and documented reference code,
- provision of complete, fixed but parameterized algorithms,
- principle of orthogonality of the orders (independence of the context of use),
- objective of complétude of modelings usable.

## 1.2

### **Method for calculation with Code\_Aster**

A structural analysis carried out with Code\_Aster consists of the sequence of a certain number of orders described within a “command file” in format text. The engine and the interpreter this command file is the language script PYTHON. It is thus possible to use all them functionalities brought by PYTHON. See in particular the docs [U1.03.01], [U1.03.02] and them examples of use [U1.05.00] and [U1.05.01]. Each order (for example reading of the grid, affection of the data material, linear static calculation) produced a “concept result”, together of structures of data which the user can handle and re-use in the further orders of calculation (for example grid, the field of data material, the field of displacements...).

The syntax of all the orders is described and commented on in the handbooks U4 and U7 of documentation of Use.

In order to simplify the task of the user, there are total orders which gather the sequence ad' hoc of operations for a certain number of calculation case (for example static linear - order MECA\_STATIQUE, nonlinear statics - order STAT\_NON\_LINE, thermics



*nonlinear - order THER\_NON\_LINE, etc). Some were developed directly of integrated manner, others are macros-orders in Python which do nothing but manage the calls with the various unit orders (as MACRO\_MATR\_ASSE which makes it possible to calculate and to assemble the matrices of mass, damping and rigidity of a structure).*

*There are also macro-orders especially dedicated to certain applications (see [§4]).*

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*At the end of a calculation, it is often possible to enrich the data-processing object containing the “concept result” obtained, by carrying out other calculations a posteriori: for example, starting from the field of displacements and of the constraints at the points of Gauss obtained in a mechanical calculation, one can*

*to calculate the field of deformations, the stress field interpolated to the nodes, etc One then invites that to implement a “option” of calculation, which is affublée of a barbarian name, but which follows one*

*logic “quoi\_où\_comment” (for example option EPSI\_NOEU\_DEPL for the deformations data with the nodes starting from the values of displacements).*

## **1.3**

***Phenomena, modelings, finite elements and behaviors***

### ***1.3.1 Concepts***

***One calls “phenomenon” a family of physical problems resting on the same type unknown factors (and associated a type of conservation equation): for example, the phenomenon mechanics calls upon the unknown factors of displacement, the thermal phenomenon with the***

*unknown factors of temperature. According to modeling used, the number of unknown factors of this type can vary (for example one needs in each node only for one unknown factor for temperature in 3D, but 3 unknown factors are used for the hulls).*

*Note:*

*For the coupled problems of thermo-hydro-mechanics, this concept was extended in measure where one gathers, in this case, under the “mechanical” phenomenon, the whole of conservation equations associated with the problem thermo-hydro-mechanics.*

*One calls modeling the manner according to which continuous equations governing a phenomenon given are discretized, with the assistance of possible complementary assumptions (plane deformations, model of beam, models hull...). In mechanics, for example, one can find modelings 3D, 2D plane deformations, 2D forced plane, hulls 3D, plates, beams of Euler, beams of Timoshenko, pipes, etc... Each modeling uses a set of degrees of freedom which is to him clean: for example displacements in the 3 directions of space for modelings of continuous medium 3D, 3 displacements and 3 rotations for hulls 3D, etc*

*The couple phenomenon/modeling makes it possible to affect in a bijective way a type of finite element to each type of mesh of the grid.*

*In Code\_Aster, one calls “finite element”, for a given modeling, the triplet consisted:*

*.  
the nature of the mesh support (representing a piece of volume or border: hexahedron, tetrahedron, triangle, quadrangle, segment...): it is topological information (it includes it a number of nodes);*

*.  
laws of interpolation of the unknown factors (functions of form);*

*.  
“options” of calculation which the element “can” calculate (the operations for which calculation of the adequate integrals was programmed: for example, elementary term of rigidity, elementary term of surface force, elementary term of mass...).*

*A characteristic of Code\_Aster is to affect the boundary conditions and the loadings of edges to specific elements of edge, and not with the borders of the finite elements of volume.*

*The behavior is at the base a physical notion related to the properties of material. It is expressed then in a mathematical way. For example, in mechanics, one calls relation of behavior the relation which binds the stress field to the field of deformations, is in a direct way*

*(elastic behavior), that is to say in an incremental way (incremental behavior). During one calculation, the relation of behavior is expressed in each point of Gauss. In thermics, one used the term "behavior" to qualify the physical field associated with the resolution of the equation model of conduction-diffusion: two great classes of behaviors, which comprise each one several subcategories, are it thermal (possibly coupled with the hydration) and it drying.*

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### *1.3.2 The mechanical phenomenon*

*The mechanical phenomenon is modelled to achieve two principal goals:*

*.*

*determination of the internal state, in particular of the state of stress in any point of one structure, under various requests representing the conditions of operating.*

*knowledge of this state of stress makes it possible to continue the analysis of the behavior mechanics from the point of view:*

*- rules of construction particular to each type of structure, in particular them*

*Rules of Design or Construction (RCC...);*

*- harmfulness of defects and their possible propagation: defects inherent in*

*development process of the component or the structure (inclusions, imperfections*

*geometrical...) or resulting from the conditions of operating (cracking, erosion...);*

*-*

*study of the behavior in cyclic loading and analysis with tiredness;*

*-*

*prediction of the working loads with evolution of the internal state.*

.

*determination of the deformed configuration induced by a permanent loading (static) or resulting from a slow evolution (quasi-static) or more rapid (dynamic) of loadings or of the boundary conditions. The knowledge of this deformed configuration, and possibly speeds and of corresponding accelerations, allows to continue analysis of the mechanical behavior from the point of view:*

-

*vibratory and acoustic behavior;*

-

*transmission of the requests to other structures or components;*

*- risks of impact with the close structures to determine the anomalies of operation or the parameters of wear which can result from it.*

*The levels of modeling which intervene for the study of this phenomenon are:*

.

*the representation of the structure starting from the geometrical form, with several modes of representation possible being able to coexist:*

*- continuous medium corresponding to a three-dimensional, or two-dimensional geometry with various assumptions (forced plane, plane deformations, axisymetry complete or adapted to the decomposition of the loadings in modes of FOURIER),*  
*- structural elements corresponding to a medium with average layer, a medium with fibre average or a discretized medium.*

.

*the representation of the behavior of materials, possibly different, in any point of a structure, with relations of behavior allowing to represent different conditions of use. Many relations of behavior are available (cf plate): linear and nonlinear elasticity, nonlinear hyperelasticity, viscoelasticity, elastoplasticity, élasto-visco-plasticity, damage. Coefficients of the relations of behavior can in general depend on variables known as “of piloting” such as temperature, the metallurgical state, the degree of hydration or drying of the concrete, fluence, etc*

.

*the representation of the boundary conditions and the loadings, for which one has functionalities allowing to represent in any point of the structure, total reference mark or in reference mark defined by the user:*

*- conditions of DIRICHLET: imposed displacement or linear relations enters components of displacement,*

-

*conditions of NEUMANN: force imposed specific or surface loadings and linear, in particular allowing to represent the loadings of pressure,*

-

*voluminal loadings, in particular allowing to represent gravity and them centrifugal loads of the bodies in rotation.*

*These boundary conditions and loadings can depend on time (or of the frequency) and of one or more variables of space.*

*Nonthe linearities taken into account in the mechanical phenomenon are nonthe linearities of behavior, and nonlinearities geometrical (great displacements and great rotations, large deformations, contact and friction, buckling).*

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### **1.3.3 Associated phenomena**

***To supplement the representation of the environment of exploitation of the mechanical components, it choice was made include in Code\_Aster of the functionalities allowing the modeling of phenomena frequently associated the mechanical phenomenon.***

#### **1.3.3.1 Phenomenon**

##### ***thermics***

*It makes it possible to determine the thermal response of solid media in steady operation (problem stationary) or transient (evolutionary problem). One models solid conduction, the convectif exchange, the heat transfer between walls, and the radiation ad infinitum. The thermal phenomenon can include modeling with the heating or the cooling of the metallurgical phase shift of steels, what makes it possible to simulate the operations of heat treatment or welding (the identification of behavior is based on experimental diagrams TRC).*

*By analogy solved equations, the thermal phenomenon can also be used for to model the hydration (the unknown factor is the degree of hydration) or the drying of the concrete (the unknown factor is water concentration).*

### **Acoustic 1.3.3.2 Phenomenon**

*The acoustic phenomenon is modelled to achieve two principal goals:*

*.  
the study of the acoustic propagation in closed medium corresponding to the equation of HELMHOLTZ*

*in a compressible fluid, for fields of propagation to complex topology.*

*knowledge of the field of pressure makes it possible to continue the acoustic analysis for to determine:*

*-  
the field of noise levels (expressed in dB),*

*-  
fields of active and reactive acoustic intensity.*

*.  
the study of the vibroacoustic coupled problems 3D corresponding to the behavior vibratory of a structure in a limited field of compressible, nonviscous fluid.*

### **1.3.4 “Couplings” of phenomena**

*So that there is no ambiguity, one will distinguish:*

*.  
the chaining of two phenomena: preliminary study of the first phenomenon which one uses them results like data of the second,*

*.  
coupling of two phenomena: simultaneous resolution of the two phenomena with actually coupled equations (cf [§ 1.3.4.2]).*

#### **1.3.4.1 the chainings intern in Code\_Aster**

*The chaining can be carried out inside Code\_Aster or between this one and an external software (cf [§5.2]).*

*The chainings currently carried out within Code\_Aster are as follows:*

*.  
thermics - mechanics: all the mechanical characteristics of materials can to depend on the temperature and the algorithms available for the mechanical phenomenon allow to exploit the results of a preliminary thermal calculation*

*(deformations*

*anelastic*

*: thermal dilations, shrinking of the concrete...) carried out on a grid*

*possibly different,*

.

*thermics - metallurgy: after a thermal calculation, it consists in calculating the proportions of various metallurgical phases of steels,*

.

*thermics - metallurgy - mechanics: taking into account of four mechanical effects of metallurgical transformations (deformation of phase shift, modification of mechanical characteristics, plasticity of transformation, restoration of work hardening of origin metallurgical),*

.

*electric - mechanics: integrated into the mechanical phenomenon, the electric coupling is limited to the taking into account of the forces of LAPLACE induced by currents of short-circuit in electric cables,*

.

*fluid-mechanics: assignment of field of pressure on a wall deduced from a calculation from mechanics of the fluids.*

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*1.3.4.2 truths couplings*

*Porous environments*

***The or not saturated porous environments (géomatériaux, grounds, concrete) must be studied in***

***coupling the three equations of mechanics, thermics and hydraulics. The user chooses the behaviors which it wishes to use among a kit of models thermo-hydro-mechanics known as “THM”. It can thus choose to take into account or not the effect of the temperature, and to represent one or two pressures. The choice of each behavior associated with the phenomena selected is carried out within this framework also.***

### ***Interaction fluid-structure***

***Three types of couplings are available in the field of the interaction fluid-structure:***

***·  
the calculation of clean modes of a structure containing (or bathing in) a fluid at rest (with or without free face),***

***·  
the calculation of the vibrations of a structure in a flow and the estimate of the damage while resulting by vibratory tiredness or wear,***

***·  
the taking into account of a boundary condition of infinite fluid the field type.***

## ***1.4***

### ***Several methods of analysis***

#### ***1.4.1 Quasi-static/Transitory statics/***

***To implement various modelings, one has several methods of analysis which correspond to various processes of application of the requests.***

***Analyze static: it corresponds to permanent requests for the treatment of thermics stationary and the thermomechanical one. For the linear analyses, the results obtained can be compounds linearly, according to the needs, and are usable to describe the initial state of a process evolutionary.***

***Quasi-static analysis: for all the mechanical processes where one can neglect the phenomena of inertia, implicit incrémentaux algorithms are available to solve the equations of behavior nonlinear with taking into account of loadings and boundary conditions evolutionary.***

***Analyze transitory: in linear and nonlinear thermics, with possible taking into account of the effects metallurgical for metals and of the hydration and drying for the concretes, like for problems of thermo-hydro-mechanics by neglecting the effects of inertia on the mechanical part.***

#### ***1.4.2 Dynamics: physical or basic concept basic modal***

***For the processes where the effects of inertia and propagation must be taken into account***



*(vibratory mechanics, accoustics), one speaks about dynamic analysis.*

*The analysis in physical base is the resolution of the equations in the traditional base of the degrees of freedom physics.*

*The analysis in modal base rests on the preliminary calculation of the values and clean vectors of structure, and consists in projecting the equations to be solved on a basis of clean vectors: the number degrees of freedom of the system to be solved is proportional to the size of the modal base used. It is necessary that the selected modal base is of sufficient size to reproduce the principal ones physical phenomena: modal basic quality standards exist and can be checked (cf [§3.4.3]).*

*For these two types of analyses in physical or modal base, the calculation of answer can be carried out into temporal or harmonic (in the linear case).*

*For the seismic analysis, one can also formulate the problem moving imposed in one relative reference frame (without the movement of drive).*

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*The linear dynamic analyses can be made by including the effects, of the second order on rigidity, of the initial static stresses calculated as a preliminary (geometrical rigidity, stiffening centrifugal).*

*For the nonlinear problems, two methods of analysis are available:*

•  
*analysis by modal recombination with boundary conditions nonlinear localised for problems with shock,*

•  
*nonlinear dynamic analysis in physical base.*

### *1.4.3 Decomposition in modes of Fourier*

*The analysis in mode of Fourier is intended to calculate the linear response of a structure for geometry axisymmetric subjected to nonaxisymmetric loadings by netting only one section of structure.*

*Concretely, the loading being broken up into Fourier series, the resolution is made for each mode of Fourier then the total answer is obtained by recombination of the results on each mode.*

### *1.4.4 Under-structuring*

*Under structuring consists in gathering several finite elements within a macronutrient and with “to condense” the whole of their rigidity on the degrees of freedom (fewer) of it macronutrient.*

*The resolution of the total problem is limited then to the determination of the unknown factors carried by macronutrients then with the calculation of the unknown factors carried by each “small” element in manner independent within each macronutrient.*

*The advantages of this method are the savings of time and memory, when the complete structure is made of reproduced elements several times by translation or rotation.*

*In dynamics: the modal analysis and calculation of the harmonic or transitory answer can be carried out in traditional dynamic under-structuring by the methods of Craig-Bampton, Mac Neal or for the method known as of the modes of interface.*

*For the structures having a cyclic repetitivity, the methods available allow to calculate the clean modes of the total structure starting from the dynamic behavior of a sector basic.*

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## ***A method of resolution: finite elements***

*For the resolution of the various mentioned problems, the only method of established discretization currently is the finite element method.*

2.1

### ***A parameterized establishment of the finite element method***

*A particular effort was made to parameterize the establishment of the finite element method. options of calculation necessary to each method of analysis (static, quasi-static, dynamic) and for each phenomenon (mechanical, thermal, acoustic) are treated overall for all structure, whatever the modelings retained for a particular study.*

*Among the possibilities offered by this architecture, let us quote:*

.

*independence enters the topology of discretization (“grid*

*”) and properties*

*of interpolation of the finite elements assigned to these meshes (“model”) from where the diversity of modelings usable on the same grid,*

.

*the diversity of the relations of behavior and the properties of materials usable in the same model,*

.

*treatment of the boundary conditions and the loadings by specific finite elements of edge, to allow their localization without ambiguity, in particular for the mediums*

*continuous,*

.

*a systematic procedure allowing to treat the dependence of the material properties and of the boundary conditions with various parameters (temperature, time, variable of space...),*

.

*structures of data allowing to use all modelings with the different ones algorithms of resolution.*

*Concerning the treatment of the boundary conditions, let us announce that the method currently privileged is that of the dualisation. It makes it possible to represent any system of linear relations between discretized unknown factors, in particular for the connection of different modelings or the catch in consideration of additional local assumptions (flatness of a face of continuous medium...). One another method by elimination of the imposed degrees of freedom, exists in complement for calculations linear.*

*Concerning the methods of classification of the unknown factors, of storage of the assembled matrices and resolution of the linear systems on which the various algorithms rest, one has today of two direct methods, and an iterative method:*

.

*multi-frontal method,*

.

*factorization LDLT,*

.

*packaged combined gradient (iterative method).*

*One can add solver FETI for decomposition of fields of which a first version (limited to linear and with certain types of boundary conditions) is present in version 7.4.*

*These methods are associated algorithms of renumerotation of the degrees of freedom allowing to optimize the size memory necessary to store the matrices.*

## **2.2**

### ***A wide library of finite elements***

*The library of finite elements is parameterized to allow the assignment, with the various meshes recognized, of the discretized formulations of the phenomena available.*

#### ***2.2.1 Continuous mediums***

***One calls continuous medium a portion of three-dimensional or two-dimensional structure, treated like a volume.***

*Modelings 3D are the simplest forms of continuous medium, because they do not call upon no additional assumption. In modelings 2D, one removes an equation, but one must add assumptions: for example of plane strains or plane stresses in mechanics, of axisymetry in thermics and mechanics.*

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*There are also elements taking of account discontinuities (eg: fissure) by the method level-sets (elements XFEM).*

### *2.2.2 Components of structure*

*The structural elements are built by integrating assumptions on the behavior kinematics three-dimensional (representing more or less well the phenomena of inflection, torsion, shearing, warping...). One can classify them in three categories:*

*elements with average layer (plates, hulls): each type of element rests on assumptions of variation of the unknown factors in the thickness, which makes it possible to calculate the value in any point from that taken on the average layer (and possibly the faces lower and higher in thermics),*

*elements with average fibre (bars, beams, pipes, cables): the assumptions connect for each transverse section the value of the unknown factors in any point with that taken on fibre average,*

*discrete elements (masses, springs, shock absorbers...) : they make it possible to introduce on specific meshes or of the segments of the characteristics expressed in a reference mark Cartesian unspecified.*

### **2.2.3 Connections of modelings**

*The establishment retained for the Finite element method makes it possible to treat structures modelled with various types of machine elements (continuous mediums or structural elements). The connection of finite elements being based on different degrees of freedom, in the same node, can to be made by writing linear relations adapted to the nature of the connection. A methodology particular was developed to transmit as correctly as possible (within the meaning of least squares) torques of effort. One can thus represent the connection satisfactorily between a medium 3D and beams, plates, hulls or pipes, as well as the connections hull-beam, hull-pipe or beam-pipe.*

*The method HARLEQUIN also makes it possible to make connections between grids and/or phenomena different.*

## **2.3**

### **Heterogeneous modelings**

*Techniques of homogenisation make it possible to represent at lower cost a network of tubes bathing in an incompressible fluid, multi-layer composite hulls, or beams multifibre.*

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3

## *Tools of study*

3.1

### *Complements and operations on the grid*

*The concept of grid used by Code\_Aster is tiny room to its simpler expression: list nodes and their co-ordinates, lists meshes and of their topology. With these entities the notion is added of groups of nodes and group of meshes. These groups make it possible to affect different characteristics of modeling (finite elements, materials, boundary conditions, loadings...) and to lead the examination of the results (selective extraction of components). This party taken allows to build a grid, either by manual drafting without useless heavinesses, or by interfacing with mailleurs commercial (Gibi, I-DEAS, GID) or free (GMSH).*

*The user can create groups of nodes or meshes constantly in the unfolding of calculation, thanks to logical or geometrical criteria. One can also modify the structure of data containing the grid: change of reference mark, addition of additional nodes on meshes, creation of new meshes or groups of meshes, destruction of meshes, etc the addition and the ablation of matter can thus be modelled simply.*

3.2

### *Catalogue data material*

*A catalogue of data material under AQ gives access to the values of the parameters of laws of behavior for various materials usually used in the studies. Characteristics materials can be directly included in the command file thanks to an operator specific. For the free version, all the equipment of the catalogue is available but the base is empty (with the load of the user to fill it with his data).*

3.3

### *Treatment and analysis of the results*

#### *3.3.1 Operations on the fields*

*The computed fields can be used in all kinds of algebraic combinations. In analyze linear, one can thus for example deduce the response to a loading complexes answers to the unit loadings on which it break up.*

#### *3.3.2 Statement of values*

*Operations of extraction of the fields of results are available on nodes or meshes. It*

*is also possible to define a way of unspecified observation independent of the initial grid. Various calculations are proposed on the extracted fields (average, standard deviations, invariants tensorial, passage in local axes, etc). For the temporal or frequential evolutions, it is possible to extract the deformation at one moment (a frequency) or the answer from a particular size.*

### **3.3.3 Impression of the results**

*The results can be printed in an easily consultable form or with the format of the tools of visualization (Gibi, I-DEAS, GMSH or ENSIGHT). The user can integrate into the impressions of results of the personalized titles integral of the information extracted the context automatically from the study. Several tools are available to limit the impression to portions of the computed fields.*

*One can also plot curves with various formats (postscript or other formats of images) with assistance of the tracer xmgrace.*

## **3.4**

### **Quality control of the results**

*Many functionalities make it possible to control the quality of the results of a study or of in to facilitate its implementation.*

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### **Estimators of error and adaptive grid**

*Two categories of estimator of error are available. Coupled with the software of refinement/*



*déraffinement LOBSTER (chaining interns in Code\_Aster via macros-order), they make it possible to adapt the grid in the course of calculation in order to reach a given precision, for one cost optimal calculation.*

### *Checking of the quality of a modal base*

*Criteria of checking of the quality of a modal base make it possible to make sure that the number of clean modes selected makes it possible to correctly represent the phenomena which one wishes to study.*

### *Use of incompatible grids*

*Operators of projection allow to continue on a second grid a calculation carried out on a first grid. One can thus use different grids in thermics and mechanics (including for example a block fissures in the structure only at the time of its analysis in exploitation, after having calculated on a simpler grid the residual stresses due to sound manufacturing process).*

### *Automatic Recutting of the step of time and piloting of the loading*

*In the event of nonconvergence of the total algorithm of resolution, the user can ask so that the code engages of him even a recutting of the steps of time in order to allow convergence. In addition, it is also possible, in order to facilitate the convergence of calculations, to control the application progressive of the loading by the value of a degree of freedom or a deformation.*

### *Indicators of discharge and loss of radiality*

*These indicators make it possible a posteriori to check the validity of the assumptions formulated on nonlinear behavior of a structure, and relevance of the mode of application of the loading retained (not of load).*

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**4 Them**

**tool-dedicated**

**4.1**

**Definition and procedure**

***One calls tool-dedicated of the tools very related to the trade of owner of materials of production and electric distribution, and using Code\_Aster as solver. Tool-dedicated can have one more or less strong integration with Code\_Aster. One distinguishes two cases from figure:***

***integration with the command file Aster as an macro-order (including creation grid starting from simple geometrical data),***

***production by a separate tool (pre-post autonomous processor) of command files controlling calculation Aster, and treatment in this tool of the files of the recovered results.***

**4.2**

**The dedicated available ones**

**The dedicated following ones are available in the form of macro-orders of Code\_Aster:**

**ASCOUF**

***: analyze with the rupture of fissured elbows or with under-thicknesses,***

**ASPIC**

***: analyze nonlinear healthy or fissured prickings,***

**CABRI**

***: calculation of supports,***

**CALC\_PRECONT**

***: setting in tension of cables of prestressing.***

**The dedicated following ones communicate with Code\_Aster by command files and of**

**results:**

.

**MEKELEC**

*: analyze switchyards and air lines,*

.

**EVEREST**

*: dimensioning of the metal frames and the pylons in lattice,*

.

**GEVIBUS**

*: flow induced vibrations of the tubes of steam generators,*

.

**EPICURE/SECURE:** *harmfulness of defects in a tank.*

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**5**

**Exchanges with other software**

**5.1**

**Modes of exchanges**

**Code\_Aster can receive in data of the files coming from calculations carried out beforehand by external software. It can also export its results under an exploitable format by others tools. For certain types of analyses (for example interaction ground-structure or ground-fluid-**

*structure with software MISS3D) the two types of chaining can be activated.*

*The exchanges with other software are currently done either with format I-DEAS, or in a format specific to the chained software. Several orders of Code\_Aster allow the reading or the writing objects to be transmitted (fields of results, matrices, loadings...). In certain cases (MISS3D), of the macro-orders facilitate the implementation of a chained calculation. Lastly, it development of format MED creates a standard for the exchange of the files which is brought to to develop.*

## 5.2

### *Software interfaced with Code\_Aster*

*The software of grid interfaced with Code\_Aster is Gibi (subset of CASTEM2000), I-DEAS or GMSH. For the visualization of the results, one can use Gibi, I-DEAS, ENSIGHT or GMSH.*

*The principal computation softwares which can be chained with Version 7 of Code\_Aster are them following:*

- .  
**CIRCUS**  
*: vibrations of the circuits of pipings and lawful calculation,*
- .  
**N3S-SYRTHES**  
*: analyze thermal in the presence of flow,*
- .  
**EOLE**  
*: acoustic propagation in flow,*
- .  
**Dynamic EURO\_PLEXUS**  
*rapid*
- .  
**MISS3D**  
*: propagation of waves in the grounds laminated (seism) by elements of border,*
- .  
**LADY**  
*: analyze vibratory experimental,*
- .  
**LOBSTER**  
*: refinement and déraffinement of grid starting from an estimator of error,*
- .

**MEFISTO**

**: calculation of reliability,**

.

**SATURN**

**: code of mechanics of the fluids.**

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## ***Great principles of operation of Code\_Aster***

### ***Summary:***

***One presents here in a summary way the principles of operation of Code\_Aster and the principal rules of use.***

***This document remains a description general and the reader will refer usefully to the other documents, for all details of use.***

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### ***1 Principles Generals***

***Version 6 of the Code Aster makes it possible to carry out structural analyses for the phenomena thermics, mechanics, thermomechanical, or thermo-hydro-mechanics coupled, with one or not linear linear behavior, and of calculations of internal accoustics.***

***Nonthe linearities relate to the behaviors of the materials (plasticity, viscoplasticity,***

*damage, effects metallurgical, hydration and drying of the concrete,...), the large ones deformations or great rotations and the contact with friction. One will refer to the plate of presentation of version 6 for the presentation of the various functionalities.*

*The current industrial studies require the placement of tools of grid and visualization graph, which does not form part of the Code. However, several tools are usable for these operations via procedures of interface integrated into the Code.*

*To make a study, the user must, in general, prepare two data files:*

*· the file of grid:*

*to define geometrical and topological description grid without choosing, at this stage the type of formulation of the finite elements used or the physical phenomenon to model. Some studies can result in using several files of grid.*

*This file of grid, in general, is produced by an interface integrated into the Code Aster to leave of a file coming from a software of grid used out of preprocessor (GIBI, GMSH, IDEAS...). Information which this file must contain is specific to Code\_Aster. They define traditional entities of the finite element method:*

*· nodes: points defined by a name and their Cartesian co-ordinates in space 2D or 3D,*

*· meshes: plane or voluminal named topological figures (not, segment, triangle, quadrangle, tetrahedron,...) to which will be able to apply various types of elements stop, boundary conditions or loadings.*

*To improve safety of use and comfort of the operations of modeling and of examination of the results, one can define, in the file of grid, of the levels of entities superiors, having an unspecified property jointly and who could be used directly by their name:*

*· groups of nodes: named lists of names of nodes,  
· groups of meshes: named lists of names of meshes.*

*One will note, as of now, that all handled geometrical entities (nodes, meshes, groups of nodes, groups of meshes) are named by the user and usable with all moment by their name (8 characters to the maximum). The user will be able to use this possibility to identify explicitly certain parts of the studied structure and to thus facilitate it examination of the results. The classification of the entities is never clarified: it is useful only in-house to point on the values of the various associated variables.*

*· the command file: to define the text of order which allows:*

-

*of reading and if required enriching the data of the file by grid (or other sources of external results),*

-

*to affect the data of modeling on the entities of the grid,*

-

*to connect various operations of treatment: specific calculations, postprocessings,*

-

*to publish the results on various files.*

*The text of order refers to the names of geometrical entities defined in the file of grid. It also makes it possible to define new groups constantly.*

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*From the data-processing point of view, these two files are ASCII files in free format. One gives some here*

*principal characteristics:*

*Syntax of the file of grid:*

*· length of line limited to 80 characters,*

*· the allowed characters are:*

-

*26 tiny capital letters A-Z and 26 a-z converted automatically in capital letters, except in the texts (provided between quotes),*

-

*ten figures 0-9 and signs of representation of the numbers (+ - . ),*



## ***character***

***\_*** *white underlined usable in key words or names,*

- *a word must always start with a letter,*
- *the white character is always a separator,*
- *the character % indicates the beginning, until the end of the line, of a comment.*
- *The other rules of reading are specified in the booklet [U3.01.00]*

***Syntax of the command file:***

- *syntax related to the language Python, allowing to include instructions of this language*
- *character # indicates the beginning, until the end of the line, of a comment.*
- *The orders must start in column 1, unless they do not belong to a block indenté (buckles, test)*

***The other rules of reading are specified in the booklet [U1.03.01].***

## ***2 Grid***

### ***2.1 General***

***The structure and the syntax of the file of grid are detailed in the Booklet [U3.01.00].***

***This file can be written (for elementary grids) or be modified manually with does not import which text editor. It is a file read in free format, structured in records or under file by imposed key words.***

***Several utilities of conversion are available to allow the file conversion of grid products by other software packages (IDEAS, GIBI, GMSH...) or of the files of grid to format MED.***

### ***2.2***

***The file of grid Aster***

***The file of Aster grid is read first line until the first occurrence of a line begin with the FINE word. This key word is obligatory. The file of grid is structured in independent subfiles starting with a key word and finished by the key word imposed FINSF.***

***This file must comprise at least two subfiles:***

- *co-ordinates of all the nodes of the grid in a Cartesian reference mark 2D (COOR\_2D) or 3D (COOR\_3D).*
- *the description of all meshes (TRIA3, HEXA20, etc...), on which one will affect then physical properties, finite elements, boundary conditions or loadings.*

*It can possibly contain groups of nodes (GROUP\_NO) or meshes (GROUP\_MA) for to facilitate the operations of assignment, but also the examination of the results.*

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*It is essential to explicitly create at this stage the meshes located on the borders of application of the loadings and boundary conditions. One will find then, in the file of grid:*

- meshes of edge of the elements 2D necessary,*
- meshes of face of the elements 3D solid masses necessary;*
- groups of meshes of associated edge and/or face.*

*This constraint becomes bearable when one uses an interface, which does the work from indications provided at the time it grid (see documents PRE\_IDEAS [U7.01.01] or PRE\_GIBI [U7.01.11]).*

*2.3*

*The description of the meshes*

*Conventions of description of the topology of the meshes and conditions of use of different types of meshes are described in the booklet [U3.01.00].*

*The principal types of meshes recognized are identified by the following reserved key words [U3.01]:*

*/*

*POII*

*specific mesh*

*/SEG2/*

*SEG3/SEG4*

*segments with 2, 3, or 4 nodes*

*/TRIA3/TRIA6/TRIA7 triangles to 3, 6 or 7 nodes*

*/QUAD4/QUAD8/QUAD9 quadrangles to 4, 8 or 9 nodes*

*/HEXA8/HEXA20*

*/HEXA27*

*hexahedrons with 8, 20 or 27 nodes*

*/*

*PENTA6*

*/*

*PENTA15*

*pentahedrons with 6 or 15 nodes*

*/*

*TETRA4*

*/*

*TETRA10 tetrahedrons to 4 or 10 nodes*

*/*

*PYRAM5*

*/*

*PYRAM13 pyramids to 5 or 13 nodes*

**2.4**

*interfaces*

*These interfaces make it possible to convert the files, with or without format, used by different computer software package or codes, with the conventional format of the file of grid Aster.*

*The currently available interfaces are those which make it possible to use maillor IDEAS, it maillor GIBI of CASTEM 2000, maillor GMSH, and to treat the files of grid with the format of exchange MED.*

**2.4.1 Universal file IDEAS**

*The interface is made using order PRE\_IDEAS [U7.01.01]*

*The convertible file is the universal file defined by documentation I-DEAS (see Fascicule [U3.03.01]). The recognition of version IDEAS used is automatic.*

*A universal file IDEAS consists of several independent blocks called “dated sets”. Each “set dated” is framed by the character string -1 and is numbered. “Dated recognized sets” by the interface are described in the booklet [U3.03.01].*

#### ***2.4.2 The file of grid GIBI***

*The interface is made using order PRE\_GIBI [U7.01.11].  
The convertible file is the ASCII file restored by the order TO SAVE FORMAT of CASTEM 2000.  
The precise description of the interface is given in [U3.04.01].*

#### ***2.4.3 The file of grid GMSH***

*The interface is made using order PRE\_GMSH [U7.01.31].  
The convertible file is the ASCII file restored by order SAVE of GMSH.*

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## **2.4.4 The file of grid to format MED**

The interface is made using order LIRE\_MAILLAGE (FORMAT: "MED") [U4.21.01]).

MED (Modeling and Data exchanges) is a neutral format of data developed by EDF R & D for the data exchanges between computer codes. Files MED are binary files and portables. The reading of a file MED by LIRE\_MAILLAGE, makes it possible to recover a grid product by any other code able to create a file MED on any other machine. This format of data is in particular used for the exchanges of files of grids and results between ASTER and the tool of refinement of grid LOBSTER. The precise description of the interface is given in [U7.01.21].

## **2.5**

### **The use of incompatible grids**

Although the finite element method recommends the use of regular grids, without discontinuity, to obtain a correct convergence towards the solution of the continuous problem, it can be necessary for certain modelings to use incompatible grids: on both sides of a border, the grids do not correspond. The connection of these two grids is then managed on the level of the command file by key word LIAISON\_MAIL of the order AFFE\_CHAR\_MECA. This makes it possible in particular to finely connect a zone with a grid with another zone where one can be satisfied with a coarse grid.

## **2.6**

### **Adaptive grid**

Starting from an initial grid, it is possible to adapt the grid, to minimize the made error, with assistance of the macro order MACR\_ADAP\_MAIL, which calls upon the software LOBSTER.

Software of  
adaptive grid LOBSTER functions on grids made of segments, triangles, tetrahedrons.

This adaptation of grid is placed after the first calculation with *Code\_Aster*. An indicator of the error will have been calculated. According to its value nets by mesh, the software LOBSTER will modify it

grid. It is also possible to interpolate fields of temperature or displacement with nodes of the old grid towards the new one [U7.03.01].

### 3 Orders

#### 3.1

##### The command file

The command file contains a whole of orders, expressed in a specific language in *Code\_Aster*. In complement of the characteristics of file described in paragraph 1, one will find the detailed syntax of the language in the booklet [U6.02.00]. These orders are analyzed and carried out by a software layer of *Code\_Aster* called “supervisor”.

#### 3.2

##### The role of the supervisor

The supervisor carries out various tasks, in particular:

- a phase of checking and interpretation of the command file,
- a production run of the interpreted orders.

These tasks are detailed in the booklet [U1.03.01].

The command file is treated starting from the line where the first call to the procedure is **BEGINNING ()** or with the procedure **CONTINUATION ()**, and until the first occurrence of the order

**END ()**. The orders located before **BEGINNING ()** or **CONTINUATION ()** and after **END ()** are not

carried out, but must be syntactically correct).

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**· Syntactic Phase of checking:**

**-**

**reading and syntactic checking of each order; any error of detected syntax makes the object of a message, but the analysis continues,**

**- checking that all the concepts used as arguments were declared in one order preceding like produced concept of an operator; it is also checked that the type this concept corresponds to the type required for this argument.**

**· Production run:**

**-**

**the supervisor activates successively the various operators and procedures, which carry them out tasks envisaged.**

### **3.3**

#### **Principles and the syntax of the process control language**

**The modular concept of *Aster* makes it possible to present the Code like a succession of orders independent:**

- the procedures, which do not produce results directly, but ensure, amongst other things, management of the exchanges with the external files,**
- the operators, who carry out an operation of calculation or data management and produce one concept result to which the user gives a name.**

**These concepts represent structures of data, that the user can handle. These concepts are typified at the time of their creation and could be used only as argument of entry of corresponding type.**

**The procedures and the operators thus exchange information necessary and of the values by the intermediary of the named concepts**

**The complete syntax of the orders and its implications on the drafting of the command file**

are detailed in the booklet [U1.03.01]. Here an example of some orders is given (extracted the example with accompanying notes in [U1.05.00]):

```
email = LIRE_MAILLAGE ()

mod1 = AFFE_MODELE (GRID = email,
AFFE=_F (TOUT=' OUI',
PHENOMENE=' MECANIQUE',
MODELISATION=' AXIS'))

f_y = DEFI_FONCTION (NOM_PARA = "Y"
VALE =_F (0. , 20000. ,
4., 0. )
)

charg = AFFE_CHAR_MECA_F (MODEL = mod1
PRES_REP =_F (GROUP_MA = ("lfa", "ldf"),
CLOSE = f_y))

.....
res1 = MECA_STATIQUE (MODELE=mod1,
.....
EXCIT=_F (LOAD = charg),
....)

res1 = CALC_ELEM (reuse=res1, RESULTAT=res1,
.....
MODELE=mod1,
OPTION= ("SIGM_ELNO_DEPL", "EPSI_ELNO_DEPL"))
```

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**Some general points will be noted, which one can observe on the preceding example:**

- **any order starts in first column,**
- **the list of the operands of an order is obligatorily between brackets, as well as the lists elements,**
- **a nom\_de\_concept can appear only once in the text of order like produced concept, on the left of the sign =,**
- **the re-use of an existing concept like produced concept, is not possible that for operators specified to this end. When one uses this possibility (réentrant concept), order uses the reserved key word then “reuse”.**

**This operation is done:**

- **is with crushing of the initial values. As example let us announce factorization in place of a matrix of rigidity:**

**matass = FACT\_LDLT (reuse=matass, MATR\_ASSE= matass)**

- **is with enrichment of the concept.**

### **3.4**

#### **Regulate of overload**

**A rule of overload usable, in particular for all the operations of assignment, was added with the rules of use of a mot\_cle\_factor with several lists of operands:**

- **the assignments are done by superimposing the effects of different mot\_clé,**
- **in the event of conflict, the mot\_clé last overrides the precedents.**

**Example: one wishes to affect various materials MAT1, MAT2 and MAT3 with certain meshes:**

**to subdue = AFFE\_MATERIAU (MAILLAGE= mon\_mail**

**AFFE = \_F (ALL = “YES”, MATER = MAT1),**

**\_F (GROUP\_MA = “mail2”, MATER = MAT2),**

**\_F (GROUP\_MA = “mail1”, MATER = MAT3),**

**\_F (MESH = (“m7”, “m8”), MATER = MAT3))**

- **One starts by assigning material MAT1 to all the meshes.**
- **One assigns then material MAT2 to the group of meshes mail2 which contains, the meshes m8, m9 and m10.**
- **One assigns finally material MAT3 to the group of meshes mail1 (m5, m6 and m7) and to the meshes m7 and m8, which causes conflict since the mesh m7 forms already part of the mail1 group. regulate of overload will then be applied and one will obtain finally the field of following material:**

**MAT1**

**:**  
**meshs m1 m2 m3 m4**

**MAT2**

**:**  
**meshs m9 m10**

**MAT3**

**:**  
**meshs m5 m6 m7 m8**

### **3.5**

#### **Data bases associated with a study**

***Code\_Aster* rests, for the management of all the structures of data associated with different concepts handled, on software package JEVEUX. This one deals with the space management memory asked by the user at the time of the request for execution (parameter Report expressed in Megabytes). This space is frequently insufficient to store central all them structures of data. The software package takes then charges some, the management of the exchanges between the memory power station and of the auxiliary auxiliary storages on files.**

**Each entity is affected, during its creation by the code, with a file of direct access. This one can to be regarded as a data base, since it contains, at the end of the execution the repertory (names and attributes) which makes it possible to exploit all the segments of values that it contains.**

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**Code\_Aster uses several data bases:**

- **the TOTAL data base, which contains all the concepts produced by the operators, thus that contents of certain catalogues on which the concepts are pressed; the file associated with this the later continuation of a study allows. It must thus be managed by the user.**
- **other data bases, used only by the Supervisor and the operators, with the course of an execution, do not require a particular intervention of the user.**

**To make a study, it is to ask for the sequence of several orders:**

- **of the procedures to exchange files with the external world,**
- **of the operators to create concepts progressively produces course of operation of modeling and calculation.**

**The orders which correspond to this sequence of operations can be carried out of various ways, starting from the single achievable module of Code\_Aster:**

- **in only one sequential execution, without intervention of the user,**
- **by splitting the study in several successive executions, with re-use of the results former; starting from the second execution, the access to the data base is done in continuation; with the occasion of a continuation, one can redemand the last order, if it stopped prematurely (lack of time, incomplete or incorrect data detected in phase of execution,...).**

**Beginning**

**order 1**

**order 1**

**order 2**

**order 2**

- 
- 
- 
- 

**Study**

**order I**

**order I**

**Study**

**End**

**order i+1**

**Continuation**

**order i+1**

- 
- 
- 
- 

**order J**

**order J**

**End**

**order j+1**

**Continuation**

**order j+1**

**The continuation is not possible**

- 
- 

**that within the framework of one**

- 
- 

**even version**

**order N**

**order N**

**End**

**To manage these possibilities, it will be noted that three orders play a paramount part. They are those**

**who correspond to the procedures which activate the supervisor:**

**• BEGINNING ()**

**obligatory for the first execution of a study,**

· **CONTINUATION ()**

**obligatory starting from the second execution of a study,**

· **FINE ()**

**obligatory for all the executions.**

**For a given study, one can subject command files having the following structure:**

**Note:**

· *Order INCLUDE makes it possible to include in a flood of orders the contents of another command file. This allows in particular, to preserve a file of the orders principal readable and to place in annexed files of the numerical data bulky (ex: definition of functions).*

· *The command files can be cut out in several files which will be carried out one after the other, with intermediate safeguard of the data base. For that, it is necessary to define the successive command files, whose suffix will be: .com 1, .com 2,..., .com 9. The executions of these files are connected. The data base of the last execution who finished well is preserved.*

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**3.6**

**Contribute to the definition of the values**

**3.6.1 Substitution of values**

**Several orders are available to help the user to define the values used like**

arguments, therefore to parameterize its command file:

- to give a name to one or more values:

**name = DEFINI\_VALEUR (STANDARD = [value]);**

or quite simply:

**name = value**

- Evaluer certain mathematical expressions:

**EVAL (expression)**

For example:

**Eptub = 26.187E-3**

**Rmoy = 203.2E-3**

**Rext = DEFINI\_VALEUR (R8 = EVAL ("'''' Rmoy+ (Eptub/2) ''''))**

**= AFFE\_CARA\_ELEM (MODEL will cara = model**

**BEAM =\_F (GROUP\_MA = all, SECTION: "CIRCLE",**

**CARA = ("R", "EP"), VALE = (Rext, Eptub)))**

These possibilities result in a simple substitution of the values each time the Supervisor meet the name chosen by the user.

### 3.6.2 Functions of one or more parameters

It is also often necessary to use sizes functions of other parameters.

Those can be:

- is defined on an external file read by the order, **LIRE\_FONCTION**.

- is defined in the command file by:

-

**DEFI\_CONSTANTE** produces a concept function with only one constant value,

-

**DEFI\_FONCTION** produces a concept function for a size function of one real parameter,

-

**DEFI\_NAPPE** produces a concept function for a list of functions of same size, each element of the list corresponding to a value of another parameter reality.

The concept produced by these operators is of function type and can only be used as argument of operands which accept this type. The operators who accept one argument of the function type have as a suffix **F** (ex: **AFFE\_CHAR\_MECA\_F**). Functions in this case are defined point by point, with a linear interpolation by defect, therefore

closely connected by pieces.

The functions created are discrete tables of the sizes specified with creation.

At the time of a search for value, one proceeds according to the specified characteristics, by direct research or by interpolation in the table (linear or logarithm). One can to specify, during the creation of the function, the prolongation out of the field of definition table, with various rules, or to prohibit it.

· is defined using their analytical expression by the operator FORMULATES: for example:

$\Omega = 3.566;$

linst = (0. , 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.20, 0.40 )

F = FORMULA (REAL = '' (REAL: INST) = COS (OMEGA\*INST) '')

F1=CALC\_FONC\_INTERP (FONCTION=F, VALE\_R= linst, NOM\_RESU=' ACCE',)

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The analytical function  $F(T) = \cos(T)$  is then calculated by CALC\_FONC\_INTERP for the moments of the list linst list of moments T.

**3.7**

**How to write its command file with EFICAS?**

To write a command file of *Code\_Aster*, most immediate consists starting from an example already written by others. In particular, the whole of the tests of *Code\_Aster* often constitutes one good starting base for a new modeling.

But there is better: tool EFICAS makes it possible to write in an interactive and convivial way its file of orders, by proposing for each order the list of the possible key words while checking automatically syntax, and by giving access to the documentation of the Instruction manual (booklets [U4] and [U7]).

## 4 Great stages of a study

The great stages of a study are in the case general:

- the preparation of the work, which finishes after the reading of the grid,
- the modeling during which are definite and affected all the properties of finite elements and of materials, boundary conditions and loadings,
- calculation can then be carried out by the execution of total methods of resolution [U4.5-], which are possibly based on orders of calculation and assembly of matrix and vectors [U4.6-]
- operations of postprocessings complementary to calculation [U4.8-],
- operations of impression of the results [U4.9-]
- operations of exchange of results with other software (graphic visualization by example) [U7.05-]

Another way of using *Code\_Aster* consists in exploiting tools trades, available in Code in the form of MACRO\_COMMANDES: let us quote for example the tools trades:

- ASCOUF (modeling of fissured elbows or elbows with under-thicknesses),
- ASPIC (modeling of or not fissured prickenings),
- GOUJ2ECH (modeling of the behaviour of the threaded assemblies).

### 4.1 To start the study and to acquire the grid

One will not reconsider here the possible fragmentation of the command file, which was presented in a preceding paragraph.

The first achievable order is:

```
BEGINNING  
( )
```



**The argument of this order are useful only for the maintenance actions or in case of very large studies.**

**For the reading of the grid, coming from a software of external grid, one can operate of two ways:**

**· to convert the file of a software package by a separated execution, which allows, if required, to modify it by text processing and to preserve it:**

**BEGINNING**

**()**

**PRE\_IDEAS ()**

**END ()**

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**the normal study will be able to then begin for example by:**

**BEGINNING**

**()**

**my = LIRE\_MAILLAGE**

**()**

**· to convert the file right before reading it:**

**BEGINNING**

**()**

**PRE\_IDEAS**

**()**

**my = LIRE\_MAILLAGE**

**()**

## **4.2**

**To assign data of modeling to the grid**

**To build the modeling of a mechanical problem, thermal or acoustic, it is essential to assign to the topological entities grid:**

- a model of finite element,**
- properties of the materials (law of behavior and parameters of the law),**
- of the geometrical or mechanical characteristics complementary,**
- of the boundary conditions or the loadings.**

**These assignments are obtained by various operators whose name is prefixed by AFFE\_. syntax and the operation of these operators already uses the facilities brought by the rules mentioned previously on the use of the key words factor.**

### **4.2.1 Definition of a field of assignment**

**To carry out an assignment, it is essential to define a field of assignment per reference to names of the topological entities defined in the file grid. Five key words are usable for that, according to the specification of the operator:**

- to refer to all the grid by**

**TOUT= “YES”**

- to assign to meshes by**

**MAILLE= (list of names of meshes)**

- to assign to groups of meshes by**

**GROUP\_MA= (list of names of groups of meshes)**

- to assign to nodes by  
**NOEUD=** (list of names of nodes)
- to assign to groups of nodes by  
**GROUP\_NO=** (list of names of groups of nodes)

#### 4.2.2 To affect the type of finite element

On the meshes of the studied structure, which are at this stage only topological entities, it is essential to affect:

- one or more phenomena studied: “**MECHANICAL**”, “**THERMAL**”, “**ACOUSTIC**”;
- a model of finite element compatible with the topological description of the mesh. This assignment induces an explicit list of degrees of freedom in each node and a law of interpolation in the element.

One uses for that the operator **AFFE\_MODELE** [U4.41.01], who can be called several times on even grid. It uses the rules of overload and remanence.

#### Foot-note:

*For a study with several treated phenomena (“**MECHANICAL**”, “**THERMAL**”), it is essential to build a model for each phenomenon, by as many calls to **AFFE\_MODELE**. On the other hand, for a given calculation (mechanical, thermal,...) one needs one and only one model.*

To know the characteristics of the various finite elements available one will refer to booklets [U2-], and [U3-].

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### 4.2.3 To affect material characteristics

It is necessary to assign to this stage characteristics of material, and the parameters associated, with each finite element of the model (except for the directly definite discrete elements by a matrix of rigidity, of mass and/or damping). In other words, **DEFI\_MATERIAU** is used to define one material and **AFFE\_MATERIAU** are used to define a material field by association of the grid. For one calculation given, one needs one and only one field of material.

One can also use the validated characteristics of the catalogue material using the procedure **INCLUDE\_MATERIAU** [U4.43.02].

A certain number of models of behavior are usable: rubber band, orthotropic rubber band, thermics, accoustics, elastoplastic, elastoviscoplastic, endommagment. Let us note that it is possible to define several material characteristics for the same material: rubber band and thermics, elastoplastic, thermoplastic,...

### 4.2.4 To assign characteristics to the elements

During the use of certain types of elements, for the “MECHANICAL” phenomenon, the definition geometrical deduced from the grid does not allow to describe them completely.

One must assign to the meshes the missing characteristics:

- for the hulls: the constant thickness on each mesh and a reference mark of reference for representation of the state of stress,
- for the beams, bars and pipes: characteristics of the cross section, and possibly orientation of this section around neutral fibre.

These operations are accessible by the operator **AFFE\_CARA\_ELEM** [U4.42.01]), who uses, for to simplify the drafting of the order, the rules of overload and remanence.

Another possibility is offered by this operator: that to introduce, directly in the model, of matrices of rigidity, mass or damping on meshes **POI1** (or nodes) or meshes **SEG2**. These matrices correspond to the types of discrete finite elements with 3 or 6 degrees of freedom by node **DIS\_T** or **DIS\_TR** which must be affected at the time of the call to the operator **AFFE\_MODELE**.

### 4.2.5 To affect the boundary conditions and the loadings

**These operations are, in general, essential. They are carried out by several operators of which its name is prefixed by AFFE\_CHAR or CALC\_CHAR. On the same model, one will be able to carry out several calls to these operators to define, progressively study of the boundary conditions and/or loadings.**

**The operators used differ with the phenomenon:**

**“MECHANICAL”**

**AFFE\_CHAR\_CINE**

**AFFE\_CHAR\_MECA given of real type only**

**AFFE\_CHAR\_MECA\_F**

**data of the function type**

**“THERMAL”**

**AFFE\_CHAR\_THER given of real type only**

**AFFE\_CHAR\_THER\_F**

**data of the function type**

**“ACOUSTIC”**

**AFFE\_CHAR\_ACOU given of real type only**

**Moreover, one can establish the seismic loading to carry out a calculation of response moving relative compared to the supports, using order CALC\_CHAR\_SEISME.**

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**The boundary conditions and loadings can be defined according to their nature:**

- with the nodes,
- on meshes of edge (edge or face) or meshes support of finite elements, created in the file grid. On these meshes operator **AFFE\_MODELE** has affected the types of elements stop necessary.

**For the detailed description of the operands of these operators and the rules of orientation of the meshes support (total reference mark, local reference mark or unspecified reference mark) one will refer to the documents [U4.44-01], [U4.44-02], and [U4.44-04].**

**The boundary conditions can be treated in two ways:**

- by “elimination” of the degrees of freedom imposed (for linear mechanical models implementing that boundary conditions kinematics (degrees of freedom blocked) without linear relation. One will define in this case the boundary conditions by the order **AFFE\_CHAR\_CINE**.
- by dualisation [R3.03.01]. This method because of its greater general information allows to treat all the types of boundary conditions (degree of freedom imposed, relations linear between degrees of freedom,...) ; the method used results in adding 2 multipliers of **LAGRANGE** for each ddl imposed or each linear relation.

**Each concept produced by the call to these operators, of type **AFFE\_CHAR**, corresponds to a system boundary conditions and loadings indissociable. In the orders of calculation, one can to incorporate these concepts while providing for the operands **CHARGES** a list of concepts of this type.**

## **4.3**

### **To carry out calculations by total orders**

#### **4.3.1 Analyze**

##### **THERMICS**

**To or not calculate to it (S) field (S) of temperature corresponding to a linear thermal analysis linear:**

- stationary (moment 0),

- **evolutionary** whose moments of calculation are specified by a list of realities defined as a preliminary

The orders to be used are:

- **THER\_LINEAIRE** for a linear analysis [U4.54.01],
- **THER\_NON\_LINE** for a nonlinear analysis [U4.54.02],
- **THER\_NON\_LINE\_MO** for a problem of live loads in steady operation [U4.54.03].

Calculations of the matrices and vectors elementary and assembled necessary to the implementation of methods of resolution are dealt with by these operators.

### 4.3.2 Analyze STATIC

To calculate the mechanical evolution of a structure subjected to a list of loadings:

- **MECA\_STATIQUE** [U4.51.01]: linear behavior, with superposition of the effects of each loading,
- **MACRO\_ELAS\_MULT** [U4.51.02]: linear behavior, by distinguishing the effects of each loading,
- **STAT\_NON\_LINE** [U4.51.03]: quasi-static evolution of a structure subjected to a history of loading in small or great transformations, made of a material of which its behavior is linear or not linear, with taking into possible account of the contact and friction.

If this mechanical calculation corresponds to a study of thermoelasticity, one will refer to one moment thermal calculation already carried out. If the material were defined with characteristics depending on the temperature, those are interpolated for the temperature corresponding to the moment of calculation asked.

For the problems of thermohydrromecanic coupled, it is the operator **STAT\_NON\_LINE** who is used to solve simultaneously the 3 problems thermics, hydraulics and mechanics.

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**Calculations of the matrices and vectors elementary and assembled necessary to the implementation of methods of resolution are dealt with by these operators.**

### **4.3.3 MODAL analysis**

**To calculate the clean modes and eigenvalues of the structure (correspondent to a problem vibratory or with a problem of buckling).**

- MODE\_ITER\_SIMULT [U4.52.03]: calculation of the clean modes by simultaneous iterations; eigenvalues and vector clean are real or complex,**
- MODE\_ITER\_INV [U4.52.04]: calculation of the clean modes by iterations opposite; values clean and vector clean are real or complex,**
- MACRO\_MODE\_MECA [U4.52.02]: reduce the modal analysis while cutting out automatically the interval of frequency in under intervals,**
- MODE\_ITER\_CYCL [U4.52.05]: calculation of the clean modes of a structure with repetitivity cyclic starting from a base of real clean modes.**

**These four operators require as a preliminary the calculation of the assembled matrices [U4.61-].**

### **4.3.4 Analyze DYNAMIC**

**To calculate the dynamic response, linear or not linear, of the structure. Several operators are available. One can quote for example:**

**DYNA\_LINE\_TRAN [U4.53.02]: temporal dynamic response of a linear structure subjected to one transitory excitation,**

**DYNA\_LINE\_HARM [U4.53.02]: dynamic response complexes of a linear structure subjected to one harmonic excitation,**

**DYNA\_TRAN\_MODAL [U4.53.21]: transitory dynamic response in coordinated generalized by modal recombination.**



**These three operators require as a preliminary the calculation of the assembled matrices [U4.61-].**

**DYNA\_NON\_LINE [U4.53.01]: temporal dynamic response of a nonlinear structure subjected to a transitory excitation, which also calculates the assembled matrices.**

## **4.4 results**

**Results produced by the operators realizing of calculations by finite elements [U4.3-], [U4.4-] and [U4.5-] are of two principal types:**

- **is of the type of field (by elements or with the nodes) when it acts operators not producing that only one field (for example RESO\_LDLT),**
- **is of the RESULT type strictly speaking which gathers sets of fields, accessible by a variable allowing to distinguish them (urgent for a result resulting from one evolutionary calculation, frequency for a result coming from an algorithm of search for modes clean or of harmonic answer,...).**

**A field in a concept of the RESULT type is located:**

- **by a variable of access which can be:**
  - **a simple sequence number referring to the order in which the fields were arranged,**
  - **a parameter preset according to the type of the concept RESULT:**
    - **frequency or number of mode for a RESULT of the mode\_meca type,**
    - **moment for a RESULT of the evol\_elas type, temper, dyna\_trans or evol\_noli.**

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· by a reference symbol of field referring to the type of the field: displacement, speed, state of stress, efforts generalized,...

In addition to the variables of access of other parameters can be attached to a type of concept RESULT. The contents of these concepts are completely described in the booklet [U5-].

The various fields are built-in in a concept result:

- is by the operator who created the concept, a total order (MECA\_STATIQUE, STAT\_NON\_LINE,...) or a simple order (MODE\_ITER\_SIMULT, DYNA\_LINE\_TRAN,...),
- is during the execution of an order which makes it possible to add an option of calculation in form of a field by element (CALC\_ELEM) or of a field to nodes (CALC\_NO); one says then explicitly that one enriches the concept:

resul

=

operator

(reuse=resul, RESULT =

resul...);

## 4.5

### To exploit the results

The whole of the preceding orders made it possible to build various concepts which are exploitable, by operators of postprocessing of calculations:

- general operators of postprocessing (see booklet [U4.81]), for example CALC\_ELEM, CALC\_NO, POST\_ELEM, POST\_RELEVE\_T,

- operators of breaking process (see booklet [U4.82]), for example CALC\_G\_THETA,
- operator of metallurgy: CALC\_META,
- static mechanical postprocessing (see booklet [U4.83]), for example POST\_FATIGUE, POST\_RCCM,
- dynamic mechanical postprocessing (see booklet [U4.84]), for example POST\_DYNA\_ALEA, POST\_DYNA\_MODAL\_T.

· operators of extractions:

-

of a field in a concept result RECU\_CHAMP [U4.63.1],

-

of a field in co-ordinates generalized for a dynamic calculation with modal base RECU\_GENE [U4.63.2],

- of a function of evolution of a component starting from a concept result RECU\_FONCTION [U4.63.3],

-

and of restitution of a dynamic response in physical base REST\_BASE\_PHYS,

-

an operator of postprocessing of functions or tablecloths CALC\_FONCTION which allows research of peaks, extremums, combinations linear,... [U4.21.9].

Finally two procedures IMPR\_RESU [U4.91.01] and IMPR\_COURBE [U4.33.01] allow the impression and

possibly the creation of exploitable files by other software packages in particular of visualization graph One will retain in particular graphic visualization by IDEAS, GMSH, or GIBI whatever the tool for grid used at the beginning.

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## 5 Print files and error messages

*Aster* writes information relating to calculation in three files whose significance is as follows.

### **File Contained**

#### **ERROR**

Errors met during the execution

#### **MESSAGE**

Information on the course of calculation.

Repetition of the command file, provided and its interpretation by

*Aster*.

Execution time of each order.

Messages “system”

#### **RESULT**

Only expressly written results requested from the request of the user and the error messages

Other files are used for the interfaces with the programs of graphic examination.

One distinguishes various types of error messages. The transmitted messages will be only directed according to their type:

### **Code**

#### **Type of message**

#### **Output files**

F

fatal error message, the execution stops after various ERROR

impressions. The concepts created during the execution are lost. MESSAGE

It is used within the framework of the serious detection of error which cannot RESULT

to allow the normal continuation of an order *Aster*

E

error message, the execution continues a little: this type of message ERROR

allows to analyze a series of errors before the program stop. (by MESSAGE

example, syntactic analysis of the command file by the RESULT

Supervisor).

*The emission of a message of the <E> type is always followed by the emission of a message of the <F> type.*

S

error message, the concepts created during the execution are ERROR

validated by the supervisor, the execution stops with “clean” closing MESSAGE TOTAL base. It is thus reusable in CONTINUATION. This RESULT message makes it possible in particular to be secured against a stop system with run of an iterative process.

With

message of alarm. The number of messages of alarm is limited MESSAGE automatically with 5 identical **successive** messages.

RESULT

**It is recommended to the users who have messages of the type**

**With “to repair” their command file to do them**

**to disappear**

I

message of information of the supervisor

MESSAGE

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***Document: U1.03.01***

***Process control supervisor and language***

***Summary:***

***This document describes the role and operation:***

***.  
of the supervisor who ensures the piloting of an execution of Code\_Aster;***

***.  
and of the process control language which ensures the communication between the user and the  
Code.***

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**Count****matters**

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## ***1 Introduction***

***The role of the supervisor is to ensure the command of the course of operations in progress of execution of a program. The instructions of execution are generally provided by the user. This requires a formalization of the communications between the code and its owner, it is the language of order.***

***The Python language is employed to write the catalogue of orders, the supervisor and the files orders user. For the command files, that makes it possible to discharge the supervisor from the task of syntactic analysis, reserved for Python itself.***

***A command file is a succession of call to functions Python (orders), defined in the catalogue of orders. These functions have arguments of entry: words keys and their contents, and of the arguments of exit: produced concepts. The user who composes sound command file must thus be subjected to the general syntax of Python (parenthèsage, indentation...) and with the rules imposed by the catalogue of orders (the provided arguments are coherent with until the function waits).***

***For a first making of contact with the code, the reader will be able not to approach chapter 2.***



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***2***

***Mechanism general of operation of the supervisor***

***2.1 Structure***

***general***

***The basic elements brought into play during an execution of an Aster calculation are:***

***.  
the command file, provided by the user,***

***.  
the catalogue of orders: it is a module python of name cata placed in the package  
Cata,***

***.  
the SUPERVISORY high level object,***

***.  
object JDC created by this last and which is finally carried out.***

***The SUPERVISORY object is a python object which analyzes the options transmitted on the line of order, imports the catalogue of orders, created object JDC starting from the command file and carry out this one.***

***Object JDC (name for Command set) is a python object created by the SUPERVISORY object with to leave the text of the command file and the module catalogues orders. It contains the objects***

**STAGE. Object JDC is representative of the command file user.**

**The STAGE objects are representative of each call to Aster orders in the file of order. Each STAGE object bears the name of the order that it reference, the list of the key words credits and their values, the type and the name of the produced concept.**

**Construction then the execution of object JDC start the following actions:**

.  
**analyze syntactic command file user: it is on this level that syntax python is checked (brackets, commas between key words, indentation...). The detection of one error (Syntax Error Python) causes the stop of the execution of Aster. The first error is fatal: the following errors are not sought,**

.  
**construction of the stages: that consists in creating a STAGE object for each call to one order Aster in the command file. This object is recorded at JDC which manage the list of the stages and related concepts,**

.  
**checking of each STAGE: if the call to an order in the file user is incoherent with the catalogue of orders, a report is posted and the execution is stopped on this level. It is the semantic checking,**

.  
**execution itself of the orders: for each stage taken in the order, call to high level routine FORTRAN (op0nnn.f) corresponding.**

## **2.2**

**Total execution or step by step**

**A command set can be built and carried out according to two modes:**

.  
**the total mode for which all the stages of the command set are initially built then carried out in their order of appearance. This mode is chosen by the key word PAR\_LOT=' OUI' in the ordering of starting BEGINNING,**

.  
**the mode step by step for which each stage is immediately carried out after its construction. This mode is chosen by key word PAR\_LOT=' NON' in the order BEGINNING.**

**If the user does not specify anything in the order starting, the total mode (PAR\_LOT=' OUI') is retained. These two modes present each one their advantages and disadvantages.**

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*The total procedure guarantees to the user that all its file is semantically correct before starting calculations which could fail or not converging. It would be a pity indeed to stop in fatal error after a long resolution because of a key word forgotten in one order postprocessing.*

*The mode step by step builds a stage only after having carried out the preceding one. It thus does not detect that the semantic errors of the pending order and presents the disadvantage described above. It however allows to exploit a result calculated (in a concept) in the command file for, for example, to place conditional instructions there.*

*Here an example of loop with a criterion of stop on the value of a calculated size, stored in the concept of the type counts: RELV [K]. If for example an obligatory key word misses in the call to POST\_RELEVE\_T, that will be detected only after the complete execution of the first MECA\_STATIQUE.*

*On the other hand, the mode step by step makes here possible the assignment of variable SYX since the concept RELV [K] was completely calculated at the time when the supervisor carries out this line.*

**BEGINNING (PAR\_LOT=' NON')**

**RESU= [None] \*10**

**RELV= [None] \*10**

**for K in arranges (1,10):**

**RESU [K] =MECA\_STATIQUE (...)**

**RELV [K] =POST\_RELEVE\_T (...)**

***SYX=RELX [K] [“VMIS”, 4]***

***yew SYX < criterion:  
station-wagon***

***END ()***

***It should be noted that the choice of a procedure conditions the order in which the analysis will proceed semantics (STAGE by STAGE or overall for all the JDC). But, in both cases, the analysis syntactic python is always made as a preliminary for all the command file.***

***Note:***

***EFICAS can exclusively generate and read again only command sets containing orders ASTER, without other instructions python; this independently of the mode Selected PAR\_LOT.***

***2.3***

***The construction of the stages***

***During the construction of each STAGE object, one checks his semantic coherence with the catalogue order to which it refers. Any detected error is consigned in a report who, in total procedure, is delivered after the analysis of all the command file.***

***Semantic examples of checks:***

- respect of the number of arguments of the key words,***
- respect of the type of argument,***
- membership of an argument to a list of possible values,***
- exactitude of the orthography of a key word or a key word factor,***
- compliance with the rules of exclusion or implication between key words,***
- presence of the obligatory key words.***

***This stage, if the order is an operator and produces a concept, this one is typified. The supervisor check that a of the same concept name was not already defined, or if it is employed again, that the order authorizes.***

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***2.4***

***Treatment of the macro-orders***

***An macro-order, considering the user, is an ordinary order. In fact, it does not call directly a high level routine FORTRAN but generates other orders.***

***Two types of macro-orders exist:***

***•  
macros in Python,***

***•  
macros supervisory: they are the orders special (BEGINNING, FORMULA, INCLUDE, INCLUDE\_MATERIAU, CONTINUATION) which require a treatment the level of their construction.***

***As well as the JDC itself, the call to an macro-order produces a father object (of type MACRO-ETAPE) which contains wire objects: the stages which the macro one generates, even others macros.***

***An macro-order of the JDC is first of all treated like the other orders (checking syntactic, construction of the macro stage). Then it “is built” by application of the method Build python on object JDC. After its construction, stages of the orders produced by macro are substituted at the stage of macro itself, for later execution.***

*It is important to note that the phase of construction of the macro-orders proceeds right front their execution, and not at the time the total master key on the command file in mode PAR\_LOT=' OUI'.*

*That has two consequences:*

- EFICAS analyzes the syntax of the macro-order itself, but not that of its subcommands.*
- One can on the other hand exploit, in the programming of the macros, the data previously calculated and repatriated in the space of names python, without having to impose it mode PAR\_LOT=' NON' with the user the macro one.*

## **2.5**

### **Procedures of starting**

*The procedures of starting available are:*

**BEGINNING** (cf [U4.11.01] and **CONTINUATION** [U4.11.03])

*At least one of these two procedures must be obligatorily present in the file of order. No other Aster order must precede them. If it is the case or if none is present, the execution will be stopped as of the creation of the JDC. These are the procedures which contain*

*information on the procedure (PAR\_LOT=' OUI' or "NOT") which conditions the mode of execution of the orders which follow.*

*In fact macro-orders supervisor, with their construction, call routines FORTRAN allowing to initialize calculation by the following tasks:*

*·  
"connection" of the logical units of the standard files,*

*·  
opening of the data bases,*

*·  
reading of the catalogue of elements.*

*The first task consists in putting in correspondence numbers of logical units of files of input/output standards (message, error, result).*

*The second task consists to define and open the data bases (file of direct accesses used by the manager of memory) in accordance with the instructions of the user, who can redefine parameters of these files (see documents [U4.11.01] and [U4.11.03] on the procedures of starting). One invites for that the routines of initialization JEVEUX (see document [D6.02.01] it Manager of memory, JEVEUX).*

*The sequence of the orders to be carried out ends obligatorily in the order END. The text*

*who follows FINE must be commentarisé (i.e. begin with #). For a file included, it is order RETURN which marks the end of the instructions that ASTER must take into account.*

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*Note:*

*In interactive mode, seized of the manual controls, not to put of order END and to pass the argument interact on the line of ordering of tender of the job.*

*2.6*

*Bonds with EFICAS*

*The core of the supervisor is common with Efficas, the editor of command files Aster. At the time of the edition of a command file, this one carries out the syntactic analysis and the checks of coherence of the concepts by construction of the JDC and its STAGE objects. Efficas does not realize of course*

*not the task of construction of the macro-orders which would require the source code of Aster.*

*3*

*The process control language*

*3.1*

*Python and the language process control*

*A command file for Code\_Aster is exclusively made up of Python instructions.*

*first of the constraints is thus to conform to the rules of this language. One will be able to read the tutorial*

*Python (www.python.org) or many books of introduction to Python for more detail, but it is not necessary for the use of Aster.*

*A command file can contain instructions python of two natures: orders Aster and... any other instruction python. Indeed, a command file is one program python with whole share and one can place in particular there structures of control (loops), numerical tests (yew), calculations, calls to functions the pre one and postprocessing.*

*Within the framework of a “traditional” use of the code where the command file contains exclusively orders Aster, the two rules specific to Python to be retained are:*

.

*No the indentation on the first line of declaration of an instruction.*

*email = LIRE\_MAILLAGE ()*

*One should place neither white, nor tabulation before the character string email.*

.

*Arguments of the functions, in other words the key words of the orders, are separated by commas; they are composed of a key word, sign “=”, contents of the key word.*

***Important:***

*Editor EFICAS allows to produce only command files of this type: container exclusively orders ASTER, without another instruction Python. Utiliser EFICAS guarantees primarily three things:*

.

*the produced file will have a correct syntax python,*

.

*the produced orders will be coherent with the catalogue of orders,*

.

*the produced concepts being correctly connected (not of use of a concept without it was created by a preceding order).*

*The user having composed his command file thus will be safe from one stop to the execution with the reason*

*of a problem of syntax.*

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## 3.2

### ***Concept of concept***

***Definition: one calls concept the structures of Aster data, that the user can handle and to name. These concepts are typified at the time of their creation and could be used only like argument of entry of the type corresponding in a further order.***

***The concept of concept thus makes it possible the user symbolically to handle objects and independently of their internal representation (which it can not know). Moreover, the python object indicated by the name of the concept any other information but its type, its class with the direction does not contain***

***python (cf Doc. D). Its name, transmitted by the supervisor to FORTRAN, makes it possible Aster to find***

***corresponding structure of data in the total base. But it is not possible to have visibility structure of data since the command file. For example, following instructions do not allow to print the structure of data of the grid type and name email:***

***mail=LIRE\_MAILLAGE ()***

***print email***

***but generate the following message:***

***SD grid name: email***

***There is an exception to this rule: tables. Indeed, an artifice of programming allows to simply recover information contained in a structure of data COUNTS while handling this one like a table at two entries:***

***to print all the table: print***

*resu*

*to print a value:*

*print*

*resu ["DX", 1]*

*to assign it to a variable: value = resu ["DX", 1]*

*That supposes of course that the structure of data resu, type COUNTS, was already calculated with moment when this instruction is met: thus in procedure step by step (PAR\_LOT='NON').*

*Lexical remark:*

*The names of concepts should not exceed 8 characters. Alphanumerics are licit (small letters and capital and figures not placed in first position) like the underscore "\_". Breakage is important: the concepts "EMAIL" and "Email" could be used in the same command file and will be regarded as different... it is however disadvised for the legibility of the file!*

### *3.3 Operations*

*possible*

*The structure of the process control language is appeared as a linear succession of instructions. In addition to the instructions python other than of the Aster orders, of which it is not question for moment, three natures of instructions (or orders) are available:*

- *the operator who carries out an action and who provides a produced concept of a preset type exploitable by the following instructions in the command set,*
- *the procedure which carries out an action but does not provide a concept,*
- *the macro-order which generates a sequence of instructions of the two preceding types and who can produce zero, one or more concepts.*

*Typically, an operator will be an ordering of assignment or of resolution, a procedure will be an ordering of impression (in a file).*

*From the syntactic point of view an operator presents himself in the form:*

*nomconcept = operator (arguments...)*

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*Whereas a procedure arises in the form:  
procedure (arguments...)*

*The syntax of an operator or a procedure is described in the following paragraph.*

### **3.4**

***Rules on the concept produced by an operator***

#### ***3.4.1 Guiding principle***

***With each execution of an operator, this one provides a new produced concept of the preset type in the catalogue of order.***

***The concepts appearing in argument of entry of the orders, are not modified.***

#### ***3.4.2 Produced concept and re-used concept***

***One calls re-used concept, a concept which being produced by an operator, is modified by one new occurrence of this operator or by another operator.***

***The use of a re-used concept is not possible, like exemption of the guiding Principle that from two conditions:***

.

***authorization given, by the catalogue and the programming of the order, to use reusable concepts for the operator: the reentrant attribute of the catalogue is worth “O” or “F”,***

.

***request clarifies of the user of the re-use of a concept produced by the attribute***

*reuse=nom\_du\_concept in the arguments of the orders which allow it.*

### **3.4.3 Checks carried out by the supervisor on the concepts produced**

*Produced concept respecting the guiding principle:*

*The supervisor checks that the name of the produced concept is not already allotted by one of preceding orders, in particular by an ordering of a preceding execution in the case of a CONTINUATION or a INCLUDE.*

*Concept used in re-use:*

*The supervisor checks that:*

*- the name of the produced concept is already well allotted.*

*- the operator is well entitled to accept re-used concepts,*

*- the type of the concept is in conformity with the type of concept produced by the operator.*

*Examples with accompanying notes:*

**BEGINNING ()**  
**concept=operator**  
(  
)  
#  
(1)

*is correct: one definite the concept,*  
**concept=operator**

(  
)  
#  
(2)

*is incorrect: one tries to redefine it*

#

*concept but without the statement,  
concept=operator (reuse = concept) # (3)*

*is correct, if the operator accepts*

#

*existing concepts and if the type is*

#

*coherent; it is incorrect if the operator*

#

*does not accept them.*

*END ()*

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*In fact a concept can be created only once: what means to appear sign on the left = (equal) without reuse is employed in the arguments of the order.*

*In the case of a re-use, to again specify the name of the concept behind the attribute reuse is redundant; more especially as the supervisor checks that the two names of concept are identical.*

*Note:*

*One can destroy a concept, and thus re-use his name then.*

*3.5*

*Body of an order*

*3.5.1 Introduction*

*The body of an order contains the “variable” part of the order. The declarations are separated by commas and separately the attribute reuse mentioned above, they all are of the form:*

*[mot\_clé] = [argument]*

*The key word is necessarily a key word of the pending order, declared in the catalogue of this one.*

### **3.5.2 Word**

#### **key**

*A key word is a formal identifier, it is the name of the attribute receiving the argument.*

*Example: STAMP =...*

*Syntactic remarks:*

*.  
the order of appearance of the key words is free, it is not imposed by the order of declaration in catalogues,*

*.  
the key words cannot exceed 16 characters (but only the first 10 characters are meaning).*

*There are two types of key words: single-ended spanner words and the key words factors which differ by nature of their arguments.*

### **3.5.3 Argument of a single-ended spanner word**

#### **3.5.3.1 the type of the arguments**

*The basic types recognized by the supervisor are:*

- entireties,*
- realities,*
- complexes,*
- texts,*
- logics,*
- concepts,*
- as well as the lists of these types of bases.*

*The entireties and realities correspond exactly to the equivalent types in python.*

*.  
Optional single-ended spanner word awaiting a reality:*

*Catalogue*

*: VALE = SIMP (statut=' f', typ = "R"),*

*Command file*

*: VALE = 10.*

*,  
.*

*Optional single-ended spanner word awaiting an entirety:*

## ***Catalogue***

***: INFORMATION = SIMP (statut=' f', typ = "I"),***

***Command file***

***: INFORMATION = 1***

***,  
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***The representation of the complex type is a "tuple" python containing a character string indicating the mode of representation of the complex number (parts real and imaginary or modulates phase) then numerical values.***

## ***Catalogue***

***: VALE\_C = SIMP (statut=' f', typ = "It),***

***Command file***

***: VALE\_C = ("IH", 0.732, -0.732),***

***Command file***

***: VALE\_C = ("MP", 1. , -45. ),***

***The two notations are strictly equivalent. In notation "MP", the phase is in degrees.***

***The text type is declared between simple dimensions. Breakage is respected. However, when a key word***

***must take a value in a preset list in the catalogue, the use wants that this value is***



*today always in capitals.*

*Catalogue*

*: ALL =SIMP (typ= `TXM', into= ("YES", "NOT")),*

*Command file*

*: ALL = "YES",*

*Breakage is important and, in the context above, the line of following order will fail:*

*Command file*

*: ALL = "yes",*

*The logical type is not used today in the catalogue of orders.*

*The concept is declared simply by its name, without dimensions nor quotation marks.*

### *3.5.3.2 Concept of list*

*Caution:*

*the word "list" is an abuse language here. It is not a question of the type "lists" python but rather of tuples, within the meaning of python: different the items is declared between an opening bracket and a closing bracket; they are separated by commas.*

*The lists are homogeneous lists, i.e. whose elements are of the same basic type. All basic type can be used in list.*

*Examples of list:*

*list entirities*

*(1, 2, 3, 4),*

*list text*

*("this", "is", "one", "list", "of", "text"),*

*list concepts*

*(resu1, resu2, resu3),*

*Facility of employment:*

*It is allowed that a list reduced to an element can be described without bracket.*

*Example of erroneous list:*

*Heterogeneous list of entirety and reality*

*(1,*

3,  
4.)

### **3.5.4 Key word factor**

*Certain information cannot be given overall (in once in the order), it is thus important to envisage the repetition of certain key words, to be able to affect arguments to them different. The key word factor offers this possibility; under a key word factor, one will thus find one together of key words (simple), which could be used with each occurrence of the key word factor. That makes it possible moreover to improve the legibility of the command file by gathering key words which*

*divides a common direction: for example various parameters of the same material.*

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*Contrary to the single-ended spanner word, the key word factor can receive one type of object: the object supervisor “\_F”, or a list of this one.*

*That is to say the key word factor has only one occurrence and one can write for example, with the choice:*

*IMPRESSION =*

*\_F (*

*RESULT =*

*resu, UNIT = 6),*

*or*

```
IMPRESSION = (_F (  
RESULT =  
resu, UNIT = 6),),
```

*In the first case, the key word factor IMPRESSION receives a \_F object, in the other, it receives one singleton. Attention with the comma; in python, a tuple with an element is written: (element,)*

*That is to say the key word factor has several occurrences, two in this example:*

```
IMPRESSION = (_F (  
RESULT =  
resu1, UNIT = 6),  
_F (  
RESULT =  
resu2, UNIT = 7)  
),
```

*The number of occurrence (minimum and/or maximum) waited of a key word factor is defined in catalogue orders.*

*Concept of default value*

*It is possible to make affect by the supervisor of the default values. These values are defined in the catalogue of orders and not in FORTRAN.*

*There is no distinction from the point of view of the routine associated with the order between a value provided by the user and a default value introduced by the supervisor. This appears at the time of impression of the orders user by the supervisor in the file of messages: all them default values appear in the text of order, if they were not provided by the user*

*Recall: one cannot give default value to a concept.*

**4**

*Definition of values and evaluations of expressions*

*It is possible to assign values to variables python in order to use those like arguments simple key words: these variables are called parameters in EFICAS. They can contain values whole, real, complex, texts or lists of these types.*

*Example:*

```
Young = 2.E+11  
chechmate
```

=  
**DEFI\_MATERIAU**  
(**ELAS = \_F (E = Young, NAKED = 0.3)**)

*At the end of the execution, the context python is safeguarded with the base. Thus, in the continuation which will follow, the parameters will be always present, with their preset values, just like the concepts ASTER.*

*It is possible to carry out operations in python on the simple arguments of key words:*

**Pisur2 =**  
**pi/2.**  
**chechmate**  
  
**= MA\_COMMANDE (VALE = Pisur2)**

**or:**

**VAr**  
**=**  
**,**  
**world'**  
**chechmate**  
**= MA\_COMMANDE (VALE =**  
**pi/2.**  
**,**  
**VALE2**  
**=**  
**Pisur2+cos (30.)**  
**,**  
**TEXT = `hello'+var**  
**)**

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***Use of python in the command files***

***It is not necessary to know the language python to use Code\_Aster. Indeed, realising some basic rules to respect on the indentation and parenthesizing, only the knowledge of process control language describes in the catalogues of order is necessary. And still, EFICAS allows to exempt itself to resort to the catalogue or the paragraph “syntax” of the orders in proposing the key words graphically to inform.***

***However, the advanced user will be able to use cheaply the power of the language PYTHON in sound command file, since this one is already written in this language.***

***The four principal uses can be: the writing of personalized macro-orders, the use general instructions python, the importation of useful modules python, the recovery of information of structures of Code\_Aster data in variables PYTHON.***

**Note:**

***If one wants to use French characters accentuated in the command file or them imported modules, it is necessary to place the following instruction in first or second line of file:***

***# \* coding: iso88591 \****

***In python 2.3, the absence of this line causes a warning which will become an error in python 2.4; in ASTER, it is systematically an error.***

***5.1 Macro-orders  
personalized***

***See the document [D5.01.02]: To introduce a new macro-order***

***The personalized macro-orders are very easy to program. They can be used for to capitalize recurring diagrams of calculation and thus to constitute a tool-trade. It is strongly advised to take example on the existing macro-orders: macro package in bibpyt.***

## 5.2

### *General instructions PYTHON and useful modules*

*The advanced users can benefit great from the use of loops (for), of tests (yew), of exceptions (try, except) and in a general way of all the power of the language PYTHON directly in their command file. The list of the uses is impossible to establish exhaustively. Many examples are present in the cases tests of the base of tests. One can for example to make adaptation of grid while placing the sequence calculation/mending of meshes in one buckle, to establish a criterion of stop of the iterations by a test on a computed value.*

*Concerning the exceptions, only the errors of the <S> type are recoverable as an exception in the command set. That authorizes for example “to try” an order then to begin again hand if this one “plants” while raising this exception.*

*In a loop, if an already existing concept is recreated, it is necessary to think of destroying it as a preliminary by order TO DESTROY.*

*The other various functionalities of python interesting for the user of Code\_Aster can to be:*

- the read-write on file,*
- numerical calculation (for example by using Numerical Python),*
- the call via the module bone with the language of script, and in particular the launching of a third code (os.system)*
- the handling of character strings*
- the call to graphic modules (grace, gnuplot)*

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### **5.3**

#### ***Recovery of computed values in variables PYTHON***

***To exploit the language PYTHON in its command file is not interesting that if one can conditionally to launch actions according to what the code calculated.***

***Certain footbridges exist between python and the structures of data calculated by the code and present in memory JEVEUX. Others remain to be programmed; this is a field in evolution and of future developments are awaited.***

***It is essential to understand that to recover calculated data requires that the instructions involving their obtaining were indeed carried out as a preliminary. In other words, it is essential to carry out the code in mode PAR\_LOT='NON' (key word of the order BEGINNING). Indeed, in it case, it does not have there total analysis of the command file, but each instruction is carried out sequentially. When one arrives on an instruction, all the concepts preceding thus have it already summer calculated.***

***Here some access methods to the structures of data. The list is nonexhaustive, to refer to documentation [U1.03.02].***

#### ***Structure of data Method***

***Python type turned over turned over Information***

***listr8***

***LIST\_VALEURS***

***list***

***List values***

***grid***

***LIST\_GROUP\_NO***

***list***

***List groups of nodes***

***LIST\_GROUP\_MA***

***list***

***List groups of meshes***

***count***

***[...]***

***reality***

***Contents of the table***

***function***

***LISTE\_VALEURS***

***list***

***List values***

***result***

***LIST\_CHAMPS***

***list***

***List computed fields***

***LIST\_NOM\_CMP***

***list***

***List components***

***LIST\_VARI\_ACCES lists***

***List variables of access***

***LIST\_PARA***

***list***

***List parameters***

***cham\_no***

***EXTR\_COMP***

***post\_comp\_cham\_no***

***Contents of the field in a table***

***cham\_elem***

***EXTR\_COMP***

***post\_comp\_cham\_el***

***Contents of the field in a table***

***Any object JEVEUX***

***getvectjev***

***list***

***List objects of the jeveux vector***

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***Method Python of access to the Aster objects***

### ***Date:***

***25/03/05***

### ***Author (S):***

***C. DURAND, A. ASSIRE Key***

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***Organization (S): EDF-R & D /AMA***

### ***Instruction manual***

***U1.0- booklet: Introduction to Code\_Aster***

***Document: U1.03.02***

***Methods Python of access to the Aster objects***

### ***Summary:***

***This document presents the Python methods giving access the information contained in structures of data Aster. This information can be processed by programming python, or to be useful for***

*the conditional sequence of the following orders.*

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*Introduction and precautions for use*

*In Code\_Aster, the majority of the orders are programmed in FORTRAN. Structures of produced data are accessible only via the manager from memory JEVEUX, him even written in FORTRAN. In a standard execution of the code, only names of the concepts (and not of objects carrying themselves calculated information) are transmitted to the level of the supervisor, of order from order by the key words.*

*In a more advanced use of Python than the simple declaration of Code\_Aster orders, it command file written in Python can use the contents of the structures of data suitable for Code\_Aster. Indeed, Python can be used in the command files to create macro-orders and of the operations like loops (for, while,...), of the tests (yew,...), of external executions of orders (via the module bone), etc... The page "Use/Examples/ Examples of use of Python in Aster" of the Web site [www.code-aster.org](http://www.code-aster.org) gathers some a number of cases of application. It is then interesting for the user to recover the product of calculations FORTRAN in space python, i.e. its command file. Several methods Python were developed in order to reach the contents of other structures of data.*

*To recover calculated data (in memory JEVEUX), it is absolutely necessary that the instructions involving their obtaining were indeed carried out as a preliminary. In other words, it is*

*essential to carry out the code in mode `PAR_LOT='NON'` (key word of the order `BEGINNING` or `CONTINUATION`). Indeed, in this case, there is no total analysis of the command file, but each instruction is carried out sequentially. When one arrives on an instruction, all the concepts preceding it already were thus calculated.*

### ***BEGINNING (PAR\_LOT = "NOT")***

*It should then be noted that the command file thus produced is not readable by EFICAS which does not tolerate that files exclusively made up of orders specific to ASTER. Only variables simple (realities, entreties, strings) defined in declaratory mode (`a='toto'`) or algebraic (`n=3+4`) are readable by EFICAS.*

*The information read again in the memory JEVEUX, product of a preliminary calculation, can be exploited by example for (nonexhaustive list):*

- Enchaîner conditionally other orders (execution of loop while until obtaining a computed value of stress ultimate)*
- Manipuler in python of the contents of a table, a function, at ends of calculations*
- Récupérer attributes of a grid: list groups of nodes and meshes, co-ordinates.*

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***2 Them***

**tables**

*The structures of data table are produced in ASTER by creation (CREA\_TABLE), by reading in a file (LIRE\_TABLE) or recovery in another concept (RECU\_TABLE). It is functionally heterogeneous tables of figures (whole, real, character strings) of which the columns are identified by names of label.*

*These are practical structures whose employment is generalized in the code. For example, majority of orders of postprocessing produce tables: to raise of the constraints in places geometrical given, to produce calculated macroscopic sizes (postprocessings of breaking process).*

*That is to say for example the table tab1 following exit of a calculation ASTER:*

**NODE NUME\_ORDRE DX**

**N2 14**

**0.93**

**N2 15**

**1.16**

**N1 3**

**0.70**

**N1 2**

**0.46**

**N1 1**

**0.23**

*It could also have been directly created like concept ASTER of the type counts by:*

**tab1=CREA\_TABLE (LIST = (**

**\_F (PARA=' NOEUD',**

**VALE\_K= ("N2", "N2", "N1", "N1", "N1"),),**

**\_F (PARA=' NUME\_ORDRE',**

**VALE\_I= (14,15,3,2,1),),**

**\_F (PARA=' DX',**

**VALE\_R= (0**

**.93,1.16,0.70,0.46,0.23),),)**

*One can directly recover an unspecified value of the table which one knows the access key (name of label of column) and the number of line:*

```
>>> print tab1 ["DX", 3]
0.70
```

*It is also possible to recover the totality of the table in the environment python via a class dedicated, produced by method EXTR\_TABLE, attached to the class of the concept ASTER:*

```
tab2 = tab1.EXTR_TABLE ()
```

*tab2 is an object python, authority of the Table class of the Utilitai.Table module. It is easy to handle with the methods associated with this class; one will be able to make help (Table) for to know the methods of this class.*

*The table tab2 could also have been directly defined by a dictionary:*

*From Utilitai.Table importation Counts*

```
listdic = [
{"NODE": "N2", "NUME_ORDRE": 14, "DX": 0.93},
{"NODE":
"N2"
, "NUME_ORDRE":
15, "DX":
1.
16},
{"NODE":
"N1"
, "NUME_ORDRE":
3
, "DX":
0.70,
},
{"NODE":
"N1"
, "NUME_ORDRE":
2
, "DX":
0.46,
},
{"NODE":
"N1"
, "NUME_ORDRE":
1
```

```
, "DX":  
0.23,  
},  
  
]  
listpara= ["NODE", "NUME_ORDRE", "DX"]  
listtype= ["K8", "I", "R"]  
tab2=Table (listdic, will listpara, listtype)
```

*The possible operations on tab2 are described hereafter.*

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### *2.1 Impression*

```
>>> tab2
```

```
-----  
NODE  
NUME_ORDRE  
DX  
N2  
14  
9.30000E-01  
N2  
15  
1.16000E+00
```

```
N1  
3  
7.00000E-01  
N1  
2  
4.60000E-01  
N1  
1  
2.30000E-01
```

*Also possible:*

```
>>> print tab2
```

*Posting of only one parameter:*

```
>>> t.DX
```

```
-----  
DX  
9.30000E-01  
1.16000E+00  
7.00000E-01  
4.60000E-01  
2.30000E-01
```

*Order IMPR\_TABLE exploits the functionalities of impression offered by this class. interested reader will be able to read the programming python of this macro-order. In particular possibility of printing cross tables.*

*2.2*  
*Creation or impression of a under-table extracted by filter*

*Extraction according to only one criterion:*

```
>>> print tab2.NUME_ORDRE <=5
```

```
-----  
NODE  
NUME_ORDRE  
DX  
N1  
3  
7.00000E-01  
N1  
2
```

**4.60000E-01**

**N1**

**1**

**2.30000E-01**

***Extraction according to two criteria with logical association “&”/AND:***

**>>> print (t.NUME\_ORDRE < 10) & (t.DX>=0.3)**

-----  
**NODE**

**NUME\_ORDRE**

**DX**

**N1**

**3**

**7.00000E-01**

**N1**

**2**

**4.60000E-01**

***Extraction according to two criteria with logical association “|”/OR:***

**>>> print (t.NUME\_ORDRE < 2) | (t.DX<0.5)**

-----  
**NODE**

**NUME\_ORDRE**

**DX**

**N1**

**1**

**2.30000E-01**

**N1**

**2**

**4.60000E-01**

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*Extraction of a restricted number of labels:*

```
>>> T ["DX", "NUME_ORDRE"]
```

```
-----  
DX  
NUME_ORDRE  
9.30000E-01 14  
1.16000E+00 15  
7.00000E-01 3  
4.60000E-01 2  
2.30000E-01 1
```

*Extraction according to a criterion of equality (here with value of the criterion deduced itself from the table)*

```
>>> t.DX == max (t.DX)
```

```
-----  
NODE  
NUME_ORDRE  
DX  
N2  
15  
1.16000E+00
```

## **2.3 Sorting**

*Sorting of the whole table according to a label:*

```
>>> t.sort ("NUME_ORDRE")
>>> T
```

```
-----
NODE
NUME_ORDRE
DX
N1
1
2.30000E-01
N1
2
4.60000E-01
N1
3
7.00000E-01
N2
14
9.30000E-01
N2
15
1.16000E+00
```

*For sorting according to several labels, the order of precedence being that in which the labels are declared,*

*it is necessary to write:*

```
>>> t.sort ("NUME_ORDRE", "NODE")
```

**2.4**

*Access to the values*

*The contents of the table accessible by the method are been worth () which produces a dictionary of which them*

*keys are the parameters of access of the table and the values the columns:*

```
>>> tab2.values ()
{"NODE": ["N1", "N1", "N1", "N2", "N2"], "NUME_ORDRE": [1, 2, 3, 14, 15],
"DX": [0.23, 0.46, 0.70, 0.93, 1.156]}
```

*The parameters are given by the attribute para (idem tab2.values () .keys ())*

```
>>> will tab2.para
["NODE", "NUME_ORDRE", "DX"]
```

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**3**

**Simple access methods on the concepts**

**Access to the contents of a SD lists**

**lst = [lstr8]. Values ()**

**lst is a list python which contains the values of the Aster list: lst = [0. , 1.1, 2.3,...]**

**Access to the contents of a SD function or a SD tablecloth**

**lst1, lst2, (lst3) = [function/tablecloth]. Values ()**

**lst1 and lst2 are two lists python which contain the X-coordinates and the ordinates. If the function is complex, a third list is obtained and lst2 and lst3 will contain the lists of the real parts and imaginary.**

**lst1 = [function]. Absc ()**

**lst1 is the list of the X-coordinates, that is to say also the first list returned by Valeurs ().**

**lst2 = [function]. Ordo ()**

**lst2 is the list of the ordinates, that is to say also the second list returned by Valeurs ().**

*dico1 = [function]. Parameters ()*

*turn over a dictionary containing the parameters of the function; the type jeveux (FUNCTION, FONC\_C, TABLECLOTH) is not turned over, the dictionary can thus be provided to CALC\_FONC\_INTERP just as it is (see efica02a).*

*Evaluation of a SD function or formula*

*The functions in R and the formulas are appraisable simply in the space of name python, therefore the command file, as follows:*

```
FONC1=FORMULE (VALE=' (Y ** 2) +
X',
NOM_PARA= ("X", "Y",)),
```

```
);
>>> print FONC1 (1. , 2.)
5.
```

*or with a function:*

```
FONC2=DEFI_FONCTION (NOM_PARA=' X', VALE= (0. , 0. , 1. , 4. ,))
>>> print FONC2 (0.5)
2.
```

*Access to the contents of a SD grid*

*Two methods make it possible to recover the list of the groups of meshes and nodes of a structure of data of the grid type:*

```
[(tuple),...]
= [grid] .LIST_GROUP_MA ()
```

*return a list of tuples, each one containing the name of each group of meshes, the number of meshes which it contains and the dimension (0, 1, 2 or 3) highest of its meshes:*  
*tuple = ("GMA", Nb meshes, dim. meshes)*

```
[(tuple),...]
= [grid] .LIST_GROUP_NO ()
```

*return the list of the groups of nodes in the form:*

*tuple = (name of the group\_no, Nb of nodes of the group\_no)*

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*Access to the keys of a SD result*

*If EVOL is a structure of data result, then:*

*dictionary = EVOL.LIST\_CHAMPS ()*

*is a dictionary whose keys are the names of the fields  
who index the list of the calculated sequence numbers.*

*Example:*

```
>>> print dictionary ["DEPL"]
```

*(field DEPL is calculated with the numbers*

*[0,1,2]*

*of order 0, 1 and 2)*

```
>>> print dictionary ["SIEF_ELNO_ELGA"]
```

*(the field is not calculated)*

```
[]
```

*dictionary = EVOL.LIST\_VARI\_ACCES ()*

*is a dictionary whose keys are the variables of access*

*who index their own values.*

*Example:*

```
>>> print dictionary ["NUME_ORDRE"]
```

*(sequence numbers of result EVOL*

*[0,1,2]*

*are: 0, 1 and 2)*

```
>>> print dictionary ["INST"]
```

*(calculated moments of result EVOL*

*[0., 2., 4.]*

*are: 0.s, 2.s and 4.s)*

*dictionary = EVOL.LIST\_PARA ()*

*is a dictionary whose keys are the parameters of*

*calculation which indexes the lists (of cardinal equal to the number*

*calculated sequence numbers) their values.*

*Example:*

```
>>> print dictionary ["MODEL"]
```

*(name of the concept models reference*

*["MO", "MO", "MO"]*

*for each sequence number)*

```
>>> print dictionary ["ITER_GLOB"]
```

*(iteration count of convergence*

*[4,2,3]*

*for each sequence number)*

**4**

*Access method to an unspecified structure of data*

*It is possible, with the help of the knowledge of name JEVEUX of the object, to recover any vector or any collection presents in the memory.*

*Two methods are available: getvectjev (vector) and getcolljev (collection).*

*Access to a structure of data of the vector type*

*The method getvectjev gives access to a structure of data of the vector type. It applies always on the object "aster", and takes in argument the character string supplements (space y included/understood) defining the name of the object contained in the structure of data which one*

*wants to reach.*

*This one can be given thanks to the order Aster IMPR\_CO (CO = name).*

*Example: to recover the co-ordinates of the nodes of a grid named MA:*

*LMBO = aster.getvectjev (“MA .COORDO .VALE”)*

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*Access to a structure of data of the collection type*

*In a similar way, the method getcolljev allows the consultation of the collections since python. It renvoit a dictionary whose keys are the names of the objects in the event of named collection, them numbers of index if not.*

*Example: to recover information concerning the connectivity of the elements of grid MA:*

*LMBO = aster.getcolljev (“MA .CONNEX”)*

*One obtains in this case a dictionary resembling:*

*{3: (2, 1, 5), 2: (6, 9, 10, 7, 11, 12, 13, 8), 1: (1, 6, 7, 2, 3, 8, 5)}*

*5*

*Recovery in python of the fields by elements and fields with nodes (EXTR\_COMP)*

*Method EXTR\_COMP, applied to a field, allows recovery in python of the contents of*

*field.*

*Example of use:*

*U = STAT\_NON\_LINE (...)*

```
U104 = CREA_CHAMP (  
TYPE_CHAM = "NOEU_DEPL_R",  
OPERATION = "EXTR",  
RESULT = U,  
NOM_CHAM = "DEPL",  
NUME_ORDRE = 104,  
)
```

*U104NP = U104.EXTR\_COMP ("DX", ["S\_SUP",])*

*print U104NP.valeurs*

```
V104 = CREA_CHAMP (  
TYPE_CHAM = "ELGA_VARI_R",  
OPERATION = "EXTR",  
RESULT = U,  
NOM_CHAM = "VARI_ELGA",  
NUME_ORDRE = 104,  
)
```

*V104NP = V104.EXTR\_COMP ("V22", [], 1)*

*print V104NP.valeurs*

*print V104NP.maille*

*print V104NP.point*

*print V104NP.sous\_point*

*Thus starting from the result U:*

*1) One creates a field (node or elXX) correspondent at one moment by CREA\_CHAMP.*

*2) One extracts the component by method EXTR\_COMP (declared for the cham\_elem and them cham\_no) which creates a new type of python object: post\_comp\_cham\_el and post\_comp\_cham\_no whose attributes are described hereafter.*

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**Version**

**7.4**

**Titrate:**

**Method Python of access to the Aster objects**

**Date:**

**25/03/05**

**Author (S):**

**C. DURAND, A. ASSIRE Key**

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**Arguments of order EXTR\_COMP:**

**The order has 3 arguments:**

**ch1 = EXTR\_COMP (comp, lgma, topo=0)**

**comp**

**component of the field on the list lgma.**

**lgma**

**list groups of meshes, if vacuum then one takes all the group\_ma (equivalent with TOUT=' OUI' in the orders Aster.**

**topo**

**one reference of information on topology if >0 (optional, defect = 0).**

**Results of order EXTR\_COMP:**

**ch1.valeurs: Numeric.array containing the values**

**If there is request topology (topo>0):**

- **ch1.maille: number of meshes**
- **ch1.point: number of the point in the mesh**
- **ch1.sous\_point: number of under point in the mesh**

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***Interface access to Code\_Aster: astk***

### ***Date:***

***05/04/05***

### ***Author (S):***

***Key COURTEOUS Mr.***

***:***

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***Organization (S): EDF-R & D /AMA***

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***Document: U1.04.00***

***Interface access to Code\_Aster: astk***

### ***Summary:***

***This document presents astk (contraction of Aster and Tk, to pronounce “astek”), the interface making it possible to organize its calculations Aster.***

*One describes the logic of operation of astk, the graphic interface itself, bsf which makes it possible to explore them*

*files on the various waiters, then it is explained how the user can configure astk according to its needs.*

*Lastly, on a concrete example, one shows how to use astk to make a study, an overload, to launch one list case-tests.*

*For the people having access to the waiter of calculation Aster of network EDF, one explains how to reach cards of experience feedback (REX), and, developer, tool of the AGLA (data processing department Aster).*

*The functionalities of astk version 1.2 are described here which supports versions 6 (starting from the STA6.5), 7 and 8 of Code\_Aster.*

*Version 5 is not supported by astk.*

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***1***

***General presentation and concepts***

***The provision of a tool as Code\_Aster which functions on multiple platforms require a graphic interface to simplify the work of the user.***

***In addition, the evolution of the centralized means of calculation and the diffusion into free of Code\_Aster have***

***need the development of a portable product whose architecture can adapt to different computer set-ups.***

***astk is the graphic interface which makes it possible to organize its Aster calculations: to prepare its data,***

***to organize the files, to reach the tools the pre one and postprocessing, to launch and follow the evolution of***

***calculations. astk also makes it possible to choose the version of Code\_Aster to be used among those available***

***(STA, NEW...). Only versions 6 and following are supported by astk.***

***The name “astk”, to pronounce “astek”, comes from the contraction from Aster and Tk which is the bookshop***

*graphics used (as asterix was resulting from Aster and X for X Windows).*

## **1.1 Starting**

*To launch the interface, it is enough to type in a terminal: astk*

*In general, the order was placed in the way by defect of the users, the interface opens with a configuration by defect (see [[§ 4](#)] [Configuration](#)).*

*If the order is not found, it is necessary to launch: [to install\_dir] /ASTK\_CLIENT/bin/astk where [to install\_dir] is the repertory of installation of astk (contact possibly your administrator).*

*Access to the waiter of calculation Aster (EDF and people receiving benefits)*

*On the waiter of calculation Aster of EDF, to use the /aster/outils/astk order. It is advised with units EDF to install the interface on a departmental waiter.*

## **1.2 Functionalities**

*STUDY: astk makes it possible to launch an Aster calculation on the local machine (for example within the framework of one use on micro-computer), a waiter of departmental calculation or on the waiter of calculation Aster of EDF-R & D (access restricted to EDF and its people receiving benefits of studies).*

*OVERLOAD: The diffusion of the source code of Code\_Aster authorizes each one to test its clean developments. astk makes it possible “to overload” the code, i.e. to add or modify files sources, to create a particular version and to use it on case-tests or for studies. One can thus to create and use the new achievable ones, catalogues of orders or elements, and modules python.*

*TESTS: It is often judicious to test that its own developments do not impact the code in addition; astk makes it possible to easily launch a list of case-tests with a personal version.*

*AGLA: To the developers of the version of reference EDF, astk offers the access to the data processing department*

*Aster, AGLA, which makes it possible to organize the collaboratif development of the version of development (to avoid the conflicts, to ensure nonthe regression...).*

*REX: To make live the code passes by the taking into account of the remarks, needs, opinions of the users.*

*Cards of experience feedback can be emitted and consulted by the users since the interface, the developers can answer it (access to necessary waiter EDF).*



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*MULTI-MACHINES: Files necessary to its various actions (files of grid, source, results...) can be distributed on various machines on the network (declared in *astk*), *astk* ensuring the transfer and compression/decompression.*

*The passage of a firebreak is not proposed.*

*TOOLS: The user can launch various predefined tools and configure those which it needs (maillor, tool for postprocessing, editor...).*

*BSF: A navigator is provided (called *bsf*, box of selection of files), it allows to traverse them filing systems of the definite distant machines and to carry out current operations on files: copy, suppression, renaming, impression, or to open a window of orders on these machines.*

*ASJOB: One can follow calculations, their state (in particular in the case of launching in batch) since the window "Followed by the jobs", also called *asjob*.*

## **1.3**

### **Operating mode**

*Architecture client/server authorizes a clear separation between the interface (customer) and the tools used*

*to reach the code (services). It makes it possible to use the whole of scripts of the AGLA to manage version of reference in batch and *as\_run* (cf Appendix 1), a service *astk*, for the other versions available in room or on the network.*

*The communications protocol between the various machines is *rsh* or *ssh* for the orders Shell and CCP, SCP or *rsync* for the copy of files.*

**Example:** *The customer (i.e. the interface launched by the order ask) request launching of a calculation on a waiter of calculation.*

*The interface carries out a service on the waiter in question (order rsh or ssh) by indicating them to him parameters necessary to calculation (contained in a profile, [to see \[§ 1.5\]](#)). [The service](#) takes then in charge the operations necessary: to repatriate the files necessary to the calculation of different machines towards the waiter of calculation, launching of calculation, return of the files results...*

## **1.4 Waiters**

### **ask**

*For ask, a waiter is:*

- is a waiter of Aster calculation: a machine on which one can find the part “waiter” of ask, i.e. the whole of the services which give access the code; one will be able to launch calculations via this waiter and to use files on this waiter for a calculation,*
- is a file server: one will be able simply to use files on this waiter at the time of one calculation.*

*The waiter called “Room” is in fact a file server (only information of connection are necessary for a file server, but on the local machine, one knows them easily).*

*If one wishes to launch calculations on the local machine (on which are installed a version of Aster and the waiter part of ask), it is also necessary to declare this machine like a waiter of calculation (Local and*

*Machine in the following example).*

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**Example of configuration:** ([see \[§ 2.1.2\]](#))

*astk is used on the machine of name mach00, on which Code\_Aster is installed. One has access to a departmental file server file01, the files of this waiter is accessible (assembly NFS) since two machines of calculation comp02, comp03. One has also access to a cluster with NR nodes of calculation whose frontal machine is front04.*

*One has then:*

- “Local” (reserved label): one has it always to explore the files which are on mach00;*
- “Machine” (label unspecified, the procedure of installation fixes this name at the value turned over by the order `uname N `): whose address IP is that of mach00 which is the waiter of calculation (services astk installed) of the local machine;*
- “Departure” (unspecified label): whose address IP is that of file01, which allows to explore the files lodged by the file server, configured like a waiter of calculation Aster (services astk installed) having comp02 and comp03 seen like nodes of calculation (comp0i can be the same machine as file01);*
- “Cluster” (unspecified label): whose address IP is that of front04 which is a waiter of calculation (services astk installed) having NR nodes, the only machine accessible being front04.*

*The difference between “Departure” and “Cluster” is that in general the stations of calculation are accessible directly (one could thus subject a calculation in interactive on one or the other), whereas for a cluster, the users see only the frontal machine in general, distribution being made on the nodes by a sequencer of batch processings.*

*One can as well have several waiters of calculation “Departure” or “Cluster” that not to have only the station “Local+Machine”.*

## **1.5 Profile**

### **astk**

*A profile astk is a file which contains all information relating to your study, your overload, etc: the site of the files of the study, in data, result, the type associated with each file, parameters of tender of calculation (memory, time, machine of calculation, interactive batch/...), in case of overload, the site of the source files, achievable, the catalogues produced...*

*The profile also contains parameters on the interface itself to resume a study exactly in the same state that it had been left.*

*The profile is recorded on request of the user (finely Fichier/Enregistrer or To record under...) and with each launching of a calculation.*

*For the users of asterix: the profile astk includes the profile of study and execution to the direction asterix, and the parameters of tender which were not stored in asterix. The file, even if it remains with ASCII format, is despite everything more complicated to read.*

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**2**

## ***Description of the graphic interface***

*The graphic interface (IHM) breaks up into 4 parts:*

*1) A bar of menu*

*2)*

*mitres*

*3) Parameters of tenders*

*4) The bar of state*

*1.*

*2.*

*4.*

*3.*

**[Appear 2-a: Principal window](#)**

## **2.1**

### **Bar of menu**

The menu “Assistance” also makes it possible to reach the description of the menus.

#### **2.1.1 Menu**

##### **File**

- *Nouveau*: Allows to create a new profile.
- *Ouvrir*: Open a profile created before by ask. One cannot open the profiles created by asterix in this way.
- *Enregistrer*: Safeguard the profile running (this is made automatically during the launching of one calculation).
- *Enregistrer under*: Safeguard the profile running while giving the choice of the name of the profile and sound site.

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· *Copier under*: Copy the profile running in another repertory and proposes to copy the files (in data and/or results) that it reference.

· *Importer:*

- *asterix*: Reads again a file *.pret* or *.prex* produces by *asterix* (the contents of the *.pret* being less rich, final improvements will be probably necessary, to consult *INFORMATION*).
- *astk\_serv*: Reads again a file *.export* of a preceding execution (or the file *\*.pNNN* of repertory *\$HOME/flashor*).
- *Exporter under*: Allows to export the profile running to the format *astk\_serv* (for the services *ASTK\_SERV*).
- *Impression*: Configuration of the orders of impression  
The user defines orders of impression (*lpr*, *a2ps*...) who will be used to print files, and files of impression (printing). The order can be carried out on one distant waiter.  
For the code *@P* of the line of order the name of the file of impression will be substituted, the name of file will replace *@F* (see [§ 2.1.3] for the field codes).  
Example of ordering of impression:  
*lpr - H - P @P @F*  
or */usr/bin/a2ps - P @P -2 --print-anyway=yes --sides=tumble @F*
- *Quitter*: Finish the session
- The *NR* the last open profiles are directly accessible starting from small *Fichier*.

## **2.1.2 Menu Configuration**

- *Serveurs*: Allows to modify the configuration of the waiters: waiters of calculation or waiters of file.
  - For the waiters of calculation, to choose the mode of remote loading of the configuration *Aster*: waiter turns over the list of the versions available, the procedure (batch and/or interactive) and associated limits.  
It is necessary to indicate the “login” authorized to connect itself to the waiter, and the repertory where is installed  
waiter part of *astk* (*ASTK\_SERV*).
  - For the file servers, to choose “any” like mode remote loading of configuration *Aster*.
- *Interface*: Defines the preferences of the user:  
For *astk*:  
Name, first name, email will be used for the bond towards the management tool of the experience feedback  
(emission, consultation of the cards anomalies, evolution... ).  
The access to the functions of the data processing department *Aster* if the user is recognized as developer *Aster* on the machine of reference.

*The access path to the editor and the terminal (window xterm) on the local machine, the version with to select by defect, the number of remanent profiles in the small File, the level of message (debug), the domain name network of the machine and if mode DHCP (addresses IP dynamics) is active, the communications protocols used for the orders Shell (rsh or ssh) and copies it files (CCP, SCP or rsync).*

*For the follow-up of the jobs:*

*The number of lines posted during the consultation of a calculation in the course of execution (tail), and the automatic frequency of actualization in minutes.*

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## **2.1.3 Menu**

### **Tools**

· *Paramètres: Allows to configure the launching of the tools.*

*Certain tools are envisaged out of standard (without inevitably being available on the local machine):*

- *bsf: Explorer of files multi-machines,*
- *Eficas: Editor of command file Aster,*
- *Gibi: Maillor and tool for postprocessing (usable free with Aster),*
- *GMSH: Maillor and tool for postprocessing (free),*
- *Stanley: Tool for postprocessing integrated into Aster,*
- *Foresys: Tool for navigation in sources FORTRAN.*

*When one chooses Stanley throw, astk seeks in the profile the bases available (by order preferably a base in result, if there is not, a bhdf (HDF bases) in result, if not one base in data and finally, a bhdf in data), produces a temporary profile starting from the profile*



running with a command file Aster which starts with CONTINUATION () and which launches STANLEY ().

The user can add his own tools, to parameterize the access path to the tools (including to modify the ordering of access to the standard tools), to define in which types of files associate the tool and to specify if one can use the tool on a distant file.

The following codes can be used in the line of order:

- @F: absolute way of the selected file,
- @R: repertory containing the selected file,
- @f: name of the file (without the repertory),
- @D: address DISPLAY (that known at the time of the launching of the interface).

The tools are called either starting from small Outils, or starting from the contextual menu on a file of a list or in the explorer (right button).

To select a file, it is enough to click on its name in a list (in the Etude mitre, Tests or Overload).

While double-clicking on a file, association between the type of the file and the tool to be used rest on extension of the file name for the bsf, whereas the type selected by the drop-down list (cf. description of the mitres) prevails in astk.

## **2.1.4 Menu**

### **Options**

#### **· Arguments:**

Allows to position optional arguments which will have placed on the line of order of execution of Code\_Aster.

dbgjeveux: activate a mode different from the management of the objects in memory to detect them crushings and destruction of objects,

rep\_outils: the repertory defines where the tools called since Aster (onmetis are sought or gibi for example),

rep\_dex: the repertory defines where are sought the external data (given grid),

rep\_mat: the repertory defines where the data of the catalogue material are stored.

#### **· Paramètres:**

Definition of the optional parameters used during the launching of a list of tests (button TESTS).

nbmaxnook: a maximum number of invalid case-tests (NOOK, ARRET\_ANORMAL...) before the stop list of the tests,

cpresok: allows to choose which are the tests of which one keeps the files result,

RESOK: one keeps the files of tests OK and NOOK,

RESNOOK: one keeps only the files of tests NOOK,

facmtps: multiplicative factor of the time of the tests (compared to the time of reference of will.para).

Useful, for example, when one subjects tests with achievable built in debug mode, more

*slow.*

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## **2.1.5 Menu**

### **Help**

- *Introduction/Small Parameters of calculation/: access to the text of assistance*
  - *Historique of the modifications: Evolution of astk to the wire of the versions, new possibilities, corrections carried out, known anomalies...*
  - *Frequent Problèmes: Some questions frequently put with their solutions.*
  - *Fenêtre of the messages: The messages of information <INFO>, of <ERREUR> errors are written in this window. With a level of message equal to or higher than 1 (see [[§ 2.1.2](#)]), [one obtains more or less of information.](#)*
- Level 3 posts the orders subjected to the waiters, levels 4 and 5 make it possible to have complementary details in the file .o (of debug type) during the execution of as\_run (in interactive); what makes it possible to include/understand sometimes why an error occurs.*
- *By the way: the impossible to circumvent window of information.*

## **2.2**

### **mitres**

*One finds five buttons in this zone. One speaks about mitre because the contents which one finds under the buttons changes according to that which is in a hurry. Graphically, they are not “truths” mitres bus the widget does not exist in standard the Tk bookshop (and one did not want to add pre-necessary additional!).*

*STUDY, TESTS and OVERLOAD are mitres in which one informs the list of the files necessary; AGLA and REX are buttons which can use the contents of the other mitres.*

*Lastly, the check box located beside the first four buttons announces that one uses (or not) it contents of the associated mitre.*

*Examples: To launch a study, the mitre STUDY should be notched. To call upon the functions of the AGLA (on the machine of reference), mitre AGLA should be notched; one will note that in this case, TESTS and OVERLOAD are automatically notched because their contents are taken into account.*

### **2.2.1 Mitres STUDY, TESTS, OVERLOAD**

*To reach the files more easily, to traverse the tree structures more quickly (files being often gathered in close repertories), or to simplify the posting of the names of files, one can define a basic way.*

#### **Appear 2.2.1-a: Basic way**

*One defines it while clicking on the Parcourir button and one chooses the repertory which will be the repertory by defect.*

*Each mitre contains a list of files (two lists for OVERLOAD).*

#### **Appear 2.2.1-b: List files/repertories**

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*One defines a file or repertory by line. One finds left towards the line:*

- *Type: type of the file or the repertory;*
- *Serveur: name of the waiter on which is the file/repertory;*
- *Nom: access path to the file: in absolute if it starts with “/”, into relative compared to basic way in the contrary case;*
- *UL: logical number of unit associated this file;*
- *D, R, C: check boxes to indicate if the file/repertory is respectively in data, result, compressed (with gzip).*

*When one changes the type of a file/repertory, default values are positioned for indicators D, R, C and the logical number of unit.*

*Notice on the types:*

*Code\_Aster handles the files via the procedures FORTRAN which use numbers of logical unit (file fort.19 for example); it thus affects numbers of unit logic by defect to simplify the life of the user. The “type” thus makes it possible to reach easily with the numbers used by defect; it as makes it possible astk to check as the user provides coherent data (for example which one provides well one repertory for such type, or which one does not provide two objects whereas only one is authorized for such other...).*

*To handle the list, one has four buttons:*

- 
- : allows to add a new virgin entry at the end of the list;*
- 
- : allows to add a file/repertory at the end of the list by traversing the tree structure of files;*
- 
- : to remove the line currently selected in the list;*
- 
- : open the file/repertory currently selected in the list with the editor of the waiter where the file (cf [§ 4.1] is). If it is about a repertory, all the files of the repertory are opened with the editor (attention with the repertories containing many files or files binary not éditables!).*

*Arguments (mitre STUDY and TESTS only):*

*This zone of text makes it possible to transmit arguments to achievable Aster. See also [§2.1.4].*

*Finely contextual:*

*While clicking with the right button on an entry of the list, one reaches a contextual menu:*

- *Ouvrir: launch the tool associated with this type of file (determined by the “Standard” field, and not the extension of the file), if no tool is associated this type, one publishes the file;*
- *Editer: publish the file (or all the files of the repertory) in the same way as it button*
- ;
- *Imprimer: print the selected file;*
- *Ouvrir with...: one can choose to open the file selected with one of the tools available (the result can be astonishing if the tool does not know this type of file!);*
- *Default values: the interface determines a file name per defect according to “Standard” selected starting from the name of the profile (file .astk), no value is proposed if the profile was recorded yet (is used in general on a virgin line only one has just inserted, indicators D/R/C are not affected by this operation);*
- *Propriétés: post the permissions, the size, the date and the hour of the file (order ls -).*

## *Mitre OVERLOADS*

*The data (source files) are provided in the higher list, whereas them results (achievable, catalogues compiled) are provided in the lower list.*

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## *2.2.1.1 Lists types for STUDY*

*comm:*

*command files Aster (including the files of continuation)*

*email:*

*file grid with the format Aster*

*wander:*

*file of error (fort.9 of Aster)*

*mess:*

*file of the messages of the execution*

*resu:*

*file of result (impression of the tests, impression to the format Aster)*

*base:*

*repertory containing the base of calculation*

*bhdf*

*repertory containing the base of calculation to format HDF*

*cast:*

*file result with format CASTEM*

*mast:*

*kept for reason compatibility*

*mgib:*

*grid with the Gibi format*

*mmed:*

*grid with format MED*

*msh:*

*grid with the Gmsh format*

*msup:*

*grid with format IDEAS*

*pos:*

*file result with the Gmsh format*

*ensi:*

*repertory result with the Enight format*

*dat:*

*file result containing of the curves to format XMGRACE*

*PS:*

*File postscript*

*agraf:*

*file result containing the data for Agraf (old versions of Aster*

*wrote the directives and the data in the same file that it was necessary to cut out with the order post\_agraf on the machine of reference)*

*digr:*

*file result containing the directives for Agraf*

*rmed:*

*file result with format MED*

*unv:*

*file result with the “Universal” format (IDEAS)*

**para:**

*file of parameters (retranscription of the parameters of calculation for the tests)*

**repe:**

*result and/or data directory (makes it possible to transmit/recover the contents complete of a repertory; as one does not affect numbers of logical unit Aster must reach the files by their names, cf orders DEF1\_FICHER)*

**libr:**

*file or repertory with the choice of the user*

**btc:**

*script of launching generated by the service (one can thus recover it, to modify it...).*

*At the time of a astout on the machine of reference, resu\_test must be on this one.*

### **2.2.1.2 Lists types for TESTS**

**list:**

*file containing the list of the tests to be carried out (a name of test per line without .com m)*

**rep\_test:**

*repertory containing the data files of the tests (orders, grid...)*

**resu\_test:**

*repertory where the files results are recopied*

**btc:**

*idem STUDY*

### **2.2.1.3 Lists types for OVERLOAD, part GIVEN**

**F:**

*sources FORTRAN*

**C:**

*sources C*

**py:**

*python sources*

**capy:**

*sources of the catalogues of orders*

**cata:**

*sources of the catalogues of elements, options, sizes...*

**hist:**

*file histor (historical of the modifications)*

**conf:**

*file of configuration (choice of the options of compilation, the bookshops...)*

**unig:**

*file unigest containing the modules to be removed*

**datg:**

*geometrical data*

*cmat:*  
*catalogues of data materials*

*In general, one provides a repertory for the first five types (sources); all the files of which the extension corresponds to the type indicated are taken into account. Nevertheless, it is disadvised mixing*

*types of files in the same repertory.*

*hist, unig, datg and cmat are exclusively related to the management of the version of reference.*

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### **2.2.1.4 Lists types for OVERLOAD, RESULTS part**

*exec:*

*file of the achievable Aster*

*cmde:*

*repertory of the catalogue of order compiled*

*ele:*

*file of the catalogue of elements*

*forlib:*

*bookshop for FORESYS*

*btc:*

*idem STUDY*

*forlib is used only on the machine of reference.*

### **2.2.2 Button**



## **AGLA**

*This button gives access the functions of the data processing department which coordinates the actions of developers of the version of coherence. For that, the box on the right of the button must be notched, it who causes automatically to take into account the contents of the mitres TESTS and OVERLOAD, it is then enough to click on the button "Throw". One will refer to the handbook of the AGLA ([D1.02.01]) for more details on the various actions.*

- ASNO: allows "to note" modules (to announce that one envisages to restore one modification), applies to the source files and the files of test.*
- ASDENO: allows "to indicate" modules. This action does not use any the data of TESTS or OVERLOAD. When one clicks on "Launching", a window requires to choose the type of module to be indicated (fortran/C, python, catalogues or test), and to indicate the name of modules separated by a space, a tabulation or a return to the line (without the extension: op0191 to indicate the file op0191.f). For the files Python, it is necessary of to specify the name of the repertory (package in the denomination Python) in which they find (bus contrary to sources FORTRAN and C, the same name can be used in different repertories), example  
: macr\_recal\_ops@Macro (indicates the module macr\_recal\_ops of the Macro package).*

### [Appear 2.2.2-a: Fenestrate ASDENO](#)

- ASQUIT: provides in the file output the list of all the noted modules.*
- ASVERIF: check that a whole of sources can be integrated in the version of reference (compliance with the rules of programming, file histor present...).*
- PRE\_EDA: it must be carried out before the meeting of the team of development, the developer thus announce its intention to restore sources, PRE\_EDA raises the points which will have to be regulated in meeting of development (PRE\_EDA carries out a ASVERIF and a passage of tests provided in the profile).*

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*· ASREST: it is about the ultimate phase of the restitution which consists of a ASVERIF, one passage of the tests of the list of nonregression, the code return must be lower or equal to 2 so that the restitution is taken into account.*

*· FORLIB creation/suppression: allows to produce/remove a bookshop for the tool FORESYS (on the machine of reference).*

### **2.2.3 Button**

**REX**

**Notice**

*This part will be deeply modified during 2005 with the change of the tool of management of the experience feedback.*

*This button gives access the management tool of experience feedback (on the machine of reference).*

**It**

*is decontaminated when the machine of reference is not in the list of the waiters.*

*· Choix of the correspondent: The user must choose his Aster correspondent among those which him are proposed. The Aster correspondent validates the cards emitted by his front users that they are examined by the team of development (it filters the problems thus already known or solved...). The developers are their characteristic corresponding, for them, this choice of [small is thus decontaminated \(see also \[§ 2.1.2\]\).](#)*

*· Emettre a card without joining the profile: This function makes it possible the user to emit one card-index experience feedback to point out an anomaly in Code\_Aster (AI: anomaly software), to ask for an evolution of Code\_Aster (EL: evolution software), in one of the tools associated (Mongrel, Lobster, Efficas, atsk, bsf...) (AO: anomaly outil/EO: evolution tool), one modification of documentation (ED: evolution documentation), or a request for expertise in modeling (AOM: contribute to the optimization of modeling).*

*· Information relating to the transmitter of the card is accessible by the menu Configuration/Interface. The files contained in the profile running are not joined to card-index, which can make very difficult the treatment of the card. It is advised to use "to emit a card and to associate the files it".*

*· The version of Code\_Aster indicated is that selected in the interface (Parameters of calculation).*

- *Emettre a card and to associate the files it: This function makes it possible to emit the same type of card that the preceding one, this time the data included in the profile are joined to card-index. For an anomaly, the files to reproduce the error should always be provided.*
- *What does not prevent the user from trying to insulate as much as possible the problem met, in particular to try to join a study on a model which requires little of memory and of computing time!*
- *Consulter cards: The window of consultation of the cards comprises a line where one defines search criteria, the filter makes it possible to carry out a research in the text of the cards (can be rather long) by using a regular expression.*
- *“To seek”*: the list of the cards refreshes;
- *“To visualize”*: open the cards selected in the list (one can also double-click on a card to visualize it);
- *“To print”*: print the contents cards selected in the list;
- *“associated Files”*: if the selected card has associated files, this opens a bsf where these files are;
- *“associated Study”*: if the selected card has associated files, this makes it possible to import directly profile associated with the card;
- *“To print the list”*: print the list of the posted cards.
- *Fiches to be corrected: For the developers only. One finds the same window of consultation of the cards with predefined criteria which correspond to the cards that it developer must treat. An additional button “final Answer” allows him to answer the card (after having submitted it to the team of development).*
- *Supprimer a card: Allows to remove a card which is still in the state EMIS\_UA/EMIS\_CUA by that which emitted it.*

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**[Appear 2.2.3-a: Emission of a card REX](#)**

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**[Appear 2.2.3-b: Consultation of the cards](#)**

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### [Appear 2.2.3-c: Visualization of a card](#)

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## 2.3

### **Parameters of tender**

*The parameters of calculation are provided in the right part of the principal window.*

## Appear 2.3-a: Zone of the parameters of calculation

*One defines the quantity of memory used for the job (in megabytes), the maximum time of calculation (in seconds, minutes: seconds or hour: minutes: seconds).*

*One chooses on which machine calculation is carried out, the version of Code\_Aster used, if calculation is*

*subjected in batch or interactive.*

*debug/nodebug: for a study without overload, one specifies which achievable one wishes to use (under reserve that both are available); at the time of an overload, one chooses to compile with or without information of debug.*

*The button “Throw” carries out the actions according to the notched mitres.*

*The button “Followed by the jobs” opens the window described afterwards.*

### **Operating mode** (for a STUDY):

*During the launching of a study (with or without overload), a button of option is available to side button “Throw”. Three modes of launching are available:*

- “run”: carry out the study (traditional operation),*
- “dbg”: launch the study by using the debugger,*
- “pre” : prepare the repertory of work without carrying out the study.*

*When one selects “dbg” or “pre”, the mode “debug” is chosen by defect.*

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## **2.4 Bar of state**

*The zone of text located all in bottom of the principal window provides of the assistance when one sails in menus, or when the pointer passes to the top of the buttons of the interface. During the launching of a calculation, the operations in progress are posted here.*

### [Appear 2.4-a: Bar state](#)

## **2.5 Follow-up of the jobs**

*This window provides information on the state of launched calculations, which appear in the form of one list.*

*“To publish” breaks up into “File output” and “File error” which gives access to the messages envoys by the job on the standard exit (stdout) and the exit of error (stderr). A double-click on one job of the list also posts the file output.*

*“To remove” erases the selected jobs of the list, the files related to this job in the flashor and calculation stops if this one is not finished.*

*“To bring up to date” questions the waiters on which calculations are in progress. The check box allows to reactualize automatically at a frequency defined in Configuration/Interface.*

*“To seek” allows to consult the last lines of the file message of a job in progress of execution (it does not do anything on a finished job). One can use the zone of text “Filters” not to post that lines containing the character string indicated.*

### **Innovation**

*One finds the same functions in the contextual menu which appears while clicking with right button on one or more jobs. One can thus bring up to date one job among several not finished.*

*Each line corresponds to a job, one finds 13 columns:*

- The number of the job (in batch), number of the process in interactive*
- The name of the job (name of the profile for a study, an overload, or name of function AGLA)*
- Date of tender*
- Heure of tender*
- State of the job (HANGS, RUN, SUSPENDED, ENDED)*
- Diagnostic of job (OK, NOOK, <A>\_ALARME, <F>\_ERREUR, <F>\_ARRET\_ANORMAL...)*
- Nom of the tail in batch or “interactive”*

- *Temps CPU of the execution Aster*
- *Login on the waiter of calculation used*
- *Adresse of the waiter of calculation used*
- *Machine of calculation (name of the node for a cluster)*
- *Version of astk*
- *Indicateur interactive batch/*

*The diagnosis emitted by as\_run appears in English, because it is envisaged to translate them overall, but that was not carried out yet.*

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### **3** *Limp of selection of files: bsf*

*bsf is a tool delivered with astk which can only be launched. It is about an explorer of files who allows to sail on the local machine, like a traditional explorer of files, and also on various configured distant waiters.*

*bsf uses the configuration of the waiters of astk, in particular the fields necessary to connection (addresses IP, login) and orders to open a terminal or an editor.*

*The reading of the configuration is made only with the starting of bsf, if one modifies the configuration in*

*astk, it is thus necessary to close the bsf then to open it again.*



## [Appear 3-a: bsf](#)

### **Note:**

*bsf does not treat the file names and repertories containing spaces (it results one from them shift in the names and the types of the following objects).*

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### **3.1 Navigation**

***One finds two drop-down lists in the window of the bsf.***

***The first makes it possible to pass from a waiter to another, the second memorizes the list of the twelve last repertories where the user carried out an action (edition, copy...). The first entry of this list is “----- Direct -----”, which makes it possible to go directly in a repertory without traversing the tree structure.***

***Generally, when the required repertory does not exist, one turns over in the definite HOME for the current waiter.***

***One can configure this list and fix certain repertories (so that they remain present in the list) in clicking with the right button on [this one \(cf Appears 3.1-a\)](#).***

*.*

***: the contents of the current directory refresh;***

.  
: *go up with the repertory relative;*

.  
: *propose to create a new repertory in the current directory (and places itself in it new repertory);*

.  
: *open a terminal on the current waiter.*

*The bar of state gives indications on the significance of these buttons when the pointer of mouse passes to the top.*

### [Appear 3.1-a: Fenestrate configuration of the remanent repertories](#)

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## **3.2**

### ***Small File and finely contextual***

***One finds certain entries similar to the contextual menu of the files in the mitres (see [§2.2.1]): To open, Publish, Print, Open with..., Properties.***

***“To copy”:* allows to copy one or more files/repertories (shortened by CTRL+C).**

***“To cross”:* idem To copy, except that the original files will be removed (shortened by CTRL-X).**

***“To stick”:* carry out indeed the copy or the displacement of the files (shortened by CTRL+V).**

***“To remove”:* erase the selected files/repertories.**

***“New file/New repertory”***: respectively allow to create a file or one repertory in the current directory.

***“To carry out an order”***: give the possibility of carrying out an order in the repertory running, the current selection is proposed on the line of order, it is necessary to choose one of the shells available on the waiter.

### **3.3 Menu Posting**

***One can choose to post or not the files known as hidden (starting with “. ”) by notching the box envisaged.***

***bsf posts the repertories then the files, one alphabetically can Trier of the name or in function of the date in the normal or opposite order by modifying the options of the menu.***

***The preferences of posting are preserved if one selects “To record the preferences”.***

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### **4 Configuration**

***The first time that the user launches the interface, it has a configuration by defect which was defined at the time of the installation. The configuration is then stored in the repertory \$HOME/.astkrc.***

*If the user wants to return to the configuration of origin, it must erase this repertory and start again askt.*

### *Notice n°1*

*With each time one defines an order to be carried out (final, editor...), it is advised to show the absolute way (since the root) to prevent that the order that is to say not found if the variable \$PATH is incorrect.*

### *Notice n°2*

*In general, askt supplements the orders which need to post windows with the argument “- display SCREEN”, where SCREEN is the current price of the variable \$DISPLAY. If the order used does not accept this argument, it is enough to specify good syntax with the code @D which will be replaced by the current variable of \$DISPLAY (for example: mon\_editor - display=@D, cf Small Tools).*

*One can check the current price of \$DISPLAY, small Aide/Fenêtre of the messages: askt indicates in the first lines for example:*

*<INFO> Posting of the applications on mach00.domain.org: 0.0*

*It is this value which will be provided to the supposed distant machines to post a window on the machine customer.*

*The waiter part of askt (ASTK\_SERV) included tools simplifying certain tasks of the developers like the consultation of the source code or the update of a local version of development.*

*The file \$HOME/.astkrc/config thus contains two information necessary to contact machine of reference: the complete name of this waiter and the login of the user. This last must be defined in this file to avoid following alarm:*

*<A>\_ALARM remote connection may fail:*

*devel\_server\_user not defined in /home/xxxxxx/.astkrc/config*

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## **4.1 Waiters**

*One reaches the window of configuration by small Configuration/Serveurs.*

### **Configuration/Waiters**

*The first button makes it possible to pass from a waiter to another and to add a “New waiter”.*

*The fields are:*

- Complete Nom or addresses IP: it is about the name of the waiter on the network; one can indicate sound complete name with the domain name (for example: linux.labo.univ.fr) or its address IP (by example: 156.98.254.36).*
- State of the waiter: one can put on “off” a temporarily inaccessible waiter.*
- Login: identifying with which one connects oneself to the waiter.*
- Répertoire HOME: repertory by defect when one arrives on this waiter with the bsf.*
- Répertoire of the services: repertory where are installed the services on this waiter (to indicate it complete way, for example: /aster/ASTK/ASTK\_SERV/bin), to leave vacuum for one file server.*
- Mode of remote loading of the configuration: no (for a file server), handbook (it is necessary to click on the button “To download now” to recover the Aster configuration of waiter), automatic (astk questions the waiter with starting every 30 days).*
- Dernier remote loading: date from the last update of information of configuration.*

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- *Terminal*: order to open a terminal on the waiter. This makes it possible to open a window orders on the waiter when the *bsf* is used, and to follow a calculation (it interactivement terminal must accept the option *E* to carry out an order, *xterm* is appropriate).
- *Editeur*: editor text (for example, *nedit*). The procedure of installation chooses an editor among (and in this order): *nedit*, *xemacs*, *emacs*, *xedit*, *VI*.

The following values are turned over by the service *as\_info* (nothing for a file server) and thus depend on the configuration of the waiter part of *astk*:

- *Type of platform*.
- *Versions available*
- *Accessible Machines*: list accessible nodes of calculation since this waiter.
- *Interactive Batch/*: specify if the waiter accepts launching in batch, interactive and provides them limits in memory, time CPU, a number of processors fixed on the waiter. Seul LSF is supported like software of management of batch, the support of PBS is still incomplete and experimental.

## **4.2 Interface**

**One reaches the window of configuration by small Configuration/Interface.**

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*This window makes it possible to inform personal information of the user, to choose the language used by the interface.*

*For those which have access to the machine of reference, authority AGLA is posted (EDA for developer, UTL for user...). For the EDA, the organization and the name of the correspondent are automatically filled. The users must do it themselves.*

*Then, one finds the version which will be selected by defect, the orders to reach one terminal and an editor (as for the waiters).*

*“A Many profiles in small Fichier” make it possible to preserve the name of the NR the last open profiles so as to point out them quickly.*

*“Level of message” indicates the level of details of the messages written in the window of messages of the menu Helps. Niveau=0: only the messages <INFO> and <ERREUR> are written; higher levels allow debugger the behavior of the interface. Level 1 is advised, it allows to see the error messages being able to appear at the time of the problems of communication with distant waiters.*

*One must then specify the domain name network of the machine. For example, domain.org if it complete name of the machine is mach00.domain.org. If the domain name is left empty, one message of alarm is posted with starting because the distant machines are likely not to be able to contact the local machine mach00 with its short name. The name of the machine such as it will be used by the distant machines is indicated in the field Nom Customer. If mode DHCP is active, it is in this field which one can indicate address IP of the local machine.*

*For the follow-up of the jobs, one can choose the number of posted lines when the file is visualized output in the course of job (button “To seek”), and the frequency of actualization of the list.*

### 4.3 Tools

*One selects the tool to be configured with the drop-down list, or a new tool is added. Standard tools are predefined (tiny the/capital ones are taken into account in the names tools). The tools are necessarily carried out on the machine “Room” (where the interface is launched).*

*In general, the tools are launched either on a file of a mitre (STUDY, TESTS or OVERLOAD), maybe on a file when one traverses the filing system with the bsf.*

*One defines simply the line of order necessary to the launching of a tool (absolute way advised), one can place the codes @F, @R, @f, @D in the line of order (see [§ 2.1.3]) for to correctly pass a file to the tool. One can put these codes between brackets to be able to launch the tool alone, without file in argument.*

*Types of files can be associated the tool. The type taken into account to launch the tool is extension when one traverses the files with the bsf, the type of the drop-down list when it acts of a mitre.*

*One can choose if the tool is usable on a distant file. In this case, astk is given the responsibility to bring back it file in question about the local machine in a temporary repertory, of launching the tool, then to redeposit the file on the distant waiter (even if it were not modified by the tool).*

### 4.4 Impression

*The orders of impression are defined by small Fichier/Impression.*

*On the same principle that the tools, one defines any ordering of impression (LP, lpr, a2ps...) who contains the code corresponding in the name of the file (@F, to see [§ 2.1.3]). @P is replaced by the name of the file of impression.*

*Here a traditional list of order using GNU a2ps:*

*Format 2 columns/page:*

*a2ps - P @P -2 - l82 --footer --print-anyway=yes --sides=tumble @F*

*Format 136 characters/line:*

*a2ps - P @P - R - l136 --columns=1 --footer --print-anyway=yes --sides=tumble @F*

*“Transparent” format:*



*a2ps - P @P - R --columns=1 --print-anyway=yes --sides=simplex @F*

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*5*

*How to make a study?*

*In this paragraph, one describes stage by stage how to use astk to make a study.*

*The study consists in calculating the response in inflection of a bent piping. One has the elements following:*

- A command file Aster: demo01a.com m*
- The description of the geometry carried out with Gmsh: demo01.geo*
- Grid built by Gmsh: demo01a.msh*

*The following results are produced:*

- A file of grid Aster: demo01a.mail*
- A file result with the format Gmsh (fields of displacements, constraints...) : demo01a.pos*
- Traditional files of message and Aster result: demo01a.mess and demo01a.resu*

*In the example, one places all the files in the /home/tutorial/demo01 repertory.*

*Note:*

*In the case of a study with several command files, all the files must be*

*of type “comm”, associated the logical unit 1 and it is the extension which determines the order of execution: .com m, then .com 0, .com 1,..., .com 9 (there can be holes).*

## **5.1**

### **Creation of the profile**

*One launches the interface which opens on a virgin profile, or if astk is already launched, one chooses*

*New file/in the menu to create a new empty profile.*

*One places oneself in the mitre STUDY.*

## **5.2**

### **Selection of the files**

#### **5.2.1 Definition of a basic way**

*In the mitre STUDY, one chooses a basic way to simplify the access to the files.*

*One clicks on the icon*

*, the /home/tutorial/demo01 repertory is chosen.*

#### **5.2.2 Addition of existing files**

*One adds the command file while clicking on*

*, the selection of file opens directly*

*in the basic way which one has just defined. It only remains to select the file demo01a.com m (double-click or simple click + ok), and the file appears in the list. Let us note that astk identifies the type of*

*this file starting from its extension “comm”, the logical number of unit is positioned to 1, the box “D” (given) is notched.*

*One makes in the same way for the file of grid to the format Gmsh (demo01a.msh). astk recognizes the extension “msh”, the logical number of unit is positioned to 19, the box “D” is notched.*

#### **5.2.3 Addition of files...**

*Except if an execution already took place, the files results do not exist yet, one thus cannot to add by traversing the tree structure.*

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### **5.2.3.1... while inserting a blank line**

**The grid with the Gmsh format will be read again and converts in the command file Aster by order PRE\_GMSH in grid with the Aster format. One can recover this grid by adding one file of the type “email” on the logical unit 20.**

**One clicks on**

**, a line is added in the list. One chooses the type “email” in the list (what has for effect to position the logical number of unit to 20). The name is indicated /home/tutorial/demo01/demo01a.mail or demo01a.mail or ./demo01a.mail (since one can indicate the name of the file into relative compared to the basic way). The file is produced by the execution, one thus notches the box “R” (result) and one strips “D”.**

## **Notice**

**Order PRE\_GMSH uses by defect numbers 19 and 20 with inputs/outputs, if one modifies the command file to read again or write the files of grid on other units, it is necessary to be coherent for the numbers indicated in astk.**

### **5.2.3.2... with “Default value”**

**One could continue thus to add the other files, but one will use the function “Value by defect” for the following files. This function uses the name of the profile astk to build them default values (see [[§ 2.2.1 /Menu contextual](#)]), one thus will record the profile.**

**One chooses Enregistrer under... in small Fichier, one goes with the navigator in the repertory /home/tutorial/demo01, and in the line Selection, one types demo01a (the extension .astk is automatically added).**

**Let us note that the title of the principal window of astk gives the name of the current profile. The title is now: ASTK version 1.2.1 - demo01a.astk - /home/tutorial/demo01**

*One inserts a blank line while clicking on , one chooses the type of file “pos”, then one clicks with the right button in the box of the one and file name chooses “Default value”: astk builds one file name starting from the name of profile (by withdrawing the extension) and of the type “pos”, is /home/tutorial/demo01a/demo01a.pos. Moreover, astk tries to substitute the basic way for more legibility, one sees as follows: ./demo01a.pos. The box “R” was notched, and the logical number of unit fixed at 37. Let us suppose that in the file of order, one indicated:*

*IMPR\_RESU (UNITE=30,...)  
one thus modifies the logical number of unit consequently, it is enough to click on the old value, of to erase and to type 30. Only two digits are posted in this box, to avoid the errors, astk check that the numbers of logical unit lie between 1 and 99.*

*In the same way, one adds a file of the type “mess” and one of type “resu” in this manner (of leaving them numbers of logical unit per defect).*

#### **5.2.4 To remove a file**

*To remove a line of the list of the files, it is enough to select it while clicking in the zone where one indicates the name of the file and to click on the icon*

**Note:**

*Only the reference to this file in the profile astk is forgotten, the file itself is not erased!*

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### 5.3 *Launching of calculation*

*The files given and results are selected, one adjusts the parameters of calculation ([see \[§ 2.3\]](#)), and one clicks on the button “Throw”.*

*One takes care to notch the box which is just beside STUDY to announce that one wishes to use the contents of this mitre... if not interfaces it answers us “Nothing launching! ”. If the profile were not recorded yet, the interface requires to choose a place and a name for it [profile \(see \[§ 5.2.3.2\]\)](#).*

*astk calls the service which carries out calculation, and transmits to the Follow-up jobs (asjob) the number of the job*

*(number of the process in interactive) and other information which will make it possible to follow advance*

*calculation. The initial state of calculation east HANGS (on standby), when calculation starts, it becomes RUN, then*

*ENDED when it is finished (other states are possible in batch). The button “To bring up to date” calls the service which refreshes the state of calculations in progress.*

*When calculation is finished, one can consult the output of the job while double-clicking on the job, or by*

*To publish/File output.*

### 5.4 *Consultation of the results*

*One can consult the files results simply while double-clicking on their name, which opens one text editor for the files “mess” and “resu”; on the file of result to the Gmsh format, “pos”, that causes to open this file in Gmsh directly. One visualizes the deformation thus and isovaleurs (provided Gmsh were installed, and that “pos” is in the types of files associated Gmsh, to see [\[§ 4.3\]](#)).*

### 5.5 *Use of the tools*

*One can also use astk and the fact that one can freely define tools in it to gather in a profile all files necessary to a study even if those are not directly used by Code\_Aster.*

*In this example, demo01a.geo is a file that Code\_Aster cannot read again; it contains description of the geometry, Gmsh uses it to create the grid (.msh).*

*One can nevertheless insert it in the profile (button*

*), to affect an unspecified type to him (“libr” by*

*example) since it will not be used during the execution (boxes D, R not notched). One can directly open the geometry by making Ouvrir with... /Gmsh (click right on the name of file), to modify the geometry or the parameters of the grid, to re-mesh and record the grid.*

*One can then start again calculation on the new file demo01a.msh.*

*Obviously, this is not limited to Gmsh; one can use other tools (maillieurs, tool of postprocessing, graph plotter...) directly since astk and to reach all the files thus of a study since a profile with the adequate tool.*

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**6**  
*How to carry out an overload?*

*One considers in this paragraph that the user is familiar with handling of the lists of files in the mitre STUDY.*

*An overload consists to add or modify part of Code\_Aster and to use it to carry out one study. The objective of an overload is to produce achievable, a compiled catalogue of orders and/or a catalogue of elements. One can also overload the methods python defined by Aster, in this case, the sources is recopied in the repertory of execution (it does not have there a receptacle*

*object of overloaded files python).*

*One places oneself in the mitre OVERLOADS.*

## **6.1**

*Addition of the sources*

*One proceeds like adding files for a STUDY. One can select is a file, that is to say a repertory. It is often clearer and more practical to place its source files in repertories.*

*If one adds a repertory in the list of the sources (left higher the mitre OVERLOADS) type “F” (files FORTRAN), all the files whose extension is .f will be compiled and used to make new achievable.*

## **6.2**

*To define the results of the overload*

*Files C (standard “C”) and FORTRAN (standard “F”) make it possible to build achievable: type “exec”.*

*The catalogues of orders “capy” make it possible to build a catalogue of orders compiled: type “cmde” (repertory containing the files cata.py and cata.pyc).*

*The catalogues of elements, options and sizes “cata” are used to produce a catalogue compiled elements: “ele”.*

## **6.3**

*Taking into account of the overload*

*So that the data well informed in the mitre OVERLOAD are taken into account, it is necessary to notch*

*the box located just on the right of the button OVERLOADS (the mitre OVERLOAD is always notched in this paragraph).*

*One needs a receptacle in result absolutely corresponding to the data sources (“D” notched). If there are repertories “C” and/or “F” in “D” onnée, one needs a “exec” in “R” résultat; of even for “capy” with “cmde” and “cata” with “ele”.*

*One can prepare the overload independently of the study (advised) or make the overload and to launch the study in the tread.*

### **6.3.1 To prepare the overload alone, then to launch a study**

*To prepare the overload alone:*

- to strip the mitre STUDY*
- to put the sources in “D” onnée*

- *to only put the corresponding receptacles in “R” é sultat*
- *“To launch”.*

*The overload builds the results (achievable, catalogues...) starting from the data (sources).*

*Launching of the study by using this overload:*

- *to notch the mitre STUDY*
- *to strip the indicator “D” for the sources*
- *to put the réceptables in “D” onnée only*
- *“To launch”.*

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*The products of the first stage are then used as data to launch the study.*

*Caution: Not to strip OVERLOAD, if not the study will be launched with the standard version not overloaded.*

*It is rare that compilation succeeds with the first test, by separating the two tasks, one sees immediately if compilation occurs badly, or if the achievable one is not produced.*

*6.3.2 To make the overload and to launch the study at the same time*

*To connect the two stages automatically:*

- *to notch the mitre STUDY*
- *to put the sources in “D” onnée*
- *to put the corresponding receptacles in “D” onnée and “R” é sultat*
- *“To launch”.*



*In the event of problem of compilation, it may be that achievable is produced without taking in count part of the data sources. It is thus necessary to look at the output attentively of compilation. For that, the step of the preceding paragraph is advised.*

7  
*How to launch a list of tests?*

*It is necessary to approach this point after the two precedents. Indeed, throw a list of tests does not have of interest that to validate an overload is with respect to nonthe regression of the functionalities original of the code, that is to say on a whole of case testing a new functionality.*

*To use this possibility, it is necessary to notch the box located just on the right of the button TESTS (what strip STUDY automatically). In the majority of the cases, one uses an overloaded version, therefore in this case the mitre OVERLOAD is also notched.*

**Notice n°1**

*It is absolutely necessary to prepare the overload independently of the launching of test as with the § “Preparing the overload alone, then to launch a study”. One prepares overload, then one launches the tests with the results of this overload.*

**Notice n°2**

*On the machine of reference, the launching of a list of tests must be made only in batch.*

*The data are very simple, one provides a file of the type “list” (see [[§ 11](#)]); “rep\_test” indicates where are the files necessary to the launching of the tests (“given” of the tests: .com m, .mail...); “resu\_test” makes it possible to write the results of the tests in another repertory.*

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## **8 Questions frequent**

***“Nothing occurs when one tries to launch a calculation, to publish a file or to open one terminal on a distant waiter” or “Code return = 2, Profiles Copy failed in the window messages with the launching of a calculation”***

*It is probable that the local machine cannot communicate correctly with the waiter distant. Communications using protocol CCP/rsh, the files .rhosts on the local machine and on the distant waiters must be correctly well informed. If one uses protocol SCP/ssh, it is necessary that the private and public keys are coherent.*

*One can check it by leaving astk, and by starting again it in this manner:*

*astk --debug 0 - check (--debug 0 is used to limit the impressions)*

*To attentively see information which is printed. astk provides information on the variable of environment DISPLAY (to check that it is correctly defined), and tests connection between machine where is launched astk and distant waiters. In the event of problem of connection with one waiter, astk suggests a modification of the file .rhosts of the target machine.*

***“When a calculation in batch is subjected, there is the message: The number of the job and the class do not have not been able to be recovered”***

*Time or the required memory is probably beyond the limits of the classes of work. See in the window of the messages, there is probably a message of the manager of batch of the style “Cannot exceed queue' S hardware limit (S)”.*

*To decrease time or the memory, or explicitment to choose a class batch which agrees in additional options.*

***“While clicking on Default value the file name remains empty”***

*This function uses the name of the profile to determine a default value, it is necessary to record the profile before being able to use this function.*

***“On the machine of reference: the behaviors in batch and interactive are different”***

*It is possible. In batch, Code\_Aster is launched by scripts of the AGLA, in interactive, one rests on as\_run. To announce in a “AO” the differences.*

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***Appendix 1 Use of the service as\_run (of ASTK\_SERV)***

***The reading of this chapter is reserved to the users who wish to launch Code\_Aster “to the hand”, without to use the interface and with those which installed and maintain a version local.***

***When one uses the interface astk for launching calculations, this one as a customer calls upon services suggested by a waiter which can be on the same machine or a distant machine (in the case where the waiter is distant, there are exchanges of files and a Shell order through the network (protocol rsh or ssh) that we do not detail here).***

*Several services are called by the interface:*

*as\_info: recover information of configuration of the waiter: versions and machines of calculation available, limits in interactive and batch;*

*as\_actu: recover the state of a calculation in progress or finished;*

*as\_tail: recover the last lines of the output of calculation (stdout, left standard);*

*as\_del: stop a calculation in progress and/or removes the files of the flashor associated with this*

*calculation;*

*as\_edit: open the file output of a calculation (file .o of the flashor) or error (file .e) in one editor;*

*as\_exec: launch the actions indicated in the profile in argument (file of the .export type).*

*as\_run is a service called by as\_exec within the framework of an execution via the interface, it is limited to*

*to launch an execution of Code\_Aster, with or without overload, a simple study or a list of tests.*

*The options of as\_run are given while typing: as\_run --help, one obtains:*

*use: as\_run action [options] [arguments]*

*Functions:*

*- Return the hand subroutine of has code\_aster command:*

*as\_run --gettop [options] order [.capy]*

*- Return current release number of the development version:*

*as\_run --getversion [options]*

*- Show has source slips by: FORTRAN, C, python, capy, cata, histor gold test:*

*as\_run --show [options] obj1 [obj2...]*

*- Copy has source slips by in current directory:*

*as\_run --get [options] obj1 [obj2...]*

*- Build has code\_aster version (achievable, libraries, catalogs):*

*as\_run --make [--version\_dev=VERS]*

*- Perform one gold several updates of has version development:*

*as\_run --update [options] fich1.tar.gz [fich2.tar.gz...]*

*- Download available updates from has server and apply them to the current development version:*

*as\_run --auto\_update [options]*

*- The execution described by the Carries out profiles (default action):*

*as\_run --run [options] profiles*

*options:*

*--version show program' S version number and exit*

*- H, --help show this help message and exit*

*- v, --verbose print status messages*

- G, --debug print debugging information  
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- F, --force force operations which edge Be cached (download, compilation...)

--remote\_shell\_protocol=REMOTE\_SHELL\_PROTOCOL

remote protocol used for Shell commands

--remote\_copy\_protocol=REMOTE\_COPY\_PROTOCOL

remote protocol used to Copy files and directories

--editor=EDITOR editor command

--devel\_server\_user=DEVEL\_SERVER\_USER

login one the development server (name/IP address is usually set in ASTK\_SERV/conf/config)

Options for maintenance operations:

--vers=VERS Code\_Aster version to used

- has, --all get all the files of the test

--version\_dev=VERS development version of Code\_Aster to update

- L, --room files will not been searched one has server drank one the room machine

--nolocal force remote files search (reverse of --room)

Additional precise details:

· One can create a bond towards as\_run for any action to simplify the call (this is especially useful for the actions get, show and getop which one often calls):

*get - > as\_run*

*One can then use get fichier.f instead of as\_run --get fichier.f*

*· When one recovers a source file with get, show or getop, this one are put in /tmp/astk\_`login`/cache. If for the same file again is asked, this one is taken directly in this repertory except if the option --force is activated; the files which have more one day are automatically removed mask.*

*· --room--nolocal: these two options make it possible to pass in addition to the value defined in file of configuration. If the mode by defect is to seek the files locally, one can use --nolocal to force research on a distant machine (it is in particular useful for to seek the updates of Code\_Aster on the www.code-aster.org waiter). Conversely, if one systematically recovers the files on a waiter of development in network, one must use --room to visualize source files installed on the machine local.*

*· The principal file of configuration is xxxx/ASTK/ASTK\_SERV/conf/config (where xxxx are it principal repertory of installation of Aster), the user can define certain values in \$HOME/.astkrc/config (where \$HOME is the repertory by defect of the user), in particular it name of user to use on the distant waiter (devel\_server\_user) to avoid an alarm with each launching of as\_run.*

*· --version\_dev is used by the actions make, update and auto\_update. Whereas --towards is used by get, show and getop.*

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*Author (S):*

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***Document: U1.05.00***

***Simple example of use***

***Summary:***

*This document describes a very simple example of use of Code\_Aster.*

*One illustrates the orders “impossible to circumvent” on the calculation of a tank (cylinder thin under pressure hydrostatic) modelled into axisymmetric.*

*The command file is analyzed, as well as the file of results.*

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Simple example of use*

*Date:*

*26/05/05*

*Author (S):*

*Mr. ABBAS, J.M. PROIX, NR. TARDIEU Key*

*:*

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*1*

*To model a mechanical problem with Code\_Aster*

*The problem to be modelled is a thin cylindrical tank (thickness 0.02m, average radius  $R=1m$ ,  $L=4m$  height) subjected to a pressure interns variable with the height, corresponding to a pressure hydrostatic.*

*Being given symmetries of the geometry and*

*$R=1m$*

*loading, one chooses a modeling*

*two-dimensional axisymmetric.*

*It will thus be enough to represent a vertical section of this cylinder (in plan X Y)*

*The two stages to be envisaged are:*



***L=4m***

•  
***the creation of the grid***

•  
***the drafting of the command file***

2  
***Manufacture of the grid: what to envisage?***

y  
***Some is the software of grid used (GIBI, IDEAS, GMSH), it is necessary to envisage, as of the creation of the grid, of to name the entities which will be used in calculation to affect***

D  
C  
***elementary characteristics, conditions with limits, of the loadings, materials...***

***Indeed, although it is possible to use them directly numbers of nodes and meshes in the file of orders, it is preferable to use entities named. This makes it possible to have a command file ldf independent of the degree of refinement of the grid, and of a possible renumerotation of the nodes or elements.***

***In practice, these entities are groups: charg***

•  
***groups of nodes (possibly containing one only node, like the points A, B, C, D in the example),***

lfa  
•  
***groups of meshes corresponding to under-fields of the grid, or many meshes used to apply the loadings: here by example, groups of meshes lfa, ldf contain linear meshes (meshes of***

**With  
B  
skin) which will be used to apply the pressure.  
support  
X**

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**3  
How to write its command file?**

**3.1  
To start from nothing?**

**When one wants to model a new thermomechanical problem, one does not leave in general white sheet: it is useful to take as a starting point a command file of a modeling close to that to treat. How to obtain these files? The sources are varied:**

**.  
the base of the tests of Code\_Aster, with its documentation, is often an important help, because it covers most of the functionalities of the code (one can find these tests in the repertory astest),**

**.  
the formations make it possible to know the whole of the orders thoroughly paying to types of modelings  
: statics linear, thermal, dynamic,**

*thermoplasticity, post\_traitement...*

*The drafting of this command file will be largely facilitated by using the editor of file of orders EFICAS.*

**3.2**

*Orders with the magnifying glass*

*We now will detail the orders necessary to the realization of calculation considered.*

*Command file*

*Explanations*

*# TITRATES thin Cylinder under pressure*

*The comments are preceded by sign #,  
hydrostatic*

*BEGINNING ();*

*Obligatory order to start...*

*PRE\_GMSH ();*

*The grid is with format GMSH*

*email = LIRE\_MAILLAGE ();*

*Reading of the grid in the file of grid,  
and creation of the concept email containing it  
grid with the format Aster*

*# Redefinition of the groups of nodes and  
groups of meshes*

*mail=DEFI\_GROUP (reuse =mail,*

*Definition of the groups of meshes from*

*MAILLAGE=mail,*

*those created in GMSH*

*CREA\_GROUP\_MA= (\_F (NOM=' APPUI',*

*GROUP\_MA=' GM11'),*

*\_F (NOM=' LDF',*

*GROUP\_MA=' GM13'),*

*\_F (NOM=' LFA',*

*GROUP\_MA=' GM14'),*

```
_F (NOM=' ND_A',  
GROUP_MA=' GM1'),  
_F (NOM=' ND_B',  
GROUP_MA=' GM2'),  
_F (NOM=' ND_C',  
GROUP_MA=' GM3'),  
_F (NOM=' ND_D',  
GROUP_MA=' GM4'),  
),);
```

### ***# Definition of the model***

***A model is a concept containing the types  
finite elements useful for calculation***

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***modl=AFFE\_MODELE (MAILLAGE=mail,  
Associate all the meshes grid of  
axisymmetric mechanical finite elements***

***AFFE=\_F (TOUT=' OUI',***

***PHENOMENE=' MECANIQUE', the same order can continue on  
MODELISATION=' AXIS',,)); several lines***

***# Definition of material***

***acier=DEFI\_MATERIAU (ELAS=\_F (E=210000000000.0, characteristics of each material  
constituting the grid are provided***

***NU=0.3,));***

***Young modulus and Poisson's ratio***

***chmat=AFFE\_MATERIAU (MAILLAGE=mail,  
Assignment of material on the grid***

***AFFE=\_F (TOUT=' OUI',***

***Here the material is the same one for all the grid***

***MATER=acier,)); If not one could affect materials  
different on groups from meshes***

***# Definition of the boundary conditions***

***The boundary conditions can relate to***

***nodes, of the groups of nodes, the meshes or  
groups of meshes.***

***clim=AFFE\_CHAR\_MECA (MODELE=modl,***

***Here nodes of the group of meshes SUPPORT***

***FACE\_IMPO=\_F (GROUP\_MA=' APPUI',***

***(meshes of edge) are affected***

***condition:***

***DY=0,));***

***DY = 0 what means:***

***“displacement following” no one there***

***# Definition of the loading: pressure function the functions are point by point defined  
of y***

***(variation refines between two points per defect)***

*f\_y=DEFI\_FONCTION (NOM\_PARA=' Y',  
Here, the pressure varies between:  
VALE= (0.0, 20000.0,  
20000 Pa for y=0  
4.0,0.0,,);  
and 0 for y = L*

*charg=AFFE\_CHAR\_MECA\_F (MODELE=modl,  
Assignment of the pressure (function of y) on  
PRES\_REP=  
edge made up of the groups of meshes LFA LDF  
\_F (GROUP\_MA= ("LFA", "LDF"),  
PRES=f\_y,,);*

*# Resolution  
Total ordering of resolution of the problems*

*statics in thermo linear elasticity  
res1=MECA\_STATIQUE (MODELE=modl,*

*CHAM\_MATER=chmat,  
The material field  
EXCIT= (\_F (CHARGE=charg,), One defines the loadings  
\_F (CHARGE=clim,,));*

*res1 is the name of the concept result containing  
the field of displacements*

*# Calculation of the constraints  
reuse=res1 means that one “  
enriches” it  
concept  
res1=CALC\_ELEM (reuse =res1,*

*res1: the stress field will be stored*

*in addition to the field of displacements*

*RESULTAT=res1,*

*OPTION=' SIGM\_ELNO\_DEPL',);*

*Name "SIGM\_ELNO\_DEPL" means*

*"forced calculated with the nodes of each*

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*element starting from displacements"*

*# Impression of the results at points A B C D*

*IMPR\_RESU (MODELE=modl,*

*Impression of the results to the format text*

*RESU=\_F (RESULTAT=res1,*

*displacements with the nodes*

*GROUP\_MA=' ND\_A',);*

*corresponding to points A B C D*

*IMPR\_RESU (MODELE=modl,*

*RESU=\_F (RESULTAT=res1,*

***GROUP\_MA=' ND\_B',),);***

***IMPR\_RESU (MODELE=modl,***

***RESU=\_F (RESULTAT=res1,***

***GROUP\_MA=' ND\_C',),);***

***IMPR\_RESU (MODELE=modl,***

***RESU=\_F (RESULTAT=res1,***

***GROUP\_MA=' ND\_D',),);***

***# Impression of the results***

***IMPR\_RESU (MODELE=modl,***

***Impression of the results to the format text***

***RESU=\_F (RESULTAT=res1,);***

***displacements/forced on all the grid***

***# Impression of the results for visualization  
with GMSH***

***DEFI\_FICHER (ACTION=' ASSOCIER',***

***Definition of the logical unit for file GMSH***

***UNITE=37,)***

***IMPR\_RESU (MODELE=modl,***

***Impression of the results to format GMSH***

***FORMAT=' GMSH',***



**UNITE=37,  
RESU=\_F (RESULT = res1,))**

**DEFI\_FICHER (ACTION=' LIBERER',  
Closing of the logical unit  
UNITE=37,)**

**END ();**

...

**Obligatory order to close an execution  
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**4  
What contains the file of results?**

**=> a heading pointing out the date, the version, the platform used:**

**-- CODE\_ASTER -- VERSION OF DEVELOPMENT 7.04.00 --**

**COPYRIGHT EDF-R & D 2003**

**EXECUTION OF: ME June 11 - 2003 10:11: 32**

**PLATFORM: CLAI1ASTR.CLA.EDF**

**NB MAX PROC: 1**

**SYSTEM: OSF1**

**CPU: ALPHA**

-----  
**ASTER 7.01.07 CONCEPT res1 CALCULATES the 11/06/2003 A 10:11: 34 OF TYPE EVOL\_ELAS**

**=> Impression of the field of displacements to the nodes of the groups (points) A, B, C, D:**

**GROUP\_MA: ND\_A**

**FIELD WITH THE NODES OF REFERENCE SYMBOL DEPL**

**SEQUENCE NUMBER: 1 INST: 0.00000E+00**

**NODE DX DY**

**N1 4.68143E-06 3.74958E-24**

**GROUP\_MA: ND\_B**

**FIELD WITH THE NODES OF REFERENCE SYMBOL DEPL**

**SEQUENCE NUMBER: 1 INST: 0.00000E+00**

**NODE DX DY**

**N2 4.65280E-06 5.20865E-24**

**GROUP\_MA: ND\_C**

**FIELD WITH THE NODES OF REFERENCE SYMBOL DEPL**

**SEQUENCE NUMBER: 1 INST: 0.00000E+00**

**NODE DX DY**

**N3 1.20218E-06 -2.63963E-06**

**GROUP\_MA: ND\_D**

**FIELD WITH THE NODES OF REFERENCE SYMBOL DEPL**

**SEQUENCE NUMBER: 1 INST: 0.00000E+00**

**NODE DX DY**

**N4 3.31016E-09 -2.81696E-06**

**=> Impression of the stress field**

**FIELD BY ELEMENT WITH THE NODES OF REFERENCE SYMBOL SIGM\_ELNO\_DEPL**

**SEQUENCE NUMBER: 1 INST: 0.00000E+00**

**M37 SIXX SIYY SIZZ SIXY**

**N3 -5.13918E+03 -1.03624E+04 2.42856E+05 6.82275E+01 => Point C**

**N54 -4.40750E+03 -9.63147E+03 2.44564E+05 -4.70082E+01**  
**N55 4.14124E+03 1.04408E+04 3.02923E+05 -6.66820E+01**  
**N24 3.26306E+03 9.56344E+03 3.00873E+05 4.85536E+01**  
**M51 SIXX SIYY SIZZ SIXY**  
**N11 -3.38160E+03 4.89698E+03 9.41453E+05 2.91041E+04 => Point B**  
**N68 -2.46101E+03 3.32521E+03 9.46093E+05 2.90567E+04**  
**N10 -9.31239E+02 9.59144E+03 9.65451E+05 -3.32524E+04**  
**N2 -1.90427E+03 1.11108E+04 9.60688E+05 -3.32050E+04**  
**M111 SIXX SIYY SIZZ SIXY**

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**N110 -2.00922E+04 -1.00398E+04 9.51623E+05 2.92456E+04**  
**N50 -1.90559E+04 -1.15088E+04 9.56546E+05 2.92049E+04**  
**N1 -1.61470E+04 -4.53210E+03 9.76893E+05 -3.34251E+04 => Point A**  
**N7 -1.72353E+04 -3.11525E+03 9.71848E+05 -3.33844E+04**  
**M112 SIXX SIYY SIZZ SIXY**  
**N3 3.43073E+03 9.63409E+03 2.51426E+05 5.11140E+01 => Point C**  
**(belongs to several meshes)**  
**N25 -4.96037E+03 -1.02898E+04 1.93404E+05 5.97663E+01**  
**N111 -4.37491E+03 -9.70470E+03 1.94770E+05 -5.55617E+01**  
**N54 4.16274E+03 1.03658E+04 2.53134E+05 -6.42140E+01**

**=> a table summarizing the orders used and time CPU of each one:**

\*\*\*\*\*

**\* ORDER \* TO USE \* TOTAL SYSTEM \* \***

\*\*\*\*\*

- \* BEGINNING: 0.02: 0.03: 0.05 \***
- \* PRE\_GMSH: 0.02: 0.02: 0.03 \***
- \* LIRE\_MALLAGE: 0.02: 0.00: 0.02 \***
- \* DEFI\_GROUP: 0.02: 0.00: 0.02 \***
- \* AFFE\_MODELE: 0.02: 0.00: 0.02 \***
- \* DEFI\_MATERIAU: 0.07: 0.00: 0.07 \***
- \* AFFE\_MATERIAU: 0.00: 0.00: 0.00 \***
- \* AFFE\_CHAR\_MECA: 0.03: 0.00: 0.03 \***
- \* DEFI\_FONCTION: 0.00: 0.00: 0.00 \***
- \* AFFE\_CHAR\_MECA\_F: 0.02: 0.02: 0.03 \***
- \* MECA\_STATIQUE: 0.08: 0.03: 0.12 \***
- \* CALC\_ELEM: 0.03: 0.00: 0.03 \***
- \* IMPR\_RESU: 0.08: 0.02: 0.10 \***
- \* IMPR\_RESU: 0.03: 0.02: 0.05 \***
- \* IMPR\_RESU: 0.05: 0.00: 0.05 \***
- \* IMPR\_RESU: 0.05: 0.00: 0.05 \***
- \* IMPR\_RESU: 0.05: 0.00: 0.05 \***
- \* IMPR\_RESU: 0.17: 0.20: 0.37 \***
- \* END: 0.00: 0.03: 0.03 \***

\*\*\*\*\*

**\* TOTAL\_JOB: 0.83: 0.42: 1.25 \***

\*\*\*\*\*

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## 5

*And other files produced by calculation?*

## 5.1

*The file MESSAGE*

*This file contains the echo of the orders and gives additional information on the execution of each order:*

*for example MECA\_STATIQUE:*

```
# -----
# ORDERS NO: 0011 CONCEPT OF THE TYPE: evol_elas
# -----
res1=MECA_STATIQUE (CHAM_MATER=chmat,
MODELE=modl,
ANGLE=0,
NIVE_COUCHE=' MOY',
NUME_COUCHE=1,
SOLVEUR=_F (NPREC=8,
METHODE=' MULT_FRONT',
STOP_SINGULIER=' OUI',
RENUM=' METIS'),
INFO=1,
PLAN=' MAIL',
INST=0.0,
EXCIT= (_F (CHARGE=charg,
TYPE_CHARGE=' FIXE'),
_F (CHARGE=clim,
TYPE_CHARGE=' FIXE')),
);
```

*--- NUMBERS TOTAL NODES: 138 OF WHICH:  
12 NODES "LAGRANGE"*

*--- NUMBERS TOTAL EQUATIONS: 264*

*--- A NUMBER OF NONNULL COEFFICIENTS IN THE MATRIX: 2120*

*--- A NUMBER OF BLOCKS USE FOR STORAGE: 1*

## 5.2

*File GMSH*

*File GMSH (filled by IMPR\_RESU, format "GMSH") contains the data necessary to visualization.*

*In the same way for the other files of interface with software of graphic postprocessing (IDEAS, ENSIGHT)*

*or software of layout of curves XMGRACE.*

### 5.3

#### *Generation of the grid with GMSH*

*One proposes here the file geo allowing the generation of the grid with GMSH (software free and free).*

```
////////////////////////////////////  
// Grid of tank GMSH V1.60  
////////////////////////////////////
```

```
// Variables  
// Ray interns tank  
Rint = 1;  
// Thickness of the wall  
ep = 0.02;  
External // Ray of the tank  
Rext = Rint+ep;  
// Height of the tank  
H = 4;  
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```

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*// Numbers elements on the horizontal one*

```

nbelh= 5;
// Numbers elements on the vertical
nbelv= 20;

// Points
Not (1) = {Rint, 0,0,1};
Not (2) = {Rext, 0,0,1};
Not (3) = {Rext, 0.75*h, 0,1};
Not (4) = {Rext, H, 0,1};
Not (5) = {Rint, H, 0,1};
Not (6) = {Rint, 0.75*h, 0,1};

// Lines
Line (1) = {1,2};
Line (2) = {2,3};
Line (3) = {3,4};
Line (4) = {4,5};
Line (5) = {5,6};
Line (6) = {6,1};
Line (7) = {6,3};

// Surfaces regulated for regulated grid
Line Loop (1) = {- 2, - 1, - 6,7};
Ruled Surfaces (1) = {1};
Line Loop (2) = {3, 4, 5, 7};
Ruled Surfaces (2) = {2};

// Description of the groups of meshes/nodes (points)
Physical Not (1) = {1};
Physical Not (2) = {2};
Physical Not (3) = {3};
Physical Not (4) = {4};
Physical Not (5) = {5};
Physical Not (6) = {6};

// Description of the groups of meshes/nodes (lines)
Physical Line (11) = {1};
Physical Line (12) = {4};
Physical Line (13) = {5};
Physical Line (14) = {6};

// Description of the groups of meshes/nodes (surface)
Physical Surfaces (21) = {1,2};

```

*// Smoothness of the grid (regulated)*  
*Transfinite Line {1} = nbelh+1;*  
*Transfinite Line {4} = nbelh+1;*  
*Transfinite Line {7} = nbelh+1;*  
*Transfinite Line {5,3} = 0.25\*nbelv+1;*  
*Transfinite Line {2,6} = 0.75\*nbelv+1;*

*Transfinite Surfaces {1} = {3,6,1,2};*  
*Transfinite Surfaces {2} = {3, 4, 5, 6};*

*// Passage triangles->quadrangles*  
*Recombine Surface {1,2};*

*GMSH will generate the groups of meshes 1 to 6 (points), 11 to 14 (lines) and 21 groups it (surface).*

*These groups of meshes are recovered in Code\_Aster with name GM## where ## is the number of group GMSH.*

*In our example, we redefine these names by DEFI\_GROUP to have a name of it more convenient (SUPPORT, LFA, LDE).*

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*Organization (S): EDF-R & D /AMA*

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***Document: U1.05.01***

***An example of use of Code\_Aster:  
calculation of a bent pipe***

***Summary:***

***This document describes a simple example of use of Code\_Aster which is provided with the procedure***

*of  
remote loading of Code\_Aster since the code-aster.org site.*

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*1  
Facts of the case*

*1.1 Geometry*

*The study relates to a piping including/understanding two right pipes and an elbow [Figure 1.1-a].*

*The geometrical data of the problem are as follows:*

- .  
length LG of the two right pipes is 3 m,*
- .  
the Rc ray of the elbow is 0.6 m,*
- .  
the angle of the elbow is 90 degrees,*
- .  
the thickness of the right pipes and the elbow is 0.02 m,*
- .  
and the ray external Re of the right pipes and the elbow is of 0.2 Mr.*

*LG*

**D**  
**B**  
*section D*  
*section B*  
**RC**  
**C**  
**O**  
*section C*  
**Z**  
**Y**  
**E**  
**L**  
**Z**  
**G**  
**X**  
**Re**  
**X**  
**With**  
*section A*

*Appear 1.1-a*

*Note:*

*The geometry of the problem has a symmetry compared to the plan (A, X, Y).*

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## ***1.2 Loading***

***The boundary conditions are as follows:***

***there is embedding on the level of section A,***

***The loading applied is a constant force  $FY = 100.000$  NR directed according to the axis Y and applied to the section B,***

## ***1.3 Characteristics material***

***The properties of material are those of A42 steel:***

***the Young modulus  $E = 204.000. E+6$  N/m<sup>2</sup>,***

***the Poisson's ratio = 0.3.***

## ***2 Modeling of the problem***

***One can model the problem by elements of hull DKT.***

### ***2.1 Grid GMSH***

***In the case of modeling in elements hulls, the grid consists of the discretization of surface average piping. Geometry being symmetrical compared to the plan (A, X, Y), one will net that a half surfaces. The grid will have to be sufficiently fine to obtain a solution specify (elements DKT with 3 nodes having an interpolation of order 1 out of membrane).***

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Version  
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***Titrate:***

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**18/05/05**

**Author (S):**

**Mr. ABBAS, J.M. PROIX Key**

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**We propose the file geo GMSH producing this grid:**

**////////////////////////////////////**

**// Grid of the pipe bent for gmsH 1.60**

**////////////////////////////////////**

**// Variables**

**Rext = 0.2;**

**Ep = 0.02;**

**Rm = Rext - (Ep/2.);**

**RC = 0.6;**

**LG = 3.0;**

**H = 0.04;**

**Not (1) = {RC, LG, 0. , H};**

**Not (2) = {RC, LG, 0.1, H};**

**Not (3) = {(- 1\*Rm), 0, 0, H};**

**Not (4) = {0, 0, Rm, H};**

**Not (5) = {Rm, 0, 0, H};**

**Not (6) = {0, 0, 0, H};**

**Circle (1) = {3,6,4};**

**Circle (2) = {4,6,5};**

**// 1st right pipe**

**Extrude Line {2, {0, LG, 0}}**

**{Layers {50,90,1};};**

**Extrude Line {1, {0, LG, 0}}**

**{Layers {50,91,1};};**

**// Bends**

**Extrude Line {3, {0,0,1}, {RC, LG, 0.}, - (Pi/2)}**

**{Layers {30,93,1};};**

**Extrude Line {7, {0. , 0. , 1.}, {RC, LG, 0.}, - (Pi/2)}**

**{Layers {30,94,1}; };**

**// 2nd right pipe**

**Extrude Line {11, {LG, 0,0}}**

**{Layers {50,95,1}; Recombine; };**

**Extrude Line {15, {LG, 0,0}}**

**{Layers {50,96,1}; Recombine; };**

**Coherence;**

**Physical Line (27) = {2,1};**

**Physical Line (28) = {23,19};**

**Physical Line (29) = {24,16,8,5,13,21};**

**Physical Surfaces (30) = {90,91,93,94,95,96};**

**Physical Not (31) = {3};**

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**2.2 Orders**

**Aster**

**The right pipes and the elbow will be modelled by elements of hull (DKT).**

**Piping is embedded in its base, on all the nodes located in the  $Y=0$  plan. Piping present a symmetry plane  $Z=0$ .**

**.**

**An effort distributed  $F^*$  directed according to the axis  $Y$  and applied to the section  $B$ , (the effort**

*distributed is such as*

*2 Rmoy  $F^*$  = the total force which one wishes to apply).*

*One will calculate the stress field by element to nodes (SIGM\_ELNO\_DEPL), for each loading case. To use NIVE\_COUCHE to define the level of calculation in the thickness*

*The principal stages of calculation with Aster are:*

.

*Grid.*

.

*Definition of the finite elements used (AFFE\_MODELE).*

*One will use the groups of meshes resulting from the grid.*

.

*Definition and assignment of material (DEFI\_MATERIAU and AFFE\_MATERIAU).*

*The mechanical characteristics are identical on all the structure.*

.

*Assignment of the characteristics of the elements hulls (AFFE\_CARA\_ELEM) with in particular the thickness and the vector  $V$  defining the reference mark of examination (key word ANGL\_REP).*

*One can take for example  $V=Oz$ .*

.

*Definition of the boundary conditions and loadings (AFFE\_CHAR\_MECA).*

.

*Resolution of the elastic problem for each loading case (MECA\_STATIQUE).*

*Calculation of the stress field by elements to the nodes for each loading case (option "SIGM\_ELNO\_DEPL").*

.

*Impression of results (IMPR\_RESU).*

*One will print in form listing average displacement on the section B as well as the values maximum of the tensor of constraints.*

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**2.3**

**Orders with the magnifying glass**

**We now will detail the orders necessary to the realization of calculation considered.**

**Command file**

**Explanations**

**# TITRATES PIPING COMPRISING AN ELBOW**

**The comments are preceded by sign #,**

**# MODELING BY ELEMENTS HULLS DKT**

**# PRODUCES BY GMSH**

**BEGINNING ();**

**Obligatory order to start...**

**PRE\_GMSH ();**

**The grid is with format GMSH**

**EMAIL = LIRE\_MAILLAGE ();**

**Reading of the grid in the file of grid,**

**and creation of the concept EMAIL containing it**

**grid with the format Aster**

**# Definition of the finite elements used**

**A model is a concept containing the types**

**finite elements useful for calculation**

**MODMECA=AFFE\_MODELE (MAILLAGE=MAIL,**

**Associate the meshes of the grid of the groups**

**GM30 and GM28**

***AFFE=\_F (GROUP\_MA= ("GM30", "GM28"),***

***PHENOMENE=' MECANIQUE',***

***MODELISATION=' DKT',),);***

***with mechanical finite elements of hull type***

***DKT***

***# Orientation of the normals to the hulls***

***returning in the GM30***

***MAIL=MODI\_MAILLAGE (reuse =MAIL,***

***To modify the grid EMAIL***

***MAILLAGE=MAIL,***

***ORIE\_NORM\_COQUE=\_F (***

***by directing the normals***

***GROUP\_MA=' GM30',***

***group GM30***

***VECT\_NORM= (1.0, 0.0, 0.0), according to the normal (1,0,0)***

***GROUP\_NO=' GM31',),***

***defined on node GM31***

***MODELE=MODMECA,);***

***On model MODMECA***

***# Definition of material***

***ACIER=DEFI\_MATERIAU (ELAS=\_F (E=204000000000.0, characteristics of each material  
constituting the grid are provided***

***NU=0.3,));***

***Young modulus and Poisson's ratio***

***CHMAT=AFFE\_MATERIAU (MAILLAGE=MAIL,  
On the grid EMAIL***

***AFFE=\_F (TOUT=' OUI',***

***and on all the meshes***

***MATER=ACIER,)); the material STEEL is affected***

## **# Characteristic of the hulls**

**CARA\_COQ=AFFE\_CARA\_ELEM (**

*The elementary characteristics are changed*

**MODELE=MODMECA,**

*On model MODMECA*

**COQUE=\_F (**

*hulls*

**GROUP\_MA= (“GM30”, “GM28”), defined in groups GM30 and GM28**

**EPAIS=0.02,**

*by a thickness of hull of 0.2*

**ANGL\_REP= (0.0, 90.0,,),); with a local reference mark (useful in postprocessing)**

## **# Definition of the boundary conditions**

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**BLOCAGE=AFFE\_CHAR\_MECA (MODELE=MODMECA,**

*For model MODMECA*

**DDL\_IMPO= (**

***\_F (GROUP\_MA=' GM27',  
Nodes of the group of meshes GM27  
DX=0.0,  
are embedded  
DY=0.0,  
DZ=0.0,  
DRX=0.0,  
DRY=0.0,  
DRZ=0.0,)  
\_F (GROUP\_MA=' GM29',  
and the nodes of the group of meshes GM29 are  
DZ=0.0,  
such as DZ=0, DRX=0 and DRY=0  
DRX=0.0,  
DRY=0.0,)),);***

***# Definition of the loading***

***FYTOT = 100000.0;  
Definition of the constant total force  
EPTUB = 0.02;  
Definition constant thickness of the tube  
REXT = 0.2;  
Definition of constant the ray external of  
tube***

***RMOY=REXT - EPTUB/2  
Calculation of the average radius of the tube***

***FYREP=FYTOT/2. /PI/RMOY  
Calculation of the total force to apply***

***CHARG1=AFPE\_CHAR\_MECA (MODELE=MODMECA,  
Assignment on model MODMECA  
FORCE\_ARETE=\_F (GROUP\_MA=' GM28',  
Of a force on edge GM28  
FY=FYREP,)),);  
of value FYREP***

***# Resolution  
Total ordering of resolution of the problems***

*statics in thermo linear elasticity*

**RESU1=MECA\_STATIQUE (**

*RESU1 is the name of the concept result*

**MODELE=MODMECA**

*Model MODMECA*

**CHAM\_MATER=CHMAT,**

*The material CHMAT field*

**CARA\_ELEM=CARA\_COQ,**

*Elementary characteristics (hulls)*

**CARA\_COQ**

**EXCIT= (\_F (CHARGE=BLOCAGE),),**

*The conditions limit BLOCKING*

**\_F (CHARGE=CHARG1,)),);**

*Loading CHARG1*

**# Calculation of the constraints**

**RESU1=CALC\_ELEM (reuse =RESU1,**

*reuse=RESU1 means that one “enriches” it  
concept*

**OPTION=' SIGM\_ELNO\_DEPL',**

*on model MODMECA*

**RESULTAT=RESU1,);**

*with the material CHMAT field*

*and elementary characteristics CARA\_COQ*

*one calculates meaning “SIGM\_ELNO\_DEPL”*

*“forced calculated with the nodes of each*

*element starting from displacements”*

**# Impression of the results for visualization**

**with GMSH**

**DEFI\_FICHER (ACTION=' ASSOCIER',**

*Definition of the logical unit for file GMSH*

**UNITE=37,)**

**IMPR\_RESU (MODELE=MODMECA,  
Results are printed  
FORMAT=' GMSH', UNITE=37,  
coming from model MODMECA  
RESU=\_F (RESULTAT=RESU1,  
the results are  
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**NOM\_CHAM= (“DEPL”,  
with format GMSH  
“SIGM\_ELNO\_DEPL”,),)  
and are displacements  
)  
printed in the logical unit associated the file  
“POST”**

**and come from RESU1**

**with format GMSH**

**and are the constraints with the nodes**

**printed in the logical unit associated the file  
“POST”**

**and come from RESU1**

**DEFI\_FICHER (ACTION=' LIBERER',  
Closing of the logical unit  
UNITE=37)**

**# To create a group**

**MAIL=DEFI\_GROUP (  
A new group  
reuse =MAIL,  
reuse=MAIL means that one “  
enriches” it  
concept grid  
MAILLAGE=MAIL,  
From the grid EMAIL  
CREA\_GROUP\_NO=\_F (  
one creates a group nodes  
GROUP\_MA=' GM28',,));  
coming from meshes GM28  
# To create a table**

**TABDEP1=POST\_RELEVE\_T (ACTION=\_F (  
One creates a table TABDEP1 in postprocessing  
INTITULE=' DEPBI',  
whose name is “DEPBI”  
GROUP\_NO=' GM28',  
who is based on group GM28  
RESULTAT=RESUI,  
and on results RESUI  
NOM\_CHAM=' DEPL',  
displacements are wanted  
TOUT\_CMP=' OUI',  
for all the components  
OPERATION=' MOYENNE',,));  
and the average  
# To print a table**

**IMPR\_TABLE (TABLE=TABDEP1,  
table TABDEP1 is printed  
FILTRE=\_F (NOM\_PARA=' QUANTITE',  
the quantity is wanted  
CRIT\_COMP=' EQ',  
who is worth exactly**

*VALE\_K=' MOMENT\_0'),  
moment of order 0  
NOM\_PARA=' DY',);  
on displacement following y*

*END ();*

*...*

*Obligatory order to close an execution*

### *3 Visualization using GMSH*

*With version 7.4 of Code\_Aster, the direct impression of the results to format GMSH is possible. One will print on file SIGM of logical number of unit 37 constraints (component SIYY only) for postprocessing with GMSH. This component represents in fact the component axial all along piping (because of the orientation chosen in AFFE\_CARA\_ELEM):*

```
IMPR_RESU (MODELE=MODMECA,  
FORMAT=' GMSH',  
UNITE=37,  
RESU= ( _F (RESULTAT=RESU1,  
NOM_CHAM=' SIGM_ELNO_DEPL',  
NOM_CMP= ("SIXX", "SIYY"),  
)  
)  
)
```

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**4**

***Comparison of the results obtained***

***The results obtained by this modeling can be compared with those obtained by others modeling of the same problem:***

***For the loading of force constant FY applied to the section B, one compares displacement at the point B for various modelings.***

***The following table gives, for various modelings, of the indicative values obtained for average refinements of the grids:***

***Loading forces constant FY***

***Modeling DX***

***DY***

***DRZ***

***beam flexibility = 1***

***2.657E02***

***6.702E02***

***2.097E02***

***beam flexibility RCCM***

***2.983E02***

***1.156E01***

***3.530E02***

***pipe 2.935E02***

***1.083E01***

***3.326E02***

***Hull (average displacement)***

***2.891E02***

***1.053E01***

***3.242E02***

***3D (average displacement)***

***2.907E02***

***1.065E01***

**-**

***The following graph introduces the deformation and the isovaleurs of axial stresses visualized using GMSH.***

***1.056e-01***  
***0.000e+00***  
***DEPL***  
***1.659e+08***  
***-1.719e+08***  
***SIGM\_ELNO\_DEPL\_SIYY***

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*Version*

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*Titrate:*

*Note of use of the boundary conditions treated by elimination*

*Date:*

22/01/02

*Author (S):*

**J. Key PELLET**

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*Organization (S): EDF/AMA*

***Instruction manual***

***U2.01 booklet: General concepts***

***Document: U2.01.02***

***Note of use of the boundary conditions  
treated by elimination***

***Summary***

***The treatment of the boundary conditions of the type Dirichlet value of ddl imposed by elimination does not offer***

*even flexibility that by dualisation. This treatment is to be used when one seeks to improve times of execution of a calculation (although at present, the profit is not guaranteed) or if one wishes to use positive definite matrices of rigidity.*

*Let us note that all the types of boundary conditions available in AFFE\_CHAR\_\* (\* = meca/ther/acou) cannot be eliminated and treated by AFFE\_CHAR\_CINE.*

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*1*

*Principle of elimination used*

*One seeks to solve in RN the problem of minimization under constraint (Pb1) according to:*

*Min  $1 C Ku - C F$  with:  $U = U RN, U$*

*= U*

*G*

*0*

*2*

*G*

*U UG*

*where*

*uo RP is known (Ipn)*

*.*

*$G$  is the subset of  $NR = \{1, \dots\}$*

*$N$ , of cardinal  $p$ :  $G = G$*

*$G$*

*$1 \dots$*

*$p$*

*$\cdot$*

*$U$*

*$uI$*

*$I iG$*

*$G$  is the projection of  $U$  on under space generated by*

*$\cdot$*

*where  $(ui) J = ij jN$*

*$\cdot$*

*$K$  is a symmetrical matrix  $N \times N$ ,*

*$\cdot$*

*$F RN$  is fixed.*

*The constraint  $uI = U$*

*$G$*

*0 or not represent boundary conditions of the homogeneous Dirichlet type.*

*If one notes  $L = C G$ ,*

*$NR$*

*the complementary one to  $G$  in  $NR$ , one can, using the previously definite  $ui$ ,*

*$U$*

*to break up  $RN$  all in all direct of  $VG =$  vector space generated by  $I iG$  and of  $VL =$  space*

*$U$*

*vectorial generated by  $I$  it;*

*Consequently, we have  $RN = VG VL$*

*and one notes  $U = uG uL$  where  $uG = uI$  and  $U$*

*$G$*

*$L = uIL$*

*$uG$*

*that is to say still in vectorial notation  $U = U$*

*$L$*

*The problem (Pb1) can thus be written in the form of the problem (Pb2):*

*Min  $1 C K$*

*$U + 1 C K$*

*$U + C K$*

*$U - C F - C F$*

**G**  
**GG**  
**G**  
**L**  
**LL**  
**L**  
**L**  
**LG**  
**G**  
**L**  
**L**  
**G**  
**G**  
**2**  
**2**  
**UV**  
**G**  
**G**

**UV**  
**L**  
**L**  
**U = U**  
**G**  
**0**

***What amounts writing (by supposing that  $K$  is definite positive)***

**GG**

***Min 1 C K***

***U + C K***

***U - C F***

**L**

**LL**

**L**

**L**

**LG**

**0**

**L**

**L**

**2**

***(Pb1) (Pb3) U V***

**L**

**L**

$U = U U$   
 $0$   
 $1$

*One then eliminated U from the problem of minimization.*

**G**  
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*We now will seek the matric problem associated with (Pb3).*

*One seeks U minimizing*  
**L**

$1 C K U + C K U - C F$   
**L**  
**LL**  
**L**  
**L**  
**LG**  
**0**  
**L**  
**L**  
**2**

*what amounts solving the following matric problem:*

**K**



$$U = F - K$$

$U$

$LL$

$L$

$L$

$LG$

$0$

*One can thus write:*

$uL$

$K$

$0$

$F$

$-K$

$U$

$(Pb1)$

$U$

$L$

$LG$

$0$

$U$

$(Pb2) (Pb3)$

$LL$

$L =$

$, G = f' \text{ is } K'$

$U$

$0$

$I$

$G$

$U$

$G$

$0$

## *2 Treatment*

*in*

*Aster*

### *2.1*

*The loads kinematics*

*A kinematic load (standard Aster: char\_cine\_\* [\* = meca/ther/acou]) makes it possible to characterize the unit G of the imposed ddl and them (u0) I for I G which are the values assigned to these ddl.*

*The definition of a kinematic load is done via operator AFFE\_CHAR\_CINE for (u0) I constant or functions of the geometry or time.*

## 2.2

*The vectors kinematics*

0

*The vectors kinematics are*

U

*cham\_no\_\* which represents the vectors*

0

*stored in*

*the order of classification under unclaimed to the problem.*

*With each kinematic load corresponds a kinematic vector.*

*This operation is carried out by operator CALC\_CHAR\_CINE.*

## 2.3

*Calculation of K'*

*K' is directly calculated at the assembly time by operator ASSE\_MATRICE provided naturally that one provides in argument a list of loads kinematics.*

*The structure of data MATR\_ASSE\_\* was modified in order to be able to store K' when that is necessary.*

## 2.4

*Calculation of f'*

*Operator FACT\_LDLT not being modified, the concept of the produced matr\_asse\_\* type, contains factorized of K' and the unchanged matrix K.*

LG

*The calculation of f' is carried out at the time of the resolution: it is necessary to provide to operator RESO\_LDLT in*

0

*argument the kinematic vector corresponding to u0 via key word CHAM\_CINE.*

uL

*This operator calculates then*

U

*f' before solving fact (K')*

*G = f'.*

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**3**

**Examples of command files**

**3.1 In**

**using**

**FACT\_LDLT and RESO\_LDLT:**

**BEGINNING (CODE: (NAME: "SSLV101AC") CALCULATION: "LARGE");**

**MA =LIRE\_MAILLAGE ();**

**MO =AFFE\_MODELE (GRID: MA,  
AFFE: (ALL: "YES", PHENOMENON: "MECHANICAL",  
MODELING: "3D"));**

**CHECHMATE =DEFI\_MATERIAU (ELAS: (E: 202702.7, NAKED: 0.3)  
THER: (LAMBDA: 2.7 CP: 0.3));**

**CHMAT =AFFE\_MATERIAU (GRID: MA,  
AFFE: (ALL: "YES", MATER: CHECHMATE));**

**%**

=====  
**CHCINE = AFFE\_CHAR\_CINE (MODEL: MO  
MECA\_IMPO: (GROUP\_NO: GRNO7, DX: 0.0, DY: 0.01)  
(GROUP\_NO: GRNO1, DZ: 0.0)  
(GROUP\_NO: GRNO8, DY: 0.0));**

**%**

```
=====
MEL =CALC_MATR_ELEM (MODEL: MO CHAM_MATER: CHMAT OPTION: "RIGI_MECA");

NAKED = NUME_DDL (MATR_RIGI: MEL);

MATASS = ASSE_MATRICE (MATR_ELEM: MEL, NUME_DDL: NAKED
CHAR_CINE: CHCINE);

VECASS = AFFE_CHAM_NO (GRID: MA SIZE: "DEPL_R"
NUME_DDL: NAKED
AFFE: (ALL: "YES",
NOM_CMP: ("DX", "DY", "DZ")
VALE_R: (0. , 0. , 0. )) );
%
=====
VCINE = CALC_CHAR_CINE (NUME_DDL: NAKED CHAR_CINE: CHCINE);
%
=====
&MATASS = FACT_LDLT (MATR_ASSE: MATASS);

&VECASS = RESO_LDLT (MATR_FACT: MATASS CHAM_NO: VECASS CHAM_CINE: VCINE);

IMPR_RESU (MODEL: MO
RESU: (FILE: "RESULT"
CHAM_GD: VECASS));
END ();
```

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---

*Code\_Aster* ®  
*Version*  
*6.2*

*Titrate:*  
*Note of use of the boundary conditions treated by elimination*  
*Date:*  
*22/01/02*  
*Author (S):*  
*J. Key PELLET*  
*:*  
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### 3.2 In using MECA\_STATIQUE

**BEGINNING (code: (NAME: "SSLX100A"));**

**my = LIRE\_MAILLAGE ();**

**Mo = AFFE\_MODELE (Grid: my,  
Affe: (Mesh: HE1,  
Phenomenon: "MECHANICAL", Modeling: "3D")  
(Group\_ma: GRMA1,  
Phenomenon: "MECHANICAL", Modeling: "DKT")  
(Group\_ma: GRMA2,  
Phenomenon: "MECHANICAL", Modeling: "POU\_D\_E"));**

**chechmate = DEFI\_MATERIAU (Elas: (E: 2.E5 Naked: 0.3 Alpha: 0.));**

**chma = AFFE\_MATERIAU (Grid: my Affe: (All: "YES" MATER: chechmate));**

**= AFFE\_CARA\_ELEM (Model will cara: Mo,  
Hull: (Group\_ma: GRMA1, Thick: 1.)  
Beam: (Group\_ma: GRMA2,  
Section: "RIGHT-ANGLED",  
CARA: ("HZ", "HY"), VALE: (3. , 1.));**

**chci = AFFE\_CHAR\_cine (Model: Mo,  
meca\_impo: (Group\_no: GRNO1 Dx: 0. Dy: 0. Dz: 0.)  
(Node: (N10, N11, N26, N23) Dz: 0.));**  
**chme = AFFE\_CHAR\_MECA (Model: Mo,  
Liaison\_ddl:  
(Node: (N4, N21)  
Ddl: ("DX", "DX")  
Coef\_mult: (1. , - 1.)  
Coef\_impo: 0.)  
(Node: (N4, N21)  
Ddl: ("DY", "DY")  
Coef\_mult: (1. , - 1.)  
Coef\_impo: 0.)  
(Node: (N4, N21)  
Ddl: ("DZ", "DZ")  
Coef\_mult: (1. , - 1.)  
Coef\_impo: 0.)  
(Node: (N16, N25)  
Ddl: ("DX", "DX"))**

**Coef\_mult:** (1. , - 1.)  
**Coef\_impo:** 0.)  
**(Node:** (N16, N25)  
**Ddl:** (“DY”, “DY”)  
**Coef\_mult:** (1. , - 1.)  
**Coef\_impo:** 0.)  
**(Node:** (N16, N25), **Ddl:** (“DZ”, “DZ”)  
**Coef\_mult:** (1. , - 1.)  
**Coef\_impo:** 0.)  
**(Node:** (N5, N21)  
**Ddl:** (“DX”, “DRZ”)  
**Coef\_mult:** (1. , 0.5)  
**Coef\_impo:** 0.)  
**(Node:** (N17, N25)  
**Ddl:** (“DX”, “DRZ”)  
**Coef\_mult:** (1. , 0.5)  
**Coef\_impo:** 0.)  
**(Node:** (N11, N26)  
**Ddl:** (“DX”, “DRZ”)  
**Coef\_mult:** (1. , 0.5)  
**Coef\_impo:** 0.)  
**(Node:** (N3, N21)  
**Ddl:** (“DX”, “DRZ”)  
**Coef\_mult:** (1. , - 0.5)  
**Coef\_impo:** 0.)  
**(Node:** (N15, N25)  
**Ddl:** (“DX”, “DRZ”)  
**Coef\_mult:** (1. , - 0.5)  
**Coef\_impo:** 0.)  
**(Node:** (N10, N26)  
**Ddl:** (“DX”, “DRZ”)  
**Coef\_mult:** (1. , - 0.5)  
**Coef\_impo:** 0.)  
**(Node:** (N22, N23)  
**Ddl:** (“DRZ”, “DRZ”)  
**Coef\_mult:** (1. , - 1.)  
**Coef\_impo:** 0.)  
**(Node:** (N23, N24)  
**Ddl:** (“DRZ”, “DRZ”)  
**Coef\_mult:** (1. , - 1.)  
**Coef\_impo:** 0.)  
**Force\_nodale:** (Node: N29, Fy: - 1.)  
**Impr:** 0);

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**EPD = MECA\_STATIQUE (Model: Mo**

**Cham\_mater: chma**

**Cara\_elem: will cara**

**EXCIT: (Load: chme)**

**EXCIT: (Load: chci));**

**&dep = CALC\_ELEM (Model: Mo**

**Result: EPD**

**Cham\_mater: chma**

**Option: "EFGE\_ELNO\_DEPL"**

**Cara\_elem: will cara**

**Tout\_ordre: "YES");**

**&dep = CALC\_ELEM (Model: Mo**

**Result: EPD**

**Cham\_mater: chma**

**Option: "SIGM\_ELNO\_DEPL"**

**Cara\_elem: will cara**

**Tout\_ordre: "YES");**

**dep1 = RECU\_CHAMP (Result: EPD Nom\_cham: "DEPL" NUME\_ORDRE: 1);**

**IMPR\_RESU (Model: Mo Resu: (Result: EPD));**

**END ();**

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***Code\_Aster*** ®

***Version***

***7.3***

***Titrate:***

***Documentation of the sizes of Code\_Aster***

***Date:***

***02/06/04***

***Author (S):***

***J.M. PROIX, J. Key PELLET***

***:***

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***Organization (S): EDF-R & D /AMA***

***Instruction manual***

***U2.01 booklet: General concepts***

***Document: U2.01.04***

***Documentation of the sizes of Code\_Aster***

***Summary:***



*Description of the sizes associated with the fields being able to be created by the orders of Code\_Aster.*

*This document is an extract “user” of the document [D4.04.02].*

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*The following table has three columns. The name of the sizes appears in the left-hand column (classified by alphabetical order).*

*Each size is separated from following by a white line.*

*On the first line of a size, one finds the type of this size (reality: R, complex: C,...)*

*One lists then the names of the components of this size (column 2) and one makes a small comment on each one of them.*

***CORR\_R***

*Type: R*

*Corrosion*

***CORR\_R***

*CORR*

*Corrosion*

***CRRU\_R***

*Type: R*

***Criteria of rupture for the composite multi-layer hulls***

***CRRU\_R***

***SIGL***

***Constraint according to 1st dir. orthotropism***

***CRRU\_R***

***SIGT***

***Constraint according to the 2nd direction of orthotropism***

***CRRU\_R***

***SIGLT***

***Shear stress***

***CRRU\_R***

***CRIL***

***Criterion of rupture according to 1st dir. orthotropism***

***CRRU\_R***

***CRIT***

***Criterion of rupture according to the 2nde to dir. orthotropism***

***CRRU\_R***

***CRILT***

***Criterion of rupture in shearing following LT***

***CRRU\_R***

***CRITH***

***Criterion of Tsai-Hill***

***DBEL\_R***

***Type: R***

***Acoustic decibel***

***DBEL\_R***

***DB***

***decibel***

***DEPL\_C***

***Type: C***

***See DEPL\_R***

***DEPL\_R***

***Type: R***

***Displacement (unknown for the mechanical phenomenon)***

***DEPL\_R***

***DX***

***translation according to OX***

**DEPL\_R**

**DY**

*translation according to OY*

**DEPL\_R**

**DZ**

*translation according to OZ*

**DEPL\_R**

**DRX**

*rotation around OX*

**DEPL\_R**

**DRY**

*rotation around OY*

**DEPL\_R**

**DRZ**

*rotation around OZ*

**DEPL\_R**

**GRX**

*warping (for an element of beam)*

**DEPL\_R**

**NEAR**

*ddl of pressure*

**DEPL\_R**

**TEMP**

*ddl of temperature*

**DEPL\_R**

**PHI**

*angle of cracking*

**DEPL\_R**

**DH**

*hydraulic diameter*

**DEPL\_R**

**GONF**

*swelling for the quasi-incompressible elements*

**DEPL\_R**

**UI2**

*warping and ovalization in mode2 for the pipes*

**DEPL\_R**

**VI2**

*warping and ovalization in mode2 for the pipes*

**DEPL\_R**

**WI2**

*warping and ovalization in mode2 for the pipes*

**DEPL\_R**

...

...

**DEPL\_R**

**UI3**

*warping and ovalization in mode3 for the pipes*

**DEPL\_R**

**VI3**

*warping and ovalization in mode3 for the pipes*

**DEPL\_R**

**WI3**

*warping and ovalization in mode3 for the pipes*

**DEPL\_R**

...

...

**DEPL\_R**

**D1**

*projection of the translation on vector D1X, D1Y, D1Z*

**DEPL\_R**

**D2**

*projection of the translation on vector D2X, D2Y, D2Z*

**DEPL\_R**

**D3**

*projection of the translation on vector D3X, D3Y, D3Z*

**DEPL\_R**

*D1X, D1Y, components according to X Y Z of a vector (see D1)*

**D1Z**

**DEPL\_R**

*D2X, D2Y, components according to X Y Z of a vector (see D2)*

**D2Z**

**DEPL\_R**

*D3X, D3Y, components according to X Y Z of a vector (see D3)*

**D3Z**

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**DOMMAG**

**Type: R**

**Field of damage on a structure**

**DOMMAG**

**DOMA**

**value of the damage**

**DOMMAG**

**TRIAX value of the rate of triaxiality**

**DOMMAG**

**SI\_ENDO value of the constraint of damage of Lemaître-Sermage**

**DOMMAG**

**COENDO value of the constraint of damage of Lemaître-Sermage standardized**

**DOMMAG**

**DOM\_LEM value of the damage of Lemaître-Sermage**

**DOMMAG**

**D\_CUMULE value of the damage of cumulated Lemaître-Sermage**

**DURT\_R**

**Type: R**

**Initialization of the calculation of hardness associated with the metallurgy**

**DURT\_R**

**HV**

**value of hardness**

**ENER\_R**

**Type: R**

**Energy**

**ENER\_R**

**TOTAL**

**total energy of the element**

**ENER\_R**

**TRAC\_COM**

**energy in traction and compression**

***ENER\_R***

***TORSION***

***energy in torsion***

***ENER\_R***

***MEMBRANE***

***energy out of membrane***

***ENER\_R***

***INFLECTION***

***energy in inflection***

***ENER\_R***

***FLEX\_Y***

***energy in inflection Y***

***ENER\_R***

***FLEX\_Z***

***energy in inflection Z***

***ENER\_R***

***PLAN\_XY***

***energy in plan XY***

***ENER\_R***

***PLAN\_XZ***

***energy in plan XZ***

***ENER\_R***

***DX***

***energy according to DX***

***ENER\_R***

***DY***

***energy according to DY***

***ENER\_R***

***DZ***

***energy according to DZ***

***ENER\_R***

***DRX***

***energy according to DRX***

***ENER\_R***

***DRY***

***energy according to DRY***

***ENER\_R***

***DRZ***

***energy according to DRZ***

***EPSI\_R***

***Type: R***

***Deformation***

**EPSI\_R**  
**EPXX**  
*xx deformation of a continuous medium*  
**EPSI\_R**  
**EPYY**  
*yy deformation of a continuous medium*  
**EPSI\_R**  
**EPZZ**  
*zz deformation of a continuous medium*  
**EPSI\_R**  
**EPXY**  
*xy deformation of a continuous medium*  
**EPSI\_R**  
**EPXZ**  
*xz deformation of a continuous medium*  
**EPSI\_R**  
**EPYZ**  
*yz deformation of a continuous medium*  
**EPSI\_R**  
**EXX**  
*hull: generalized deformations*  
**EPSI\_R**  
**EYY**  
*hull: generalized deformations*  
**EPSI\_R**  
**EXY**  
*hull: generalized deformations*  
**EPSI\_R**  
**KXX**  
*hull: generalized deformations*  
**EPSI\_R**  
**KYY**  
*hull: generalized deformations*  
**EPSI\_R**  
**KXY**  
*hull: generalized deformations*  
**EPSI\_R**  
**GAX**  
*hull: generalized deformations*  
**EPSI\_R**  
**GAY**  
*hull: generalized deformations*  
**EPSI\_R**  
**EPX**

*beam: elongation according to the axis of the beam*

*EPSI\_R*

*KY*

*beam: curve according to the axis Y*

*EPSI\_R*

*KZ*

*beam: curve according to axis Z*

*EPSI\_R*

*INVA\_2*

*second invariant of the tensor of deformation*

*EPSI\_R*

*PRIN\_1*

*principal deformation of the tensor direction 1*

*EPSI\_R*

*PRIN\_2*

*principal deformation of the tensor direction 2*

*EPSI\_R*

*PRIN\_3*

*principal deformation of the tensor direction 3*

*EPSI\_R*

*INVA\_2SG*

*second signed invariant of the tensor of deformation*

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**ERROR**

**Type: R**



*Error analysis in mechanics with the method of the residues*

**ERROR**

**ERREST**

*absolute error estimated on the element*

**ERROR**

**NUEST**

*relative error estimated on the element*

**ERROR**

**SIGCAL**

*energy of the constraints normalizes on the element*

**ERRETEMP**

**Type: R**

*Error analysis in thermics with the method of the residues*

**ERRETEMP**

**ERTABS**

*absolute error estimated on the element*

**ERRETEMP**

**ERTREL**

*relative error estimated on the element*

**ERRETEMP**

**FOR THE THIRD TIME...**

*various terms contributing to the total error [R4.10.03]*

**FACY\_R**

**Type: R**

*Size related to tiredness with great numbers of cycles, multiaxial loading*

**FACY\_R**

*DTAUM1 first value of the half-amplitude max of shearing in the critical plan*

**FACY\_R**

*VNMIX, Y, Z components of the normal vector in the plan criticizes correspondent with dtaum1*

**FACY\_R**

**SINMAX1**

*normal maximum constraint in the plan criticizes correspondent with dtaum1*

**FACY\_R**

**SINMOY1**

*normal average constraint in the plan criticizes correspondent with dtaum1*

**FACY\_R**

**EPNMAX1**

*normal maximum deformation in the plan criticizes correspondent with dtaum1*

**FACY\_R**

**EPNMOY1**

*normal average deformation in the plan criticizes correspondent with dtaum1*

**FACY\_R**

**SIGEQ1**

*equivalent constraint associated dtaum1*

**FACY\_R**

**NBRUP1**

*a number of cycles before rupture, function of sigeq1 and a curve of Wöhler*

**FACY\_R**

**ENDO1**

*damage associated with nbrup1 (endo1=1/nbrup1)*

**FACY\_R**

*DTAUM2 second value of the half-amplitude max of shearing in the critical plan*

**FACY\_R**

*VNM2X, Y, Z components of the normal vector in the plan criticizes correspondent with dtaum2*

**FACY\_R**

...

...

**FACY\_R**

**ENDO2**

*damage associated with nbrup2 (endo2=1/nbrup2)*

**FLUX\_R**

**Type: R**

*Vectorial flow of heat in a material point of the continuous field*

:

**= - T**

**FLUX\_R**

**FLOW**

*component according to OX of*

**FLUX\_R**

**FLUY**

*component according to OY of*

**FLUX\_R**

**FLUZ**

*component according to OZ of*

**FLUX\_R**

**FLUX\_SUP**

*flow on a point of the higher face of the hulls*

**FLUX\_R**

**FLUY\_SUP**

*flow on a point of the higher face of the hulls*

**FLUX\_R**

**FLUZ\_SUP**

*flow on a point of the higher face of the hulls*

**FLUX\_R**

**FLUX\_INF**

*flow on a point of the lower face of the hulls*

**FLUX\_R**

**FLUY\_INF**

*flow on a point of the lower face of the hulls*

**FLUX\_R**

**FLUZ\_INF**

*flow on a point of the lower face of the hulls*

**G**

*Type: R*

*Rate of refund of energy and coefficients of intensity of constraints*

**G**

**GTHETA**

*rate of refund of energy*

**G**

**K1**

*stress intensity factor K1*

**G**

**K2**

*stress intensity factor K2*

**GEOM\_R**

*Type: R*

*Geometry (of a node or a point of Gauss)*

**GEOM\_R**

**X**

*co-ordinate according to OX*

**GEOM\_R**

**Y**

*co-ordinate according to OY*

**GEOM\_R**

**Z**

*co-ordinate according to OZ (0. If the model is 2D)*

**GEOM\_R**

**W**

***Weight of the point of Gauss***

***IND\_LOCA***

***Type: R***

***Indicator of localization***

***IND\_LOCA***

***INDEX***

***Criterion being worth 1 if localization (and 0 if not:  $\det NHN > 0$ )***

***IND\_LOCA***

***DIR1***

***First direction of localization***

***IND\_LOCA***

***DIR2***

***Second direction of localization***

***IND\_LOCA***

***DIR3***

***Third direction of localization***

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**IND\_LOCA**

**DIR4**

*Fourth direction of localization*

**INFC\_R**

Type: R

*Information relating to the contact*

**INFC\_R**

**CONT**

*indicator of contact*

**INFC\_R**

**PLAY**

*play enters the node slave and the associated mesh Master*

**INFC\_R**

**RN**

*multiplier of Lagrange and standard of RN*

**INFC\_R**

*RNX, Y, Z components of the vector of forces due to the contact*

**INFC\_R**

**GLIX**

*tangent displacement in X for each connection normalizes*

**INFC\_R**

**GLIY**

*tangent displacement in there for each connection normalizes*

**INFC\_R**

**GLI**

*tangent displacement for each connection normalizes*

**INFC\_R**

**RTAX**

*component X of the forces of the adherent nodes*

**INFC\_R**

**RTAY**

*component there of the forces of the adherent nodes*

**INFC\_R**

**RTAZ**

*component Z of the forces of the adherent nodes*

**INFC\_R**

**RTGX**

*component X of the forces of the slipping nodes*

**INFC\_R**

**RTGY**

*component there of the forces of the slipping nodes*

**INFC\_R**

**RTGZ**

*component Z of the forces of the slipping nodes*

**INFC\_R**

*X-ray*

*component X of the sum RN rtg and rta*

**INFC\_R**

**RY**

*component there of the sum RN rtg and rta*

**INFC\_R**

**RZ**

*component Z of the sum RN rtg and rta*

**INFC\_R**

**R**

*r\_tot normalizes*

**PRES\_C**

*Type: C*

*See PRES\_R*

**PRES\_R**

*Type: R*

.  
*Surface loading applied except for a mechanical model (, CISA)*  
.

*Unknown factor of a problem of accoustics: (pressure, speed of the fluid)*

*PRES\_R*

*NEAR*

*value of the pressure*

*PRES\_R*

*CISA*

*shearing applied to the edge of a model 2D*

*PRES\_R*

*VX*

*speed of the fluid following OX*

*PRES\_R*

*VY*

*speed of the fluid following OY*

*PRES\_R*

*VZ*

*speed of the fluid following OZ*

*PRES\_R*

*LAGR*

*parameter of lagrange of to the dualisation of the boundary conditions*

***RCCM\_R***

*Type: R*

*Sizes for the RCCM B3600*

*RCCM\_R*

*C1*

*value index of constraints*

*RCCM\_R*

*C2*

*value index of constraints*

*RCCM\_R*

*C3*

*value index of constraints*

*RCCM\_R*

*K1*

*value index of constraints*

*RCCM\_R*

*K2*

*value index of constraints*

*RCCM\_R*

*K3*  
*value index of constraints*  
*RCCM\_R*  
*TYPE*  
*type of mesh*  
*RCCM\_R*  
*E*  
*modulus of elasticity at temperature of calculation*  
*RCCM\_R*  
*E\_AMBI*  
*modulus of elasticity at ambient temperature*  
*RCCM\_R*  
*NAKED*  
*Poisson's ratio at ambient temperature*  
*RCCM\_R*  
*ALPHA*  
*dilation coefficient at ambient temperature*  
*RCCM\_R*  
*E\_REFE*  
*Young modulus of reference*  
*RCCM\_R*  
*SM*  
*acceptable equivalent constraint of material*  
*RCCM\_R*  
*M\_KE*  
*constant of material*  
*RCCM\_R*  
*N\_KE*  
*constant of material*  
*RCCM\_R*  
*IY*  
*principal moment of inertia compared to Y*  
*RCCM\_R*  
*IZ*  
*principal moment of inertia compared to Z*  
*RCCM\_R*  
*D*  
*diameter of piping*  
*RCCM\_R*  
*EP*  
*thickness of piping*  
*RCCM\_R*  
*SN*



*amplitude of variation of the linearized constraints*

*RCCM\_R*

*SALT*

*amplitude of constraint*

*RCCM\_R*

*U\_TOTAL factor of use*

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*RCCM\_R*

*TYPEKE*

*type of calculation of KE: either KE\_MECA, or K2\_MIXTE*

**RICE\_TRA**

*Sizes resulting from the calculation of growth of cavities in ductile rupture*

*RICE\_TRA TRIAX rate of triaxiality on the mesh*

*RICE\_TRA*

*RSR0 growth rate*

*RICE\_TRA*

*VOLU volume taken into account*

*RICE\_TRA*

*NUMEMA number of the mesh*

*RICE\_TRA*

*DEPSEQ*

*variation of equivalent plastic deformation*

**SIEF\_C**

Type: C

See SIEF\_R

**SIEF\_R**

Type: R

*State of stress (or of effort interns)*

SIEF\_R

SIXX

*xx constraints in a continuous medium*

SIEF\_R

SIYY

*yy forced in a continuous medium*

SIEF\_R

SIZZ

*zz forced in a continuous medium*

SIEF\_R

SIXY

*xy forced in a continuous medium*

SIEF\_R

SIXZ

*xz forced in a continuous medium*

SIEF\_R

SIYZ

*yz forced in a continuous medium*

SIEF\_R

NR

*normal effort*

SIEF\_R

VY

*shearing action according to Y (efforts intern beams)*

SIEF\_R

VZ

*shearing action according to Z (efforts intern beams)*

SIEF\_R

MT

*torque according to X*

SIEF\_R

MFY

*bending moment following Y*

*SIEF\_R*

*MFZ*

*bending moment according to Z*

*SIEF\_R*

*BX*

*Bi-moment (beam with warping)*

*SIEF\_R*

*NXX*

*efforts intern hulls*

*SIEF\_R*

*NYX*

*efforts intern hulls*

*SIEF\_R*

*NXY*

*efforts intern hulls*

*SIEF\_R*

*MXX*

*efforts intern hulls*

*SIEF\_R*

*MYY*

*efforts intern hulls*

*SIEF\_R*

*MXZ*

*efforts intern hulls*

*SIEF\_R*

*QX*

*efforts intern hulls*

*SIEF\_R*

*QY*

*efforts intern hulls*

*SIEF\_R*

*QXX, QXY,*

*constraints generalized for element QUAD4 “under-integrated” of*

*QYX, QYY,*

*modelings C\_PLAN\_SI and D\_PLAN\_SI*

*QZX, QZY*

*SIEF\_R*

*FX*

*efforts for the discrete ones, beams, bars... in total reference mark*

*SIEF\_R*

*FY*

*efforts for the discrete ones, beams, bars... in total reference mark*

*SIEF\_R*

*FZ*

*efforts for the discrete ones, beams, bars... in total reference mark*

*SIEF\_R*

*MX*

*efforts for the discrete ones, beams, bars... in total reference mark*

*SIEF\_R*

*MY*

*efforts for the discrete ones, beams, bars... in total reference mark*

*SIEF\_R*

*MZ*

*efforts for the discrete ones, beams, bars... in total reference mark*

*SIEF\_R*

*VMIS*

*constraint of Von Mises*

*SIEF\_R*

*TRESCA*

*constraint of Tresca*

*SIEF\_R*

*PRIN\_1*

*constraint principal direction 1*

*SIEF\_R*

*PRIN\_2*

*constraint principal direction 2*

*SIEF\_R*

*PRIN\_3*

*constraint principal direction 3*

*SIEF\_R*

*VMIS\_SG*

*constraint of Von Mises signed by the trace of sigma*

*SIEF\_R*

*SN*

*constraint in the section of beam due to the normal effort*

*SIEF\_R*

*SVY*

*constraint in the section of beam due to the shearing action  $V_y$*

*SIEF\_R*

*SVZ*

*constraint in the section of beam due to the shearing action  $V_z$*

*SIEF\_R*

*SMT*

*constraint in the section of beam due to the torque  $M_X$*

*SIEF\_R*

**SMFY**

*constraint in the section of beam due to moment  $M_y$  the bending*

**SIEF\_R**

**SMFZ**

*constraint in the section of beam due to moment  $M_z$  the bending*

**SIEF\_R**

**TRIAx**

*rate of triaxiality*

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**SIEF\_R**

**SI\_ENDO**

*equivalent constraint of damage*

**SOUR\_R**

*Type: R*

*Voluminal source of real type*

**SOUR\_R**

**SOUR**

*value of the voluminal source applied to a mesh*

*key word SOURCE of order AFFE\_CHAR\_THER*

**SOUR\_R**

**VNOR**

*value the normal speed applied to a face*

key word *VITE\_FACE* of order *AFFE\_CHAR\_MECA*

**SPMA\_R**

Type: R

*Calculation of the extremums of a field on a section of pipe*

*SPMA\_R*

*MIN, MAX*

*extreme values of a field on all the points of integration of a section pipe*

*SPMA\_R*

*NCOUMIN,*

*numbers of the layers carrying out the min and the max*

*NCOUMAX*

*SPMA\_R*

*NSECMIN,*

*numbers of the sectors carrying out the min and the max*

*NSECMAX*

*SPMA\_R*

*NPCOUMIN*

*numbers of the points of integration on the layers carrying out the min and the max*

*NPCOUMAX*

*SPMA\_R*

*NPSECMIN*

*numbers of the points of integration on the sectors carrying out the min and the max*

*NPSECMAX*

**TEMP\_C**

Type: C

See *TEMP\_R*

**TEMP\_F**

Type: K8

See *TEMP\_R*

**TEMP\_R**

Type: R

*Temperature (unknown of the thermal phenomenon)*

**TEMP\_R**

**TEMP**

*temperature*

**TEMP\_R**

**TEMP\_INF**

*temperature on the lower face (hulls)*

**TEMP\_R**

**TEMP\_SUP**

*temperature on the higher face (hulls)*

**VARI\_R**

*Type: R*

*Internal variables*

**VARI\_R**

*V1,... Vn*

*the number and the significance of the internal variables are specific to each relation of behavior. To refer to the reference document relative to behavior used on the mesh considered. In the case of elements with N “under-points” of integration, such as the hulls, the pipes, the beams multifibre, in each point of Gauss, the number of variables intern will be equal to the product  $n*m$ ,  $m$  being the number of variables intern behavior.*

**VNOR\_C**

*Type: C*

*Normal speed applied to a face of mesh (acoustic)*

**VNOR\_C**

**VNOR**

*value normal speed*

**WEIBULL**

*Type: R*

*Model of Beremin for the rupture by cleavage*

**WEIBULL**

**DSIGWB**

*constraint of Weibull*

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*Organization (S): EDF-R & D /AMA, MMC*

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***U2.01 booklet: General concepts***

***Document: U2.01.05***

***Constraints, efforts, forces and deformations***

***Summary:***

*This document defines the sizes characterizing the constraints, the forces and the deformations inside one structure in a calculation by finite elements in displacement and how that is translated in Code\_Aster. The expression of these sizes is given for the finite elements of mechanics: continuous medium 2D or 3D, hulls and beams.*

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## *1 Statics*

### *1.1 Constraints*

*The postulate of Cauchy is that the efforts of contacts exerted in a point by part of a medium continuous on another depends only on the normal on the surface in this point delimiting the parts.*

*In accordance with this postulate, one calls vector forced, for the nonmicropolar mediums,  $F(N)$  the vector which characterizes the forces of contact exerted through an element of surface  $dS$  of normal  $N$  on part of a continuous medium [bib1].*

*It is shown [bib3], then, that the dependence in a fixed point of  $F$  compared to normal  $N$  is linear and that there is a tensor which one calls tensor of the constraints such as:*

$$F(N) = N$$

*The unit of the constraints is  $N.m^2 Pa$ .*

*For the whole of the structure “the state of constraint” is characterized by a field of tensor of constraints which one more simply indicates by stress field.*

## **1.2 Effort**

*With regard to the structures of beams or hulls, contrary to the case of the continuous medium, it is necessary to note that:*

- only normal directions  $N$  of the cuts according to tangent space with the variety are possible,*
- the characteristic sizes are obtained by integration in the section or the thickness sizes defined for the continuous mediums.*

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### **1.2.1 Case of the beams**

*One calls effort, the end cells ( $F$ ,  $M$ ) out of  $P$ , geometrical centre of inertia of the section right-hand side, of the torque resulting from the forces of contact exerted on the section [bib2].*

*With the preceding notations:*

*$F$*

*=  $F$  ( $\cdot$ )  $ds$*

*(NR)*

$$M = \int PM F (\cdot) ds (NR)$$

$m$

$p$

.

$P$

*For the beams whose cross-section is not regarded as rigid these end cells are not sufficient: for example, for the beams taking of account the warping of sections one is brought to consider an additional size of effort due to warping (bimoment).*

*Multifibre beams (with local behavior 1D, connecting constraints to deformations, in one certain number of points of the section) and the pipes (local behavior in plane constraints) are comparable to elements of traditional beams with regard to the movement of fibre average and torques of resulting efforts.*

### 1.2.2 Case of the hulls

*Either, a point  $P$  of a surface medium  $S$  thickness  $H$ , or  $dl$  an element length on  $S$ , or  $N$  normal directing the hull in this point.*

*Maybe, end cells in this point ( $F, M$ ) of a torque resulting from the actions of contact exerted through an element of surface  $dS = H dl$  of tangent normal to  $S$  on part of  $S$ .*

*With the preceding notations:*

$$+h/2$$

$$F (P)$$

$$= \int F (\cdot) dh$$

$$(NR)$$

$- h/2$

$+h/2$

$$M (P) = \int PM F (\cdot) dh (NR.)$$

$m$

$- h/2$

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*N**dl**H**It is clear that  $M$  is in the tangent plan with  $S$  in  $P$ .**Either,  $NR(P)$  the projection of  $F(P)$  on the tangent level with  $S$  out of  $P$ , and or,  $T(P)$  its component normal in this tangent plan.**In the same way that for the continuous mediums, one shows that there are two symmetrical tensors  $NR$  and  $M$ , and a vector  $Q$ , defined in the tangent plan with  $S$ , such as:*

$$\mathbf{F} = NR$$

$$T = Q.$$

$$\mathbf{M} = N M$$

*( $NR, M, Q$ ) the efforts at the point  $P$  are called:*

- *the tensor  $NR$  characterizes the membrane efforts,*
- *the tensor  $M$ , bending moments,*
- *the vector  $Q$ , efforts sharp.*

**Note:**

- *It does not have there universal conventions on the denomination and the signs of these tensors.*

*In particular, the tensor of the bending moments is taken with a sign reverses in the teaching of the ENPC and in practice of the French engineers of the civil engineering. Our convention is used in the great codes of finite elements (ANSYS) and makes it possible to have it even sign for a beam and a plate such as =.*

*· For the curvilinear or surface material structures with nonlinear behavior, it is necessary to relocate the stress field in the section or the thickness, but them equilibrium equations always relate to the fields of effort. It is not necessary of to go down again to the constraints to define L " state of stress ".*

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### ***Bonds with the stress field***

*Under these conditions is a reference mark whose third component is carried by N, one has (, =1 or 2)*

:

*+h/2*

*NR*

*= NR =*

*dh*

*- H/2*

*+h/2*

*M*

$$= M = x^3$$

$$dh$$

$$- H/2$$

$$+ h/2$$

$$Q$$

$$=$$

$$dh$$

$$3$$

$$- H/2$$

### **1.3 Forces nodal**

*One calls equivalent nodal force or more simply nodal force, a vector  $F$  which is it representative of a linear form  $W$  (generally dependent on an energy) acting on fields of displacement  $U(X)$  discretized by finite elements.*

*The fields of displacements  $U(X)$  are expressed starting from its nodal values which form a vector  $Q$  and of the functions of form  $I(X)$  by:*

$$($$

$$U(X) = Q I(X)$$

$$I$$

$$)$$

$$I$$

*Under these conditions:*

$$W(U) = Q F$$

$$I$$

$$I$$

$$I$$

#### **Note:**

- The concept of node here is very general and wants to say, in fact, carrying degree of freedom (that it maybe of Lagrange or Hermit besides).*
- The concept of displacement is also very general and includes the concept of displacement generalized including/understanding translations and rotations.*

### **1.4 Representation of the fields**

*There are several ways of representing the fields in a modeling by finite elements:*

*· for the continuous-current fields on all the field, one uses the values with the nodes, (CHAM\_NO of Aster)*

*(X) = (X*

*I*

*I*

*)*

*I*

*one speaks then about constraints to the nodes or efforts with the nodes,*

**Note:**

*The effort or stress fields are generally discontinuous, if one them represent way continuous it is only at ends of visualization.*

*· for the discontinuous fields between the elements E, one uses the values in some then points characteristic of the element (points of Gauss or nodes).*

*One speaks then about constraints to the nodes by elements or efforts with the nodes by elements, or, of constraints at the points of Gauss or efforts to the nodes.*

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*In practice, for the discontinuous fields one uses:*

*· representations with the nodes at ends of direct uses of the results (impression or*



*postprocessing of visualization),*

*· at the points of Gauss (or in what holds place of it), to continue calculations requiring it true “state of stress” in the element: geometrical rigidity, nodal force, calculations not linear.*

## **1.5**

### **Sizes associated in Aster**

#### **1.5.1 SIGM\_R**

*Size SIGM\_R represents the “state of stress” of the structure, therefore it must have, with minimum, components:*

*· of the stress fields of the continuous mediums (in total reference mark):*

**SIXX SIYY SIZZ SIXY SIXZ SIYZ**

*· of the fields of efforts of beam (in local reference mark with the beam):*

**NR**

**VY**

**VZ**

**MT**

**MFY**

**MFZ**

*· for the beams with warping, it is necessary to add bimoment (necessarily in reference mark room with fibre):*

**BX**

*· of the fields of efforts of hull (necessarily in local reference mark on the surface):*

**NXX**

**NY Y**

**NXY**

**MX X**

**MY Y**

**MX Y**

**QX**

**QY**

*Moreover, it is sometimes convenient to be able to directly exploit the fields of efforts of beam in the total reference mark:*

***FX***  
***FY***  
***FZ***  
***MX***  
***MY***  
***MZ***

*It is also interesting to represent the components of a stress field on elements of beams or hulls in the local reference mark. For that, one will use the same ones components that in total reference mark, although confusion is possible. Into the future, one will introduce a concept of reference mark of representation attached to the fields which will overcome the difficulty.*

### ***1.5.2 FORC\_F and FORC\_R***

*These sizes represent the forces applied to the structure to an interface.  
For:*

- a continuous medium it is thus a vector of force,*
- a beam, a torque of forces,*
- a hull, a torque of forces.*

*This size must thus have the following components:*

- for a continuous medium:*

***FX***  
***FY***  
***FZ***

- more for the beams and the hulls:*

***MX***  
***MY***  
***MZ***

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### **1.5.3 DEPLA\_R**

*Since in Aster,*

- *a field can be attached only to only one size,*
- *that methods finite elements mixed (mixing unknown of displacement type and unknown factors of nodal the forces type) are not excluded,*
- *that the dualisation of the boundary conditions results in having for unknown a vector comprising variables of Lagrange which are nodal forces with the direction where one it specified higher,*
- *that it is necessary to be able to carry out any type of linear combination on nodal forces,*
- *that the classification of unknown must be the same one as that of the second members,*

*the nodal forces (dual within the meaning of energy  $W$  of nodal displacements) have necessarily them same components as displacements with knowing:*

**DX**

**DY**

**DZ**

**DRX**

**DRY**

**DRZ**

*more, for the beams with warping, bimoment: GRX.*

### **1.6**

**Options of calculation**

## ***1.6.1 Calculation of the “state of stress”***

### ***1.6.1.1 Prefixes***

***:***  
***SIEF\_ELGA***

***They are the options which calculate the field representative of the “state of stress” and allow to continue calculations (geometrical rigidity, nodal forces, etc.) in points of Gauss or it who holds place of it. The prefix of these options is SIEF, because according to the elements, they calculate constraints or of the efforts.***

#### ***Option of calculation***

***Name***

***Calculation carried out 3D, 2D,***

***Beams:***

***Plates:***

***symbolic system of***

***COQUE\_3D***

***concept***

***Coques1D***

***POU\_D\_T***

***DKT***

***RESULT***

***PIPE***

***POU\_D\_E***

***DST***

***Beams***

***POU\_D\_TG***

***Q4G***

***multifibre POU\_D\_T\_GD***

***SIEF\_ELGA\_DEPL***

***idem with***

***to leave***

***of one***

***(F, M)***

***field of***

***(NR, M, V)***

*displacement*  
*in local reference mark*  
*in local reference mark*  
*in elasticity*  
*linear*  
*SIEF\_ELGA\_DEPL\_C idem with*  
*to leave*  
*of one*

*(F, M)*

*field of*

*(NR, M, V)*  
*displacement*  
*in local reference mark*  
*(C)*  
*in local reference mark*  
*complex in*  
*(C)*  
*(C)*  
*elasticity*  
*linear*  
*RAPH\_MECA*  
*SIEF\_ELGA*  
*into nonlinear*  
*(F, M)*  
  
*FULL\_MECA*

*in local reference mark*

*These options thus calculate:*

*· the stress field for the elements of continuous mediums 2D and 3D, and the elements with local behavior*  
*: COQUE\_3D, hulls 1D (COQUE\_AXIS, COQUE\_D\_PLAN, COQUE\_C\_PLAN), pipes, beams multifibre, in each “under-point” of integration (layers in the thickness of the hulls, fibres, sectors angular and position in the thickness for the pipes). The local reference mark of the plates and hulls is specific to each element,*

· *the field of efforts for the beams (torque) and the plates (tensor) into linear.*

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*1.6.2 Other representations of the state of stress*

*1.6.2.1 Prefixes*

*:*

*SIEF\_ELNO*

*They are the options which calculate the field representative of the “state of stress” at ends of exploitation (impression or postprocessing of visualization) to the nodes of the structure.*

*Option of calculation*

*Name*

*Calculation carried out*

*3D,*

*Beam, pipe,*

*Hull, plate*

*symbolic system of*

*2D*

*beam*

*concept*

*multifibre*

*RESULT*

*SIEF\_ELNO\_ELGA*

*idem*

*by interpolation with  
(F, M)  
(NR, M, V)  
nodes of the quantities*

*in local reference mark  
at the points of Gauss  
in local reference mark  
“user” (\*)  
SIEF\_ELNO\_ELGA\_C  
idem*

*by interpolation with  
(F, M)  
(NR, M, V)  
in*

*nodes of the quantities  
in local reference mark  
at the points of Gauss  
(C)  
locate local (C) “user” (C)*

*(\*) for the elements of plate and hull, the local reference mark is that definite starting from the data of the user  
(key word ANGL\_REP in AFFE\_CARA\_ELEM).*

### **1.6.2.2 Prefixes**

**:**  
**SIGM\_ELNO**

*They are the options which calculate the stress fields whatever the modeling at ends of exploitation (impression or postprocessing of visualization) to the nodes of the structure.*

*Option of calculation  
Name  
Calculation carried out  
3D,  
Beams  
Hulls, plates  
symbolic system of  
2D*

*in 1 selected point  
concept*

*in the thickness*

*RESULT*

*(inf, moy, sup)*

*SIGM\_ELNO\_DEPL*

*idem*

*starting from a field of*

*displacement in locates some local*

*in local reference mark*

*linear elasticity*

*6 components*

*6 components*

*SIGM\_ELNO\_DEPL\_C idem*

*starting from a field of*

*displacement complexes (C) in local reference mark*

*in local reference mark*

*in linear elasticity*

*6 components 6 components*

*(C)*

*(C)*

*SIGM\_ELNO\_CART*

*idem in*

*components*

*total (Cartesian)*

*in total reference mark in total reference mark*

*starting from the field of*

*constraints in*

*local components*

*SIGM\_ELNO\_CART\_C idem in*

*components*

*total complexes*

*(C)*

*in local reference mark*

*in local reference mark*

*(Cartesian) to leave*

*6 components 6 components*



*field of*  
*(C)*  
*(C)*  
*constraints in*  
*local components*  
*complexes*

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**Note:**

1) *In this case, confusion is possible between the components in local reference mark and those in total reference mark which bears the same name. In the long term, one will introduce into Aster, a concept of reference mark related to the fields of sizes. This notion will be exploited for the writing of the fields with universal format IDEAS, and the impression on listing.*

2) *6 components delivered in the local reference marks by the beams and the hulls contain possibly null terms according to the models used. For the models most standard:*

-  
*three null terms for the beams,*

-  
*two null terms for the hulls.*

*Thus, the stress field will be complete for IDEAS, and, especially, it could be enriched each time modeling requires it (beam with shearing, hull with*

*pinching, etc...)*

### **1.6.2.3 Prefixes**

:

#### **EFGE\_ELNO**

*They are the options which calculate the efforts on the elements of beam or hull at ends of exploitation (impression or postprocessing of visualization) to the nodes of the structure.*

*Option of calculation*

*Name*

*Calculation carried out*

*3D,*

*Beams, pipes, Hulls,*

*symbolic system of*

*2Ds beam*

*plates*

*concept*

*multifibre*

**RESULT**

**EFGE\_ELNO\_DEPL**

*idem*

*starting from a field of*

*(F, M)*

*displacement in*

*not*

*(NR, M, V)*

*linear elasticity*

*in local reference mark*

*in local reference mark*

**EFGE\_ELNO\_DEPL\_C** *idem*

*starting from a field of*

*(F, M)*

*displacement complexes not*

*(NR, M, V)*

*in linear elasticity*

*in local reference mark in local reference mark*

*(C)*

*(C)*

**EFGE\_ELNO\_CART**

*idem in  
components*

*(F, M)*

*total (Cartesian) not*

*not*

*starting from the field  
in total reference mark  
efforts in*

*local components*

*EFGE\_ELNO\_CART\_C idem in  
components*

*(F, M)*

*total complexes*

*not*

*not*

*(Cartesian) to leave  
in total reference mark  
field of efforts in*

*(C)*

*local components*

*complexes*

### ***1.6.3 Calculation of the nodal forces***

#### ***1.6.3.1 Prefixes: FORC\_NODA***

***The nodal forces are calculated starting from the “state of stress”, only one option is envisaged:***

***Option of calculation***

***Reference symbol Calculation carried out***

***3D***

***Beam***

***Hull***

***of concept***

***RESULT***

***FORC\_NODA***

***idem***

***starting from a “SIEF\_ELGA\_”***

***F***

**(F, M)**

**(F, M)**

**Option REAC\_NO of operator CALC\_CHAM\_NO carries out a call to FORC\_NODA and withdrawn:**

- **the loading in statics,**
- **the loading, inertias and viscous in dynamics.**

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**2 Kinematics**

**2.1 Deformations**

**2.1.1 Medium**

**continuous**

**In this case, displacements of the structure are represented by a field of vector  $U$  to three components in general.**

**The deformation (on the assumption of the small disturbances) is defined by the tensor of deformation**

**by (option EPSI\_ELGA\_DEPL and EPSI\_ELNO\_DEPL):**

**1**

**$ij(U) =$**

2 (I

U, J + U J I,)

One can want to calculate the “mechanical” deformation, i.e. by cutting off dilations thermics (options EPME\_ELGA\_DEPL and EPME\_ELNO\_DEPL):

m

I

HT

ij (U) =

2 (I

U, J + U J I,)

In the case of great displacements, the deformations of Green-Lagrange are (options EPSG\_ELGA\_DEPL and EPSG\_ELNO\_DEPL):

I

E (U) =

S

2 (U, + U, + U U

ij

I J

J I

K I, K, J)

To which have can want to cut off the thermal deformations (options EPMG\_ELGA\_DEPL and EPMG\_ELNO\_DEPL):

I

E m

HT

ij (U) =

2 (U, + U, + U U

I J

J I

K I, K, J) -

### 2.1.2 Case of the beams

In the theories of traditional beams, each point P of the beam represents a section right-hand side. They are thus, the end cells of the torque (T (S), (S)) of displacement of presumed rigid cross-section which characterizes the displacement of the point P to the curvilinear X-coordinate (S).

T is the translation of the centre of inertia of the section, (S) the vector rotation of the section in it not.

The application of the theorem of virtual work (cf [bib2]) naturally resulted in defining as deformation the torque (,) derived from (T (S), (S)) compared to the curvilinear X-coordinate S:

$$D = T + ds$$

$$D = ds$$

$$P(S)$$

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*Let us pose then:*

$$= L + T$$

$$=$$

$$T + \mathbf{K}$$

*L is the longitudinal deflection,*  
*T is the vector of the deformations of distortion (no one on the assumption of Navier-Bernoulli),*  
*T is the deformation of torsion of the section,*  
*K is the deformation of inflection.*

**Note:**  
*For modelings of beam with taking into account of warping, kinematics is more*

*complicated to describe, but they lead however to concepts close to those presented above.*

### **2.1.3 Case of the hulls**

*We will limit ourselves here to the cases of the plates. Indeed, in the case general of the hulls:*

- space derivations use too complicated mathematical concepts for the framework this document, [R3.07.04],*
- the hulls are very often modelled by elements of assembled plates.*

*In this case, in fact only the material normals are supposed to be rigid. Displacement of these normals is thus represented by the end cells of a torque ( $T$ ).  $T$  is translation of the point located on the average layer, the vector rotation of the normal in this point. It is clear that the normal component of is null (in the case of nonmicropolar mediums). One introduced, the vector  $L$  in the tangent plan defined by:*

$$L = N$$

*where  $N$  is the normal vector directing surface.*

$N$   
 $e_2$   
 $e_1$

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***Maybe, decomposition:***

$$T = wn + C$$

*C is tangent displacement,*

*W is the arrow.*

*In the same way that for the beams, the application of the theorem of virtual work (cf [bib2]) conduit to define as deformation the unit formed by the tensors  $E$  and  $K$  and the vector all these sizes being defined in the tangent plan by:*

$$E = 2 (U, + U$$

, )

$I$

$$K =$$

$$2 (L, + L$$

, )

$$= L + W$$

,

***The deformation is thus defined by 7 realities.***

*E are the membrane deformations,*

*K are the opposite of the curves of the deformed average layer,*

*is the vector of deformation of distortion.*

***Note:***

***There still, there is no universal convention and the disparity of conventions is still larger than for the tensors of efforts. The ENPC adopts a convention reverses for tensor  $K$  for obvious geometrical ratios.***

***Bond with the three-dimensional field of deformation***

***Under these conditions, one a:***



$= E + X$

$K$

$3$

$3 =$

$33 = 0.$

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*2.2*

*Sizes associated in Aster*

*2.2.1 DEPL\_R and DEPL\_C*

*Sizes DEPL\_R and DEPL\_C have as components the degrees of freedom of modeling by finite elements and thus do not have necessarily only the components of the fields of displacement who are:*

*DX*

*DY*

*DZ*

*with which it is necessary to associate for the beams or the hulls:*

*DRX*

*DRY*

**DRZ**

*For the hulls, we need the three components of the vector of rotation, because the equation with finite elements can be expressed only in one total Cartesian reference mark.*

### **2.2.2 EPSI\_R**

*Size EPSI\_R represents the structural deformations, therefore it must have, at least, components:*

*· of the fields of deformations of the continuous mediums (in total reference mark):*

**EPXX EPYY EPZZ EPXY EPXZ EPYZ**

*· of the fields of deformations of beam (in local reference mark with the beam):*

**EPL**

**GAY**

**GAS**

**KY**

**KZ**

**GAT**

*· of the fields of deformations of hull (necessarily in local reference mark on the surface)*

**EXX**

**EYY**

**EXY**

**KXX**

**KYY**

**KXY**

**GAX**

**GAY**

## **2.3**

**Options of calculation**

**2.3.1 Prefixes: EPSI\_ELGA\_DEPL, EPME\_ELGA\_DEPL, EPSG\_ELGA\_DEPL, EPMG\_ELGA\_DEPL**

*They are the options which calculate the fields of deformations at the points of integration of the elements.*

**Option of calculation**

*Reference symbol of Calculation carried out  
3D Pipes,  
Hulls,  
concept RESULT  
Beams multi\_fibres plates  
EPSI\_ELGA\_DEPL idem  
starting from a field*

*not  
of displacement in  
in local reference mark  
small deformations  
6 components  
EPMG\_ELGA\_DEPL idem  
Tensor of Green-*

*not  
not  
Lagrange to be left  
of a field of  
displacement  
EPME\_ELGA\_DEPL idem  
starting from a field m not  
not*

*of displacement and  
of a field of  
temperature in  
small deformations  
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***EPMG\_ELGA\_DEPL idem***

***Tensor of Green- m not***

***not***

***Lagrange to be left***

***of a field of***

***displacement and of one***

***field of***

***temperature***

***2.3.2 Prefixes: EPSI\_ELNO\_DEPL, EPME\_ELNO\_DEPL, EPSG\_ELNO\_DEPL, EPMG\_ELNO\_DEPL***

***They are the options which calculate the fields of deformations whatever the modeling at ends of exploitation (impression or postprocessing of visualization) to the nodes of the structure.***

***Option of calculation***

***Reference symbol of Calculation carried out***

***3D Beams,***

***Hulls, plates***

***concept RESULT***

***Pipes,***

***in 1 selected point***

***Beams multi\_fibres in the thickness***

***(inf, moy, sup)***

***EPSI\_ELNO\_DEPL idem***

***starting from a field***

***in local reference mark:***

***of displacement in***

***in local reference mark***

***6 components***

***small deformations***

***6 components***

***EPSG\_ELNO\_DEPL idem***

***Tensor of Green-***

***not***

***not***

***Lagrange to be left***

*of a field of  
displacement  
EPME\_ELNO\_DEPL idem  
starting from a field m not  
not  
of displacement and  
of a field of  
temperature in  
small deformations  
EPMG\_ELNO\_DEPL idem  
Tensor of Green- m not  
not  
Lagrange to be left  
of a field of  
displacement and of one  
field of  
temperature*

### *2.3.3 Prefixes*

*:  
DEGE\_ELNO*

*They are the options which calculate the deformations generalized on the elements of beam or of hull at ends of exploitation (impression or postprocessing of visualization) to the nodes of structure.*

*Option of calculation  
Name  
Calculation carried out  
3D  
Beams, beams Plates,  
symbolic system of  
multifibre  
Coques1D  
concept  
RESULT  
DEGE\_ELNO\_DEPL  
idem  
starting from a field of  
(,)*

*displacement into small not  
(E, K,) deformations  
in local reference mark  
in local reference mark*

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*Organization (S): EDF-R & D /AMA, MMC*

***Instruction manual***

***U2.01 booklet: General concepts***

***Document: U2.01.05***

***Constraints, efforts, forces and deformations***

***Summary:***



*This document defines the sizes characterizing the constraints, the forces and the deformations inside one structure in a calculation by finite elements in displacement and how that is translated in Code\_Aster. The expression of these sizes is given for the finite elements of mechanics: continuous medium 2D or 3D, hulls and beams.*

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*1 Statics*

*1.1 Constraints*

*The postulate of Cauchy is that the efforts of contacts exerted in a point by part of a medium continuous on another depends only on the normal on the surface in this point delimiting the parts.*

*In accordance with this postulate, one calls vector forced, for the nonmicropolar mediums,  $F(N)$  the vector which characterizes the forces of contact exerted through an element of surface  $dS$  of normal  $N$  on part of a continuous medium [bib1].*

*It is shown [bib3], then, that the dependence in a fixed point of  $F$  compared to normal  $N$  is linear and that there is a tensor which one calls tensor of the constraints such as:*

$$F(N) = N$$

*The unit of the constraints is  $N.m^2 Pa$ .*

*For the whole of the structure “the state of constraint” is characterized by a field of tensor of constraints which one more simply indicates by stress field.*

## **1.2 Effort**

*With regard to the structures of beams or hulls, contrary to the case of the continuous medium, it is necessary to note that:*

*· only normal directions  $N$  of the cuts according to tangent space with the variety are possible,*

*· the characteristic sizes are obtained by integration in the section or the thickness sizes defined for the continuous mediums.*

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### **1.2.1 Case of the discrete ones**

*The discrete ones are finite elements which can not have of a physical size. They are represented by their matrix of stiffness. The efforts are obtained by the multiplication of this matrix by the vector displacement:*

*$F$*

*$D$*

*$= [K]$*

*M*  
*R*

### 1.2.2 Case of the beams

*One calls effort, the end cells ( $F$ ,  $M$ ) out of  $P$ , geometrical centre of inertia of the section right-hand side, of the torque resulting from the forces of contact exerted on the section [bib2].*

*With the preceding notations:*

*F*  
*= F ( ) ds*  
*(NR)*

*M*  
*= PM F*  
*.*  
*P*  
*( ) ds (NR m)*

*P*

*For the beams whose cross-section is not regarded as rigid these end cells are not sufficient: for example, for the beams taking of account the warping of sections one is brought to consider an additional size of effort due to warping (bimoment).*

*Multifibre beams (with local behavior 1D, connecting constraints to deformations, in one certain number of points of the section) and the pipes (local behavior in plane constraints) are comparable to elements of traditional beams with regard to the movement of fibre average and torques of resulting efforts.*

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### ***1.2.3 Case of the hulls***

***Either, a point  $P$  of a surface medium  $S$  thickness  $H$ , or  $dl$  an element length on  $S$ , or  $N$  normal directing the hull in this point.***

***Maybe, end cells in this point  $(F, M)$  of a torque resulting from the actions of contact exerted through an element of surface  $dS = H dl$  of tangent normal to  $S$  on part of  $S$ .***

***With the preceding notations:***

***+ $h/2$***

***$F (P)$***

***=***

***$F () dh$***

***(NR)***

***-  $h/2$***

***+ $h/2$***

***$M (P) =$***

***$PM F () dh (NR.)$***

***$m$***

***-  $h/2$***

***$N$***

***$dl$***

***$H$***

***It is clear that  $M$  is in the tangent plan with  $S$  in  $P$ .***

***Either,  $NR (P)$  the projection of  $F (P)$  on the tangent level with  $S$  out of  $P$ , and or,  $T (P)$  its normal component in this tangent plan.***

*In the same way that for the continuous mediums, one shows that there are two symmetrical tensors  $NR$  and  $M$ , and a vector  $Q$ , defined in the tangent plan with  $S$ , such as:*

$$F = NR$$

$$T = Q.$$

$$M = N M$$

*( $NR$ ,  $M$ ,  $Q$ ) the efforts at the point  $P$  are called:*

- *the tensor  $NR$  characterizes the membrane efforts,*
- *the tensor  $M$ , bending moments,*
- *the vector  $Q$ , efforts sharp.*

*Note:*

• *There are no universal conventions on the denomination and the signs of these tensors. In particular, the tensor of the bending moments is taken with a sign reverses in the teaching of the ENPC and in practice of the French engineers of the civil engineering. Our convention is used in the great codes of finite elements (ANSYS) and makes it possible to have it even sign for a beam and a plate such as =.*

• *For the curvilinear or surface material structures with nonlinear behavior, it is necessary to relocate the stress field in the section or the thickness, but them equilibrium equations always relate to the fields of effort. It is not necessary of to go down again to the constraints to define  $L$  " state of stress ".*

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***Bonds with the stress field***

***Under these conditions is a reference mark whose third component is carried by N, one has (, =1 or 2)***

:

**+h/2**

**NR**

**= NR**

**=**

**dh**

**- H/2**

**+h/2**

**M**

**= M**

**=**

**x3 dh**

**- H/2**

**+h/2**

**Q**

**=**

**dh**

**3**

**- H/2**

***1.3 Forces***

***nodal***

*One calls equivalent nodal force or more simply nodal force, a vector  $F$  which is it representative of a linear form  $W$  (generally dependent on an energy) acting on fields of displacement  $U(X)$  discretized by finite elements.*

*The fields of displacements  $U(X)$  are expressed starting from its nodal values which form a vector  $Q$  and of the functions of form  $I(X)$  by:*

$$\begin{pmatrix} U \\ X \end{pmatrix} = Q \begin{pmatrix} I \\ X \end{pmatrix}$$

*Under these conditions:*

$$W(U) = Q F$$

*Note:*

*The concept of node here is very general and wants to say, in fact, carrying degree of freedom (that it maybe of Lagrange or Hermit besides).*

*The concept of displacement is also very general and includes the concept of displacement generalized including/understanding translations and rotations.*

## *1.4*

### *Representation of the fields*

*There are several ways of representing the fields in a modeling by finite elements:*

*for the continuous-current fields on all the field, one uses the values with the nodes, (CHAM\_NO of Aster)*

$$\begin{pmatrix} U \\ X \end{pmatrix} = \begin{pmatrix} I \\ X \end{pmatrix}$$

*one speaks then about constraints to the nodes or efforts with the nodes,*

*Note:*

*The effort or stress fields are generally discontinuous, if one them represent way continuous it is only at ends of visualization.*

*for the discontinuous fields between the elements E, one uses the values in some then points characteristic of the element (points of Gauss or nodes).*

*One speaks then about constraints to the nodes by elements or efforts with the nodes by elements, or, of constraints at the points of Gauss or efforts to the nodes.*

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*In practice, for the discontinuous fields one uses:*

*representations with the nodes at ends of direct uses of the results (impression or postprocessing of visualization),*

*at the points of Gauss (or in what holds place of it), to continue calculations requiring it true “state of stress” in the element: geometrical rigidity, nodal force, calculations not linear.*

*1.5*

*Sizes associated in Aster*

*1.5.1 SIGM\_R*

*Size SIGM\_R represents the “state of stress” of the structure, therefore it must have, with*



***minimum, components:***

.

***stress fields of the continuous mediums (in total reference mark):***

***SIXX SIYY SIZZ SIXY SIXZ SIYZ***

.

***fields of efforts of beam and discrete (in local reference mark with the beam, discrete):***

***NR***

***VY***

***VZ***

***MT***

***MFY***

***MFZ***

.

***for the beams with warping, it is necessary to add bimoment (necessarily in reference mark room with fibre):***

***BX***

.

***fields of efforts of hull (necessarily in local reference mark on the surface):***

***NXX***

***NYY***

***NXY***

***MXX***

***MYY***

***MXY***

***QX***

***QY***

***Moreover, it is sometimes convenient to be able to directly exploit the fields of efforts of beam and of discrete in the total reference mark:***

***FX***

***FY***

***FZ***

***MX***

***MY***

***MZ***

*It is also interesting to represent the components of a stress field on elements of beams or hulls in the local reference mark. For that, one will use the same ones components that in total reference mark, although confusion is possible. Into the future, one will introduce a concept of reference mark of representation attached to the fields which will overcome the difficulty.*

### **1.5.2 FORC\_F and FORC\_R**

*These sizes represent the forces applied to the structure to an interface.  
For:*

- a continuous medium it is thus a vector of force,*
- a beam, a torque of forces,*
- a hull, a torque of forces.*

*This size must thus have the following components:*

- for a continuous medium:*

***FX  
FY  
FZ***

- more for the beams and the hulls:*

***MX  
MY  
MZ***

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### **1.5.3 DEPL\_R**

**Since in Aster,**

**.**

**a field can be attached only to only one size,**

**.**

**that methods finite elements mixed (mixing unknown of displacement type and unknown factors of nodal the forces type) are not excluded,**

**.**

**that the dualisation of the boundary conditions results in having for unknown a vector comprising variables of Lagrange which are nodal forces with the direction where one it specified higher,**

**.**

**that it is necessary to be able to carry out any type of linear combination on nodal forces,**

**.**

**that the classification of the unknown factors must be the same one as that of the second members,**

**the nodal forces (dual within the meaning of energy  $W$  of nodal displacements) have necessarily them same components as displacements with knowing:**

**DX**

**DY**

**DZ**

**DRX**

**DRY**

**DRZ**

**more, for the beams with warping, bimoment: GRX.**

## **1.6**

**Options of calculation**

### **1.6.1 Calculation of the “state of stress”**

### **1.6.1.1 Prefixes**

**:**  
**SIEF\_ELGA**

*They are the options which calculate the field representative of the “state of stress” and allow to continue calculations (geometrical rigidity, nodal forces, etc.) in points of Gauss or it who holds place of it. The prefix of these options is SIEF, because according to the elements, they calculate constraints or of the efforts.*

#### **Option of calculation**

**Name**

**Calculation carried out 3D, 2D,**

**Beams:**

**Plates:**

**symbolic system of**

**COQUE\_3D**

**POU\_D\_T**

**DKT**

**concept**

**Coques1D**

**POU\_D\_E**

**DST**

**RESULT**

**PIPE**

**POU\_D\_TG**

**Q4G**

**Beams**

**POU\_D\_T\_GD**

**multifibre Discrete**

**SIEF\_ELGA\_DEPL**

**idem**

**from one**

**(F, M)**

**field of**

**(NR, M, V)**

**displacement**

**in local reference mark**

*in local reference mark*

*in elasticity*

*linear*

*SIEF\_ELGA\_DEPL\_C idem*

*from one*

*(F, M)*

*field of*

*(NR, M, V)*

*displacement*

*in local reference mark*

*(C)*

*in local reference mark*

*complex in*

*(C)*

*(C)*

*elasticity*

*linear*

*RAPH\_MECA*

*SIEF\_ELGA*

*into nonlinear*

*(F, M)*

*FULL\_MECA*

*in local reference mark*

*These options thus calculate:*

.

*the stress field for the elements of continuous mediums 2D and 3D, and the elements with local behavior*

*: COQUE\_3D, hulls 1D (COQUE\_AXIS,*

*COQUE\_D\_PLAN,*

*COQUE\_C\_PLAN), pipes, beams multifibre, in each “under-point” of integration*

*(layers in the thickness of the hulls, fibres, sectors angular and position in the thickness*

*for the pipes). The local reference mark of the plates and hulls is specific to each element,*

.

*the field of efforts for the beams (torque) and the plates (tensor) into linear.*

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***1.6.2 Other representations of the state of stress***

***1.6.2.1 Prefixes***

***:***

***SIEF\_ELNO***

***They are the options which calculate the field representative of the “state of stress” at ends of exploitation (impression or postprocessing of visualization) to the nodes of the structure.***

***Option of calculation***

***Name***

***Calculation carried out***

***3D,***

***Beam, pipe,***

***Hull, plate***

***symbolic system***

***2D***

***multifibre beam,***

***of concept***

***Discrete***

***RESULT***

***SIEF\_ELNO\_ELGA***

***idem***

***by interpolation with***

**(F, M)**  
**(NR, M, V)**  
**nodes of the quantities**

**in local reference mark**  
**at the points of Gauss**  
**in local reference mark**  
**“user” (\*)**  
**SIEF\_ELNO\_ELGA\_C**  
**idem**

**by interpolation with**  
**(F, M)**  
**(NR, M, V)**  
**in reference mark**  
**nodes of the quantities**  
**in local reference mark**  
**at the points of Gauss**  
**(C)**  
**room (C)**  
**“user” (C)**

**(\*) for the elements of plate and hull, the local reference mark is that definite starting from the data of the user**  
**(key word ANGL\_REP in AFFE\_CARA\_ELEM).**

**1.6.2.2 Prefixes**  
**:**  
**SIGM\_ELNO**

**They are the options which calculate the stress fields whatever the modeling at ends of exploitation (impression or postprocessing of visualization) to the nodes of the structure.**

**Option of calculation**  
**Name**  
**Calculation carried out**  
**3D,**  
**Beams**  
**Hulls, plates**  
**symbolic system of**  
**2D**

**in 1 selected point**

*concept*  
*in the thickness*  
**RESULT**  
*(inf, moy, sup)*  
**SIGM\_ELNO\_DEPL**  
*idem*  
*starting from a field of*

*displacement in locates some local*  
*in local reference mark*  
*linear elasticity*  
*6 components*  
*6 components*  
**SIGM\_ELNO\_DEPL\_C** *idem*  
*starting from a field of*

*displacement complexes (C) in local reference mark*  
*in local reference mark*  
*in linear elasticity*  
*6 components 6 components*  
*(C)*  
*(C)*  
**SIGM\_ELNO\_CART**  
*idem in*  
*components*

*total (Cartesian)*  
*in total reference mark in total reference mark*  
*starting from the field of*  
*constraints in*  
*local components*  
**SIGM\_ELNO\_CART\_C** *idem in*  
*components*

*total complexes*  
*(C)*  
*in local reference mark*  
*in local reference mark*  
*(Cartesian) to leave*



**6 components 6 components**  
**field of**  
**(C)**  
**(C)**  
**constraints in**  
**local components**  
**complexes**

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**Note:**

**1) In this case, confusion is possible between the components in local reference mark and those in total reference mark which bears the same name.**

**2) 6 components delivered in the local reference marks by the beams and the hulls contain possibly null terms according to the models used. For the models most standard:**

**-**  
**three null terms for the beams,**

**-**  
**two null terms for the hulls.**

**Thus, the stress field will be complete and, especially, it could be enriched each time modeling will require it (beam with shearing, hull with pinching, etc...)**

**1.6.2.3 Prefixes**  
**:**

## ***EFGE\_ELNO***

***They are the options which calculate the efforts on the elements of beam or hull at ends of exploitation (impression or postprocessing of visualization) to the nodes of the structure.***

### ***Option of calculation***

***Name***

***Calculation carried out***

***3D,***

***Beams, pipes,***

***Hulls,***

***symbolic system***

***2Ds beam multifibre, plates***

***of concept***

***Discrete***

***RESULT***

***EFGE\_ELNO\_DEPL***

***idem***

***starting from a field of***

***(F, M)***

***displacement in***

***not***

***(NR, M, V)***

***linear elasticity***

***in local reference mark***

***in local reference mark***

***EFGE\_ELNO\_DEPL\_C idem***

***starting from a field of***

***(F, M)***

***displacement***

***not***

***(NR, M, V)***

***complex in elasticity***

***in local reference mark (C) in local reference mark***

***linear***

***(C)***

***EFGE\_ELNO\_CART***

***idem in***

***components***

**(F, M)**

**total  
not**

**not  
(Cartesian) to leave  
in total reference mark  
field of efforts in  
local components  
EFGE\_ELNO\_CART\_C idem in  
components**

**(F, M)**

**total complexes  
not**

**not  
(Cartesian) to leave  
in total reference mark  
field of efforts in**

**(C)  
local components  
complexes**

### **1.6.3 Calculation of the nodal forces**

#### **1.6.3.1 Prefixes**

**:  
FORC\_NODA**

**The nodal forces are calculated starting from the “state of stress”, only one option is envisaged:**

**Option of calculation  
Reference symbol Calculation carried out  
3D  
Beam  
Hull  
of concept  
RESULT  
FORC\_NODA  
idem  
starting from a “SIEF\_ELGA\_”  
F**

**(F, M)**

**(F, M)**

**Option REAC\_NO of operator CALC\_CHAM\_NO carries out a call to FORC\_NODA and withdrawn:**

**.  
the loading in statics,**

**.  
the loading, inertias and viscous in dynamics.**

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**2 Kinematics**

**2.1 Deformations**

**2.1.1 Medium**

**continuous**

**In this case, displacements of the structure are represented by a field of vector  $U$  to three components in general.**

**The deformation (on the assumption of the small disturbances) is defined by the tensor of deformation**

**by (option EPSI\_ELGA\_DEPL and EPSI\_ELNO\_DEPL):**

**(**

**1**

$$U)_{ij} = \frac{(iu J + uj I)}{2}$$

One can want to calculate the “mechanical” deformation, i.e. by cutting off dilations thermics (options EPME\_ELGA\_DEPL and EPME\_ELNO\_DEPL):

$$m_{ij}(U) = \frac{(iu J + uji)}{2}$$

In the case of great displacements, the deformations of Green-Lagrange are (options EPSG\_ELGA\_DEPL and EPSG\_ELNO\_DEPL):

$$E(U) = \frac{(U + U + U U)_{ij}}{2}$$

To which have can want to cut off the thermal deformations (options EPMG\_ELGA\_DEPL and EPMG\_ELNO\_DEPL):

$$E_m(U) = \frac{(U + u + u U)_{ij}}{2}$$

### 2.1.2 Case of the beams

*In the theories of traditional beams, each point  $P$  of the beam represents a section right-hand side. They are thus, the end cells of the torque  $(T(S), (S))$  of displacement of presumed rigid cross-section which characterizes the displacement of the point  $P$  to the curvilinear  $X$ -coordinate  $(S)$ .*

*$T$  is the translation of the centre of inertia of the section,  $(S)$  the vector rotation of the section in it not.*

*The application of the theorem of virtual work (cf [bib2]) naturally resulted in defining as deformation the torque  $(,)$  derived from  $(T(S), (S))$  compared to the curvilinear  $X$ -coordinate  $S$ :*

$$D = T + ds$$

$$D = ds$$

$$P(S)$$

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*Let us pose then:*

= +

*L*

*T*

= +

*T*

***K***

*L is the longitudinal deflection,*

*T is the vector of the deformations of distortion (no one on the assumption of Navier-Bernoulli),*

*T is the deformation of torsion of the section,*

***K*** *is the deformation of inflection.*

**Note:**

*For modelings of beam with taking into account of warping, kinematics is more complicated to describe, but they lead however to concepts close to those presented above.*

### **2.1.3 Case of the hulls**

***We will limit ourselves here to the cases of the plates. Indeed, in the case general of the hulls:***

.

***space derivations use too complicated mathematical concepts for the framework this document, [R3.07.04],***

*the hulls are very often modelled by elements of assembled plates.*

*In this case, in fact only the material normals are supposed to be rigid. Displacement of these normals is thus represented by the end cells of a torque ( $T$ ).  $T$  is translation of the point located on the average layer, the vector rotation of the normal in this point. It is clear that the normal component of is null (in the case of nonmicropolar mediums). One introduced, the vector  $L$  in the tangent plan defined by:*

$$L = N$$

*where  $N$  is the normal vector directing surface.*

$N$   
 $e_2$   
 $e_1$

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*Maybe, decomposition:*

$T = wn + C$   
 *$C$  is tangent displacement,  
 $W$  is the arrow.*

*In the same way that for the beams, the application of the theorem of virtual work (cf [bib2])*



*conduit to define as deformation the unit formed by the tensors  $E$  and  $K$  and the vector all these sizes being defined in the tangent plan by:*

$$E = (U + U$$

,

,)

2

1

$$K = (L + L$$

,

,)

2

$$= L + W$$

,

*The deformation is thus defined by 7 realities.*

*$E$  are the membrane deformations,*

*$K$  are the opposite of the curves of the deformed average layer,*

*is the vector of deformation of distortion.*

*Note:*

*There still, there is no universal convention and the disparity of conventions is still larger than for the tensors of efforts. The ENPC adopts a convention reverses for tensor  $K$  for obvious geometrical ratios.*

*Bond with the three-dimensional field of deformation*

*Under these conditions, one a:*

$$= E + X$$

 $K$ 

3

=

3

=

33

0.

2.2

*Sizes associated in Aster*

### *2.2.1 DEPL\_R and DEPL\_C*

*Sizes DEPL\_R and DEPL\_C have as components the degrees of freedom of modeling by finite elements and thus do not have necessarily only the components of the fields of displacement who are:*

*DX*

*DY*

*DZ*

*with which it is necessary to associate for the beams or the hulls:*

*DRX*

*DRY*

*DRZ*

*For the hulls, we need the three components of the vector of rotation, because the equation with finite elements can be expressed only in one total Cartesian reference mark.*

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## ***2.2.2 EPSI\_R***

***Size EPSI\_R represents the structural deformations, therefore it must have, at least, components:***

.  
***fields of deformations of the continuous mediums (in total reference mark):***

***EPXX EPYY EPZZ EPXY EPXZ EPYZ***

.  
***fields of deformations of beam (in local reference mark with the beam):***

***EPXX  
GAXY  
GAXZ  
KY  
KZ  
GAT***

.  
***fields of deformations of hull (necessarily in local reference mark on the surface)***

***EXX  
EYY  
EXY  
KXX  
KYY  
KXY  
GAX  
GAY***

## ***2.3 Options of calculation***

***2.3.1 Prefixes: EPSI\_ELGA\_DEPL,  
EPME\_ELGA\_DEPL,  
EPSG\_ELGA\_DEPL,  
EPMG\_ELGA\_DEPL***

*They are the options which calculate the fields of deformations at the points of integration of the elements.*

*Option of calculation*

*Reference symbol of Calculation carried out*

*3D Pipes,*

*Hulls,*

*concept RESULT*

*Beams multi\_fibres plates*

*EPSI\_ELGA\_DEPL idem*

*starting from a field*

*not*

*of displacement in*

*in local reference mark*

*small deformations*

*6 components*

*EPSP\_ELGA\_DEPL idem*

*Tensor of Green-*

*not*

*not*

*Lagrange to be left*

*of a field of*

*displacement*

*EPME\_ELGA\_DEPL idem*

*starting from a field m not*

*not*

*of displacement and*

*of a field of*

*temperature in*

*small deformations*

*EPMG\_ELGA\_DEPL idem*

*Tensor of Green- m not*

*not*

*Lagrange to be left*

*of a field of*

*displacement and of one*

*field of*

*temperature*

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**2.3.2 Prefixes: EPSI\_ELNO\_DEPL,  
EPME\_ELNO\_DEPL,  
EPSG\_ELNO\_DEPL,  
EPMG\_ELNO\_DEPL**

**They are the options which calculate the fields of deformations whatever the modeling at ends of exploitation (impression or postprocessing of visualization) to the nodes of the structure.**

**Option of calculation**

**Reference symbol of Calculation carried out**

**3D Beams,**

**Hulls, plates**

**concept RESULT**

**Pipes,**

**in 1 selected point**

**Beams multi\_fibres in the thickness**

**(inf, moy, sup)**

**EPSI\_ELNO\_DEPL idem**

**starting from a field**

**in local reference mark:**

**of displacement in**

**in local reference mark**

**6 components**

**small deformations**

**6 components**

**EPSG\_ELNO\_DEPL idem**

*Tensor of Green-  
not  
not  
Lagrange to be left  
of a field of  
displacement  
EPME\_ELNO\_DEPL idem  
starting from a field m not  
not  
of displacement and  
of a field of  
temperature in  
small deformations  
EPMG\_ELNO\_DEPL idem  
Tensor of Green- m not  
not  
Lagrange to be left  
of a field of  
displacement and of one  
field of  
temperature*

### *2.3.3 Prefixes*

*:*  
*DEGE\_ELNO*

*They are the options which calculate the deformations generalized on the elements of beam or of hull at ends of exploitation (impression or postprocessing of visualization) to the nodes of structure.*

*Option of calculation  
Name  
Calculation carried out  
3D  
Beams, beams Plates,  
symbolic system of  
multifibre  
Coques1D  
concept  
RESULT  
DEGE\_ELNO\_DEPL  
idem*

*starting from a field of  
(,)*

*displacement into small not  
(E, K,  
deformations  
in local reference mark  
in local reference mark*

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**Version**

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**Titrate:**

**Definition of initial fields for STAT\_NON\_LINE**

**Date**

**:**

**30/11/01**

**Author (S):**

**J. Key PELLET**

**:**

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**Organization (S): EDF/MTI/MMN**

**Instruction manual**

**U2.01 booklet:**

**Document: U2.01.09**

**Analytical definition of a stress field  
and of a field of internal variables initial**

**Summary:**

*It is explained how to manufacture two of the fields constituting the initial state of a non-linear calculation*

*(STAT\_NON\_LINE): the stress field and the field of internal variables.*

- the components of the stress field must have an “analytical” form (for example: state of a ground subjected to the “weight of the grounds”),*
- the components of the field of variables intern are nonnull constants.*

*In both cases, the solution consists in connecting a certain number of orders CREA\_CHAMP.*

*For the stress field, the difficulty consists in evaluating the “analytical formulas” (OPERATION=' EVAL').*

*For the field of internal variables, the difficulty comes owing to the fact that the size associated with the internal variables*

*(VARI\_R) has a number a priori unspecified of components: “V1”, “V2”,...*

*The solutions suggested are implemented in test ZZZZ130A.*

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*1*

*Definition of the analytical stress field*

*It is supposed that the model contains finite elements of continuous medium (MODELISATION=' 3D').*

*It is wanted that in each point of Gauss, the components of the constraints have the expressions following:*

$$SIZZ = RHO * G * Z$$

$$SIXX = SIYY = KP * SIZZ$$

where:

**RHO:** density

**G:** acceleration of gravity

**Z:** 3<sup>ème</sup> coordinated of space

**KP:** coefficient of “pushed” of the grounds

The solution suggested consists with:

- 1) to define three functions “formulas” corresponding to SIXX, SIYY and SIZZ,
- 2) to constitute a field whose components are the preceding functions,
- 3) to evaluate the formulas of the field by providing him the field of geometry necessary to their evaluation.

### 1.1

Stage 1: to define the formulas

$$RHO=1000.$$

$$G=10.$$

$$KP=3.$$

$$SIZZ = FORMULA (REEL= '''' (REAL: Z) = RHO * G * Z '''' )$$

$$SIXX = FORMULA (REEL= '''' (REAL: Z) = KP * SIZZ (Z) '''' )$$

$$SIYY = FORMULA (REEL= '''' (REAL: Z) = KP * SIZZ (Z) '''' )$$

### 1.2

Stage 2: to create the field of formulas SIG1

$$SIG1=CREA\_CHAMP (OPERATION=' AFFE', TYPE\_CHAM=' ELGA\_NEUT\_F',$$

$$MODELE=MO, PROL\_ZERO=' OUI',$$

$$AFFE=_F (ALL = “YES”, NOM\_CMP = (“X1”, “X2”, “X3”),,$$

$$VALE\_F = (SIXX, SIYY, SIZZ,))$$

### Remarks

- the field SIG1 which one creates is a cham\_elem at the points of Gauss (ELGA),
- the only fields being able to have components of the type “functions” are the fields of size NEUT\_F. It will thus have to be remembered that the CMP “X1” of SIG1 is actually “SIXX”, etc...,
- key word PROL\_ZERO=' OUI' is obligatory bus for all the types of element, them cham\_elem\_NEUT\_R currently has 6 components: “X1”, “X2”,..., “X6”. It is necessary thus to agree “to prolong” by zero the field out of the 3 nonaffected components.

*prolongation by “zero” for a field whose components are texts (names of functions) consists in assigning the chain ““to each component absent from the field. Attention thus, it is not a question of a null function. One can note it while using INFO=2 to print field SIG1.*

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*1.3*

*Stage 3: to evaluate the formulas of field SIG1*

*Field SIG1 is a field known at the points of Gauss of the elements of the model. In each point, one will want to evaluate functions SIXX, SIYY and SIZZ. For that, it is necessary to have the values of all variables appearing in functions (here Z). These variables must be known on same points as the field of functions. It is thus necessary to have a field containing the geometry of points of Gauss (cham\_elem\_GEOM\_R/ELGA).*

*This field of geometry of the points of Gauss (CHXG) is obtained starting from grid (MA) by the 2 following orders:*

*CHXN=CREA\_CHAMP (OPERATION=' EXTR', TYPE\_CHAM=' NOEU\_GEOM\_R',  
NOM\_CHAM=' GEOMETRIE', MAILLAGE=MA)*

*CHXG=CREA\_CHAMP (OPERATION=' DISC', TYPE\_CHAM=' ELGA\_GEOM\_R',  
MODELE=MO, CHAM\_GD=CHXN)*

*The first order extracts the field from geometry (with the nodes) of the grid. The second transform the field of geometry to the nodes into a field of geometry at the points of Gauss in*

*using the functions of form of the finite elements of the model.*

*One can then evaluate the functions thanks to operator CREA\_CHAMP/OPERATION=' EVAL':*

*SIG2=CREA\_CHAMP (OPERATION=' EVAL', TYPE\_CHAM=' ELGA\_NEUT\_R',  
MODELE=MO, CHAM\_F=SIG1, CHAM\_PARA= (CHXG,))*

*Field (SIG2) obtained by evaluation of a field of size NEUT\_F is a field of  
size NEUT\_R whose components have the same names as the components of NEUT\_F:  
"X1", "X2",..., "X6".*

**Caution:**

*The components "X4", "X5", "X6" are indefinite (actually they contain reality it  
larger possible), because they correspond to a non-existent function.*

*It still remains to change the size of field SIG2 (NEUT\_R - > SIEF\_R) to finish  
manufacture of our analytical stress field:*

*SIGINI=CREA\_CHAMP (OPERATION=' ASSE', TYPE\_CHAM=' ELGA\_SIEF\_R',  
MODELE=MO, PROL\_ZERO=' OUI',  
ASSE=\_F (ALL = "YES", CHAM\_GD = SIG2,  
NOM\_CMP = ("X1", "X2", "X3"),,  
NOM\_CMP\_RESU = ("SIXX", "SIYY", "SIZZ",)))*

**Note:**

*· only the components "X1", "X2" and "X3" of field SIG2 are recopied in this  
operation to give components "SIXX", "SIYY", "SIZZ" of field SIGINI.*

*This stress field must also contain the components related to  
shearings ("SIXY", "SIYZ", "SIXZ"). To obtain them (with a zero value), it is necessary  
to use the prolongation by zero (PROL\_ZERO=' OUI'),*

*· handling made to obtain the null components of shearing, would have been  
simpler if there were explicitly affected on these 3 components a null function.*

*One would not have had "to play" with the prolongations. But one would have profited from  
coincidence which sizes SIEF\_R and NEUT\_R have all the two 6 components  
for cham\_elem (ELGA) on the elements of the model.*

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***Definition of initial fields for STAT\_NON\_LINE***

***Date***

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***2***

***Definition of the field of variables intern not no one***

***2.1 Problem***

***One wants to create a field of initial internal variables for order STAT\_NON\_LINE. This field does not have to be null everywhere. More precisely, one wants:***

***STAT\_NON\_LINE:***

***COMP\_INCR= (\_F (GROUP\_MA=' MASSIF', RELATION = "CJS"),***

***\_F (GROUP\_MA=' BETON', RELATION = "ENDO\_LOCAL"),),***

***for the relation of behavior "CJS" (16 variables intern), one wants to affect:***

***V1 = 1.0 and V9 = 9.0***

***for the relation of behavior "ENDO\_LOCAL" (2 variables intern), one wants to affect:***

***V2 = 2.0***

***2.2 1st***

***method***

***The operator to be used is CREA\_CHAMP/OPERATION=' AFFE'. He makes it possible to affect (by mesh or***

***GROUP\_MA) the values which one wishes. The difficulty comes owing to the fact that the size associated with***

***internal variables (VARI\_R) is different from the different one: one does not know a priori which are its***

***components. Moreover the name of its components translates this ignorance: "V1", "V2",...***

***According to the behavior which the user in STAT\_NON\_LINE will choose, the number of variables interns changes. In our example, behavior "CJS" requires 16 variables whereas***

***"ENDO\_LOCAL" uses only 2 of them.***

***The operation of assignment is thus done in two stages: one creates initially a CHART of NEUT\_R***

**(VAIN1)**

**with ALL the components wanted including the null components:**

```
VAIN1=CREA_CHAMP (OPERATION=' AFFE', TYPE_CHAM=' CART_NEUT_R',  
MODELE=MO,  
AFFE= (  
_F (GROUP_MA= "CONCRETE", NOM_CMP= ("X1", "X2"), VALE = (0. , 2. ,)),  
_F (GROUP_MA= "MASSIVE",  
NOM_CMP= ("X1", "X2", "X3", "X4", "X5", "X6", "X7", "X8", "X9", "X10",  
"X11", "X12", "X13", "X14", "X15", "X16"),  
VALE = (1. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 9. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,)),  
)  
)
```

**One transforms then carte\_NEUT\_R into cham\_elem\_VARI\_R (VAIN11):**

```
VAIN11=CREA_CHAMP (OPERATION=' ASSE', TYPE_CHAM=' ELGA_VARI_R',  
MODELE=MO,  
ASSE= (  
_F (CHAM_GD = VAIN1, GROUP_MA= "CONCRETE",  
NOM_CMP= ("X1", "X2"),  
NOM_CMP_RESU= ("V1", "V2"),),  
_F (CHAM_GD = VAIN1, "MASSIVE" GROUP_MA=  
NOM_CMP= ("X1", "X2", "X3", "X4", "X5", "X6", "X7",  
"X8", "X9", "X10", "X11", "X12", "X13",  
"X14", "X15", "X16"),  
NOM_CMP_RESU= ("V1", "V2", "V3", "V4", "V5", "V6",  
"V7", "V8", "V9", "V10", "V11", "V12",  
"V13", "V14", "V15", "V16"),),  
)  
)  
)
```

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**Note:**

*It is very important for non-linear calculation to come that the field of variables intern is coherent with the behaviors which one will choose. Here, it is necessary that the meshes of the group “CONCRETE” have 2 internal variables (and only 2) and those of the “MASSIVE” group have some 16.*

**Caution:**

*If the model comprises other types of behavior (for which one does not wish to initialize the field with nonnull values), it is also necessary to explicitly affect to them zero values. This disadvantage (of having to know ALL the behaviors used and their number of variables intern) can be raised with the 2nd method below (but it is more complicated).*

### **2.3 2nd method**

*This method (more complicated) makes it possible to affect explicitly only the meshes which have nonnull components.*

*The problem is to obtain a field containing the good number of internal variables for each mesh according to the behavior which will be affected for him in STAT\_NON\_LINE. To solve this problem, one will carry out a non-linear calculation “can” (with the real behaviors). The field of variables interns produced will be then a “model” good of field.*

*One will thus make:*

*1) non-linear calculation can => UBID*



- 2) extraction of the field of variables intern (VBID) result UBID
- 3) assignment of the nonnull values in field VAIN2
- 4) put at zero of VBID + overload of the values of VAIN2 to produce result VAIN22

### 2.3.1 non-linear calculation can

**BETON=DEFI\_MATERIAU (ELAS=\_F (E = 20000. , NAKED = 0.),  
ECRO\_LINE=\_F (SY = 6. , D\_SIGM\_EPSI = -10000.) )**

**MASSIF=DEFI\_MATERIAU (ELAS=\_F (E = 35.E3, NAKED = 0.15),  
CJS=\_F (BETA\_CJS = -0.55, GAMMA\_CJS = 0.82, PA = -100.0,  
RM = 0.289, N\_CJS = 0.6, KP = 25.5E3, RC = 0.265, A\_CJS =  
0.25, ) )**

**CHMAT=AFFE\_MATERIAU (MAILLAGE=MA, AFFE= (  
\_F (GROUP\_MA = "MASSIVE", MATER = MASSIVE),  
\_F (GROUP\_MA = "CONCRETE", MATER = CONCRETE),))**

**TEMPS1=DEFI\_LIST\_REEL (VALE= (0. , 1.) )  
CHAR\_U1=AFFE\_CHAR\_MECA (MODELE=MO,  
DDL\_IMPO=\_F (NODE = ("N1", "N2", "N3"), DX=0., DY=0., DZ=0.))**

**UBID=STAT\_NON\_LINE (MODELE=MO, CHAM\_MATER=CHMAT,  
EXCIT=\_F (LOAD = CHAR\_U1),  
COMP\_INCR= (\_F (GROUP\_MA='MASSIF', RELATION = "CJS"),  
\_F (GROUP\_MA='BETON', RELATION = "ENDO\_LOCAL"),),  
NEWTON=\_F (MATRIX = "ELASTIC"),  
CONVERGENCE=\_F (STOP = "NOT", # to continue without convergence  
ITER\_GLOB\_MAXI = 1, ITER\_INTE\_MAXI = 1),  
INCREMENT=\_F (LIST\_INST = TEMPS1),  
)**

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### **2.3.2 Recovery of the field of variables intern “model”**

**VABID=CREA\_CHAMP (OPERATION=' EXTR', TYPE\_CHAM=' ELGA\_VARI\_R', INFO=1,  
NOM\_CHAM=' VARI\_ELGA', RESULTAT=UBID, NUME\_ORDRE=1,)**

**Note:**

**VABID is not null.**

### **2.3.3 Assignment of the nonnull values in a cham\_elem\_NEUT\_R**

**VAIN2=CREA\_CHAMP (OPERATION=' AFFE', TYPE\_CHAM=' CART\_NEUT\_R',  
MODELE=MO,  
AFFE= (  
\_F (GROUP\_MA= “CONCRETE”, NOM\_CMP= (“X2”,), VALE = (2. ,)),  
\_F (GROUP\_MA= “MASSIVE”, NOM\_CMP= (“X1”, “X9”,), VALE = (1. , 9. ,)),  
)  
)**

### **2.3.4 Zero setting of the field of variables intern “model” and overload of the values nonnull**

**VAIN22=CREA\_CHAMP (OPERATION=' ASSE', TYPE\_CHAM=' ELGA\_VARI\_R',  
MODELE=MO,  
# put at zero:  
ASSE= (\_F (TOUT= = “YES”, CHAM\_GD = VABID, CUMUL=' OUI', COEF\_R=0.),  
# overloads nonnull values:  
\_F (GROUP\_MA= “CONCRETE”, CHAM\_GD = VAIN2, CUMUL=' OUI', COEF\_R=1.,  
NOM\_CMP= (“X2”,), NOM\_CMP\_RESU= (“V2”,,)),  
\_F (GROUP\_MA= “MASSIVE”, CHAM\_GD = VAIN2, CUMUL=' OUI', COEF\_R=1.,  
NOM\_CMP= (“X1”, “X3”), NOM\_CMP\_RESU= (“V1”, “V9”,,)),  
)  
)**

**Notice;**

*For the zero setting and overloads it nonnull values, one uses the key words  
CUMUL=' OUI' and COEF\_R.*

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## ***Note of use on the choice of the finite elements***

### ***Summary:***

***The purpose of this document is to give some information on the choice of the finite elements and their modeling associated in the case of studies thermal, thermomechanical or mechanical non-linear. It acts in some kind, to propose with the user a choice a priori, allowing to avoid certain current errors. In cases of particular difficulties, other choices could be made.***

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### ***1 Introduction***

***One gives in this document the choices a priori which can be made concerning the finite elements.***

***One***

***was placed in the case of a thermomechanical chaining but the councils are valid on***

***thermal or mechanical not chained calculations (linear or not). A fast justification is given.***

***For more details on the justification of these choices, the user will be able to refer to the documents R of***

***Code\_Aster like with the note H [bib1].***

## 2

### *Choice a priori*

#### 2.1

#### *grid*

*The elements can be indifferently:*

.  
*triangular elements or quadrangles in 2D,*

.  
*tetrahedrons or hexahedrons in 3D.*

*Indeed, contrary to the often spread idea, the elements of the triangle type or tetrahedron give good results, even in plasticity, in condition of course of not using a grid too much coarse. The advantage of this family of elements, it is that it makes it possible to use the software LOBSTER which*

*carry out the adaptation of grids 2D/3D for finite elements of type triangular or tetrahedral by refinement and déraffinement. One can thus obtain the optimum grid according to an indicator of error (cf [R4.10.01], [R4.10.02], [R4.10.03], or the case test TPLL01j [V4.02.01] for one demonstration) by call to order MACR\_ADAP\_MAIL in the command file Aster.*

*On the other hand, it is advised to use:*

.  
*linear elements in thermics for chained calculations and calculations of thermics fast transient. For the other cases, one can also choose quadratic elements,*

.  
*quadratic elements in mechanics.*

*This choice is all the more important when one carries out thermal chained calculations then mechanics. It is then necessary to use two grids for thermics and mechanics. Two strategies are then possible:*

.  
*that is to say independently to net the structure for thermal calculation and mechanical calculation*

.  
*that is to say to carry out a grid with linear elements then to transform it into grid quadratic thanks to the order CREA\_MAILLAGE, key word factor LINE\_QUAD.*

*Whatever the method chosen, one can optimize separately each grid with Homard grace with the thermal and mechanical indicators of error available in Aster (cf case-test forma05b*

[V6.03.120]).

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*Note:*

**1) This remark is addressed to the users of GIBI which were accustomed to netting their structures with quadrangles or cubes and which would wish “to rock” them grid towards triangles or tetrahedrons.**

**In general, to net with tetrahedrons instead of cubes, it is not enough to change in the command file *OPTI DIME 3 ELEM CU20* by *OPTI DIME 3 ELEM TE10*.**

**Indeed, a certain number of orders GIBI are specific to the cubes and do not function to net a structure with tetrahedrons (or do not give it anticipated result). The user can thus be tempted to keep his command file initial and to use at the end of the process of creation of grid order *CHAN TET4* to make the swing.**

**By experiment, we dis advise to the users making this choice for several reasons. First of all, on certain grids, one observed a not-convergence of solution when one used an increasingly fine grid obtained by this method. In more, the change is effective only on volume: the surface meshes are always quadrangles what poses problem to impose the boundary conditions in Aster. Lastly, to net with *TETRA10*, it is necessary to pass by the stage *TETRA4* then to make *QUADRATIC CHAN*. However this change poses problem for *SEG2*.**

**Consequently, with GIBI, it is important to net directly the structure with good elements leaves to have to rewrite its command file. One also announces,**

*that in certain cases, GIBI does not manage to net with tetrahedrons when one asks an important refinement. It is then enough to net coarsely, then to refine it uniform grid of way or not with the software Lobster.*

*2) It is pointed out here that all the sizes of the type forced or deformation are calculated at the points of Gauss, and that any passage to the nodes involves a skew. That is of as much truer when one then seeks to calculate standards; we thus noticed that the tetrahedrons were more sensitive than the hexahedrons to the method of calculation of equivalent constraints for example. It is thus necessary to have an eye even more critical on results calculated with the nodes.*

## **2.2 modeling**

*That it is for the resolution of the thermal or mechanical problems, several modelings are available in Aster. These various modelings can be characterized by the number or the type degrees of freedom, the number of points of integration, treatments particular... According to calculation carried out, some of course are adapted than of others.*

### **2.2.1 In thermics**

*To make thermal calculation in Aster, two types of modelings are accessible ([U3.23.01], [U3.24.01], [R3.06.02], [R3.06.07]):*

*·  
traditional finite elements: modeling 3D, AXIS or PLAN*

*·  
finite elements lumpés or diagonalized  
: modeling 3D\_DIAG, AXIS\_DIAG or  
PLAN\_DIAG*

*We propose like choice by defect:*

*modeling with linear elements  
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### **Justification**

***In thermics, the step of time  $T$  cannot be unspecified, it must check a condition***

***$T$***

***$min < T$***

***$< T$***

***$max, T$***

***$min$  and  $T$***

***$max$  depending on the properties materials, the size of the elements stop and parameters of temporal integration (cf [R3.06.07]).***

***In the case of fast transitory problems of thermics, one can be brought to use a step of too small time. One can then observe oscillations of the solution and temperatures not physics due to the violation of the principle of the maximum (temperature higher than the initial temperature***

***of a part which one cools). The modeling DIAG, which consists with diagonaliser the matrix of mass, allows to free itself from the condition on  $T$   $min$  and to avoid the associated problems.***

***Let us note however that this diagonalisation is not enough to remove the oscillations with quadratic elements. However, in Aster, a particular treatment is made for the elements 2D: the triangles are automatically cut in linear finite elements which themselves are lumpés.***

### **2.2.2 In mechanics**

***Three types of modelings are available to solve problems of non-linear mechanics using “traditional” laws of behavior (of the elastoplasticity type):***

***.***

***isoparametric traditional finite elements: 3D, D\_PLAN, C\_PLAN, AXIS ([U3.14.01], [U3.13.01]),***

***.***

***under-integrated elements***

***: 3D\_SI, D\_PLAN\_SI, C\_PLAN\_SI, AXIS\_SI ([U3.14.01],***



[U3.13.05]),

.

*elements being based on an quasi-incompressible formulation*

*: 3D\_INCO,*

*D\_PLAN\_INCO, AXIS\_INCO ([U3.14.06], [U3.13.07], [R3.06.08]).*

*We propose like choice a priori to use:*

*quadratic elements*

*With regard to the choice of modeling, it is a function of the type of elements and the need to treat the condition of incompressibility. These considerations are summarized in the table below.*

*normal*

*quasi-incompressible*

*(strong*

*plasticity or >0.45)*

*standard triangles/tetrahedrons*

*INCO*

*quadrilaterals/hexahedrons*

*IF*

*IF or INCO*

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## ***Justifications and precautions:***

*If the material is quasi-incompressible ( $> 0.45$ ), it is preferable to use the formulation INCO, because the standard formulation in displacement does not give good results.*

*The plastic flow is done with constant volume. This condition of incompressibility can cause difficulties with traditional modeling of knowing a too rigid behavior and especially appearance of oscillations on the level of the constraints. Under-integration allows to improve these problems, because one then checks the condition of incompressibility in less points of Gauss. However, only elements QUAD8 and HEXA20 are really under-integrated, for the other meshes, it is the traditional integration which is preserved. In consequence, when phenomena of oscillations are observed for a grid composed of triangles or tetrahedrons, it is preferable to use formulation INCO. This improve the result clearly but calculations will be longer.*

*In the case general, under-integrated modeling gives of as good results as them traditional finite elements, and this for a faster computing time since one uses less points of Gauss. In the case of thermomechanical calculations, that allows to limit the difficulties at the time of the passage of the thermal deformation of origin to calculation mechanics when refinements of the grids thermics and mechanics differ. However, under-integration can sometimes lead to the appearance of parasitic modes. If at the end of calculation the deformation presents this kind of nonphysical modes of deformation, it is better to make calculation with traditional or quasi-incompressible modeling if levels of plasticity are very important.*

## **3 Implementation Aster**

*One points out here the principal stages of Aster calculation in the case of a calculation in plane deformations, while specifying explicitly where the specifications intervene about which one spoke. For the part mechanics, one wrote in fat what is specific to the case of a thermomechanical calculation.*

### **3.1 Study Thermics**

#### ***Reading of the thermal grid***

***PRE\_GIBI (UNITE\_GIBI=19,  
PRE\_GMSH (UNITE\_GMSH=19,  
UNITE\_MAILLAGE=20,)***

***UNITE\_MAILLAGE=20,)***

***MA=LIRE\_MAILLAGE (UNITE=20,)***

***MA=LIRE\_MAILLAGE (UNITE=20,)***

.

***Choice of the thermal model***

***MOTH2D=AFFE\_MODELE (MAILLAGE=MA,  
VERIF=' MAILLE',  
AFFE=\_F (GROUP\_MA= ("GMA1", "GMA2",...),  
PHENOMENE=' THERMIQUE',  
MODELISATION=' PLAN\_DIAG',,))***

.

***Thermal properties of material***

.

***Thermal loading***

.

***THER\_LINEAIRE or THER\_NON\_LINE***

***THER =...***

.

***Post possible treatments***

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### **3.2 Study mechanics**

.  
**Mechanical reading grid**

**PRE\_GIBI () or PRE\_GMSH ()**  
**MAME=CREA\_MAILLAGE (**  
  
**GRID = MA,**  
**MAME=LIRE\_MAILLAGE ()**  
**LINE\_QUAD=\_F (TOUT=' OUI'))**

.  
**Definition of the mechanical model**  
**MOME=AFFE\_MODELE (MAILLAGE=MAME,**  
**VERIF=' MAILLE',**  
**AFFE=\_F (GROUP\_MA= ("GMA1", "GMA2",...),**  
**PHENOMENE=' MECANIQUE',**  
**MODELISATION=' D\_PLAN\_SI',,));**

.  
**Projection of thermal calculation if calculation chained on 2 different grids**  
**CHTHER=PROJ\_CHAMP (METHODE=' ELEM',**  
**RESULTAT=THER,**  
**MODELE\_1=MOTH2D,**  
**MODELE\_2=MOME,);**

.  
**Mechanical characteristics of material**

...

**CHMAT = AFFE\_MATERIAU (GRID = MAME,**  
**AFFE**  
**=**  
**F (TEMP\_REF = 20. ,...)**

.  
**Mechanical and thermal loading**

**CLIM=AFFE\_CHAR\_MECA (MODELE=MOME,**  
**TEMP\_CALCULEE=CHTHER or THER if not of projection,**

*DDL\_IMPO= (...),  
...);*

*STAT\_NON\_LINE*

*Postprocessings*

#### *4 Bibliography*

*[1]*

*S. MICHEL-PONNELLE, A. RAZAKANAIVO: Quality of the Studies in Mechanics of the Solids: study of the finite elements. Note EDF HT-64/02/007/B*

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*A. ASSIRE, P. MASSIN, F. LEBOUVIER Key*

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*Organization (S): EDF/AMA, DeltaCAD*

***Instruction manual  
U2.02 booklet: Elements of structure  
Document: U2.02.01***

***Note of use of the elements plates and hulls***

***Summary:***

***This document is a note of use for modelings plates and hulls.***

***The elements of hulls and plates play a part in the numerical modeling of the mean structures with surface average, planes (modeling plates) or curve (modeling hulls).***

***They are usable in or not linear linear mechanics and thermics.***

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## **1 Introduction**

*The elements of hulls and plates are particularly used to model structures thin where the relationship between dimensions (characteristic thickness/length) is much lower than 1/10 (thin hulls) or of the order de 1/10 (thick hulls).*

*These modelings are usable in linear and nonlinear mechanics, under assumption of small deformations and small displacements or many assumptions of great displacements and of great rotations, according to modelings. A mean modeling of hull is also available in transitory linear thermics.*

*Two categories of thin elements of structures are described in this document:*

*The elements of plates, which are plane, therefore the curve of the structure to be represented is not ideally not taken into account and it is necessary to use a great number of elements of way to approach correctly the geometry of the structure (aspect facets).*

*The elements of hulls, which are curved, therefore the geometry of the structure is better approached.*

*Concerning the nomenclature and the reference materials associated with each one of modelings:*

*the plane elements of plates triangle and quadrangle are gathered under modelings, (reference material [R3.07.03]):*

*DKT: net TRIA3 element DKT, mesh QUAD4 elements DKQ (linear geometrical);*

*DST: net TRIA3 DST element, mesh QUAD4 element DSQ (linear geometrical);*

*Q4G: net QUAD4 element Q4G (linear geometrical);*

*the elements of curved hulls resulting from models 3D with a kinematics of hull are gathered under modelings:*

*COQUE\_3D: net TRIA7 and QUAD9, structure 3D with unspecified geometry ([R3.07.04] into linear geometrical, [R3.07.05] into linear geometrical and [R3.03.07] with following pressures);*

*COQUE\_AXIS: net SEG3, hulls with symmetry of revolution around the axis 0Y ([R3.07.02] into linear geometrical);*

*COQUE\_C\_PLAN or COQUE\_D\_PLAN: net SEG3, hulls with invariant geometry it length of axis OZ ([R3.07.02] into linear geometrical).*

*A characteristic: for studies on reinforced concrete structures, elements of plates specific were developed to represent the tablecloths of reinforcement made up of two metal reinforcements with 90° one compared to the other (case more general for the concrete structures armed). They are elements of orthotropic plates DKT to 3 nodes offset compared to the layer means out of concrete. This last is modelled by elements of plates DKT or DST with 3 nodes. One for the tablecloths of reinforcement a modeling defines ROASTS which uses the elements of plates DKT with 3 usual nodes. The reinforced concrete structure is then represented by the superposition of modelings ROASTS and of that used for the concrete (DKT or DST).*

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## **2 Mechanics**

### **2.1**

#### **Capacities of modeling**

##### **2.1.1 Recall of the formulation**

###### **2.1.1.1 Géométrie of the elements plates and hulls**

***For the elements plates and hulls one defines a surface of reference, or surfaces average, plane (plan  $Xy$  for example) or curve ( $X$  and define a whole of curvilinear co-ordinates in it) and one thickness  $H(X, y)$ . This thickness must be small compared to other dimensions of the structure with to model. The figure below illustrates these various configurations.***

#### **Solid 3D**

**Z**

**H**

**Y**

**B**

**X**

**L**

**Thickness  $H < L, B$**

**Z**

**Z**

**y**

**y**

**H**

*N*  
*N*  
*X*  
*X*  
*B*  
*H*  
*L*  
*L*  
*B*  
*Plate*  
*Hull*

*Appear 2.1.1.1 - has: Assumption in theory of the plates and the hulls*

*One attaches to average surface a local reference mark  $Oxyz$  different from total reference mark  $OXYZ$ . The position points of the plate or hull is given by the curvilinear co-ordinates  $(1,2)$  of surface average and rise 3 compared to this surface. For the plates the frame of reference curvilinear is a local Cartesian frame of reference.*

*2, y*  
*N,*  
*\_3, Z*  
*Z*  
*Y*  
*, X*  
*1*  
*O*  
  
*X*

*Appear 2.1.1.1 - B: Definition of an average surface*  
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*To represent hulls with symmetry of revolution around an axis (COQUE\_AXIS) or hulls with invariant geometry by translation (COQUE\_C\_PLAN in plane constraints or COQUE\_D\_PLAN in plane deformations), the knowledge of the section of revolution or the trace of surface average is sufficient, as the figure [2.1.2.1 Figure - has] shows it to us. These hulls rest on a linear grid and in a point m of average surface one defines a local reference mark (N, T, ez) by:*

*Om  
T =  
, S; N T = E  
Om  
Z.  
, S*

*When one wishes to model a solid of an unspecified form (not plan), one can use elements of hulls to account for the curve, or many elements of plates. In it last case, the geometry is approximated by a network of facets.*

*Solid complete 3D*

*Z  
Y  
X  
Z  
Z  
y  
y  
N  
X  
N  
X*

*Elements of plates: facets*

*Elements of hulls*

*Appear 2.1.1.1 - C: Modeling of an unspecified solid 3D by elements of plates or hulls*

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## **2.1.2 Formulation of the elements plates and hulls**

### **2.1.2.1 Formulation into linear geometrical**

**In this formulation, one supposes that displacements are small, one can thus superimpose initial geometry and deformed geometry. These elements are based on the theory of the plates according to which:**

**.  
the cross-sections which are the sections perpendicular to the surface of reference remain right-hand sides; material points located on a normal at not deformed average surface remain on a line in the deformed configuration. It results from this approach that the fields of displacement vary linearly in the thickness of the plate or of hull. If one indicates by  $U$ ,  $v$  and  $W$  displacements of a point  $Q (X, y, Z)$  according to  $X$ ,  $y$  and  $Z$ , one has as follows:**

**$U (X,$   
 $y Z) U (X, y)$   
 $(X, y)$**

**X**

$$v(X, y) Z = v(X, y) + Z(X, y)$$

$$W(X, y) Z = W(X, y)$$

0

*The associated tensor of deformation is written then:  $(X, y) Z = E(X, y) + (X, y) + Z(X, y)$ .*

*first term  $E$  includes/understands the deformations of membrane (for an element of plate it are the deformations in the plan of the element), the second those of shearing transverse, and third  $Z$  deformations of inflection, associated the tensor of curve. For the thick plates or hulls transverse shearings are taken in account following the formulation suggested by Reissner, Hencky, Bollé, Mindlin. This formulation includes the approach without transverse shearing, where the tensor is null, developed by Kirchhoff for the thin plates or hulls according to which points materials located on a normal  $N$  at not deformed average surface remain on normal on the deformed surface.*

*the transverse constraint is null bus regarded as negligible compared to*

*zz*

*other components of the tensor of the constraints (assumption of the plane constraints).*

*one does not describe the variation thickness nor that of the transverse deformation that one*

*zz*

*can calculate by using the preceding assumption of plane constraints.*

*the taking into account of transverse shearing depends on given factors of correction has priori by energy equivalences with models 3D, so that rigidity in transverse shearing of the model of plate is nearest possible to that defined by the theory of three-dimensional elasticity. For the homogeneous plates, the factor of transverse correction of shearing based on this method is  $k=5/6$ .*



**Note:**

*The determination of the factors of correction rests for Mindlin on equivalences of Eigen frequency associated the mode of vibration by transverse shearing. One obtains then  $K = 2/12$ , value very close to  $5/6$ .*

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*These elements utilize locally:*

.

*five variables kinematics for the elements plates and hulls unspecified; displacements of membrane  $U$  and  $v$  in the datum-line  $z=0$ , transverse displacement  $W$  and rotations  $X$  and  $y$  of the normal on the average surface in the  $yz$  plans and  $xz$  respectively.*

.

*three variables kinematics for the linear elements; displacements  $U$  and  $v$  in datum-line  $z=0$  and rotation  $N$  of the normal to average surface in the  $xy$  plan.*

**Average plan**

**Surface average**

**Trace average surface**

**Z**

**y**

**y**

**Z**

***N***  
***y***  
***X***  
***X***  
***X***  
***T***  
***y***  
***Z***  
  
***Z***  
***y***  
***y***  
***y***  
***y***  
***y***  
***W***  
***W***  
***v***  
  
***v***  
***v***  
***N***  
***X***  
***X***  
  
***X***  
***X***  
***X***  
***U***  
***U***  
***U***

***Plane elements or of plates***  
***Curved elements or of hulls***  
***Linear elements for the hulls***  
***invariant by translation***  
***and axisymmetric hulls***

***Appear 2.1.2.1 - has: Variables kinematics for the various elements of plates and hulls***

***.***  
***three efforts resulting from membrane noted  $N_{xx}$ ,  $N_{yy}$ ,  $N_{xy}$  and three noted moments bending  $M_{xx}$ ,  $M_{yy}$ ,  $M_{xy}$  whatever the element of plate or hull; two noted sharp efforts  $V_x$  and  $V_y$  in the case of elements of plates and unspecified hulls.***

**Z**  
**Vy**  
**Myy**  
**P**  
**P**  
**Vx**  
**Nyy**  
**Myx**  
**y**  
**Nyx**  
**Nxy**  
**Mxx**  
**X**  
**Nxx**  
**Mxy**

*Appear 2.1.2.1 - B: Efforts resulting for an element from plate or hull*

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### **2.1.2.2 Formulation into non-linear geometrical, Buckling of Euler**

*In the formulation into non-linear geometrical, one is in the presence of great displacements and of great rotations, one cannot superimpose the initial geometry and the deformed geometry.*

*The formulation, described in the reference material [R3.07.05], is based on an approach of continuous medium 3D, degenerated by the introduction of the kinematics of hull of the type*

*Hencky-Mindlin-Naghdi in plane constraints in the weak formulation of balance. The measurement of deformations selected is that of Green-Lagrange, vigorously combined with the constraints of Piola-Kirchhoff of second species. The formulation of balance is thus a formulation Lagrangian total. Transverse shearing is treated same manner as in the case linear [R3.07.04].*

*The element retained into non-linear is a voluminal element of hull (COQUE\_3D) of average surface curve as presented at the preceding paragraph, whose meshes supports are QUAD9 and TRIA7.*

*It is possible to apply to these elements of the following pressures, whose formulation is described in the reference document [R3.03.07]. This loading with the characteristic to follow the geometry of the structure during its deformation (for example, the hydrostatic pressure always remains perpendicular with the deformed geometry).*

*Linear buckling also called buckling of Euler, described in the reference material [R3.07.05], is presented in the form of a particular case of the geometrical non-linear problem. It is based on a linear dependence of the fields of displacements, strains and stresses by report/ratio on the level of load.*

*The element retained in linear buckling is the voluminal element of hull (COQUE\_3D) of surface curved average as presented at the preceding paragraph, whose meshes supports are QUAD9 and of the TRIA7.*

### *2.1.3 Comparison enters the elements*

#### *2.1.3.1 differences between the elements plates and hulls*

*The elements of hull are curved elements whereas the elements of plates are plane. variation of metric of the geometry (i.e. its radius of curvature) according to sound thickness is taken into account for the elements of hulls but not for the elements of plates. This variation of metric implies a coupling between the effects of membrane and inflection for nonplane structures which cannot be observed with elements of plate plan for one homogeneous material (see [bib1]).*

*The choice of the functions of form for the discretization of these elements is different bus the elements curved hulls have a more significant number of degrees of freedom. Thus, elements of plates are linear elements out of membrane whereas the elements of hulls are quadratic.*

#### *2.1.3.2 differences between the elements plates*

*One distinguishes the elements with transverse shearing (DST, DSQ and Q4G) from the elements*

*without transverse shearing (DKT and DKQ). Elements DST and DKT have triangular meshes support with 3 nodes ( $3 \times 5 = 15$  ddl) and elements DKQ, DSQ and Q4G of the quadrangular meshes supports to 4 nodes ( $4 \times 5 = 20$  ddl).*

**Important remark:**

*For the elements of plate with 4 nodes (DSQ, DKQ and Q4G), the 4 nodes must be coplanar so that the theory of the plates can be validated. This checking is carried out systematically by Code\_Aster, and the user is alarmed if one elements of the grid does not observe this condition.*

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*In the case of elements with transverse shearing, to avoid the blocking of the elements in transverse shearing (over-estimate of rigidity for very low thicknesses), a method consist in building fields of constant shearing of substitution on the edges of the element, whose value is the integral of shearing on the edge in question. In Code\_Aster, the elements of plate and hull with transverse shearing use this method in order not to block in transverse shearing. This blocking in shearing comes owing to the fact that elastic energy from shearing is a term proportional to  $H$  ( $H$  being the thickness of the plate or the hull) much more large that the elastic term of energy of inflection which is proportional out of  $H^3$ . When the thickness becomes weak in front of the characteristic length (the  $h/L$  report/ratio is lower than  $1/20$ ), for some functions of form, the minimization of the dominating term out of  $H$  leads to bad representation of the modes of pure inflection, for which the arrow is not calculated any more correctly*

(see [bib1] page 295 with  $h/L=0.01$ ).

*Element Q4G is a quadrilateral element with four nodes without blocking in transverse shearing, with bilinear functions of form in  $X$  and to represent  $W$ ,  $X$  and  $Y$ . there It is the same for elements DST and DSQ. The difference between DSQ and Q4G (DST modeling, [bib1]) comes owing to the fact that*

*one uses for the latter of the quadratic functions of form to discretize on each edge rotation  $S$  in the  $sz$  plan where  $S$  is the co-ordinate along the sides. Rotation  $N$  in the  $nz$  plan where  $N$  is the normal at the side directed towards the outside of the element remains discretized with functions of form bilinear (see it [2.1.3.2 Figure - has]).*

**Z**

$s=Lk$

$J(x_j, y_j)$

**K**

**T**

**K**

**N**

**S**

$s=0$

$nk$

$I(x_i, y_i)$

**S**

*Appear 2.1.3.2 - has: Element of plate with transverse shearing*

### *2.1.3.3 differences between the elements hulls*

*One distinguishes the linear elements of hulls COQUE\_C\_PLAN, COQUE\_D\_PLAN and axisymmetric COQUE\_AXIS of the elements of COQUE\_3D.*

*The first are used to model invariant structures according to axis OZ or of revolution of axis OY and seconds in all the other cases. In the case of invariant hulls according to direction Z, one distinguishes the free hulls in Z (forced plane COQUE\_C\_PLAN) from the hulls blocked in Z (plane deformations COQUE\_D\_PLAN). For these elements of hulls, meshes supports are linear with 3 nodes. The number of degrees of freedom of these elements is 9.*

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**The unspecified elements of hulls COQUE\_3D have triangular meshes support with 7 nodes or quadrangular with 9 nodes:**

**.**

**In the case of triangular meshes, the number of degrees of freedom for the translations is 6 (the unknown factors are displacements with the nodes tops and on the mediums on the sides of triangle) and that of rotations are the 7 (unknown factors are 3 rotations at the preceding points and in the center of the triangle). The number of degrees of freedom total of the element is thus of  $N_{dof} = 3 \times 6 + 3 \times 7 = 39$ .**

**.**

**In the case of quadrangular meshes with 9 nodes, the number of degrees of freedom for translations is the 8 (unknown factors are displacements with the nodes tops and on mediums on the sides of the quadrangle) and that of rotations is the 9 (unknown factors are the 3 rotations at the preceding points and the center of the quadrangle). The number of degrees of freedom total of the element is thus of  $N_{dof} = 3 \times 8 + 3 \times 9 = 51$ . These elements thus have about two time more degrees of freedom than the elements of plate of corresponding family DKT. Their cost in time, with an equal number, in a calculation will be thus more important.**

**The elements of COQUE\_3D automatically take into account the correction of metric between surface average and the surfaces upper and lower. For the linear elements, this correction must be activated by the user (see the paragraph [14](#)). The correction of metric brings one contribution in  $h/L$  to the constraint and  $(h/L)^2$  in displacement (see [V7.90.03]). For the plates this correction is without object.**

**For the elements of hulls the coefficient of correction of shearing  $K$  in isotropic behavior can be modified by the user. This coefficient of correction of shearing is given in**

***AFFE\_CARA\_ELEM under key word A\_CIS. By defect, if the user does not specify anything in AFFE\_CARA\_ELEM that amounts using the theory with shearing of REISSNER; the coefficient of shearing is then put at  $k=5/6$ . If the coefficient of shearing  $K$  is worth 1 one places within the framework***

***theory of HENCKY-MINDLIN\_NAGHDI and if it becomes very large ( $10^6 h/L$ ) one brings closer the theory of LOVE\_KIRCHHOFF.***

***In practice it is advised not to change this coefficient. Indeed, these elements provide one physically correct solution, that the hull is thick or thin, with the coefficient  $K = 5/6$ .***

## **2.2**

### ***Orders to be used***

#### ***2.2.1 Space discretization and assignment of a modeling***

***: operator***

#### ***AFFE\_MODELE***

***In this part, one describes the choice and the assignment of one of modelings plates or hulls thus that degrees of freedom and associated meshes. The majority of described information are extracted documentations of use of modelings ([U3.12.01]: Modeling DKT - DST - Q4G, [U3.12.02]: Modelings COQUE\_C\_PLAN, COQUE\_D\_PLAN, COQUE\_AXIS).***

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#### ***2.2.1.1 Degrees of freedom***



*The degrees of freedom of discretization are in each node of the mesh support the components of displacement with the nodes of the mesh support, except indication.*

***Modeling***

***Degrees of freedom (with each node)***

***Remarks***

***COQUE\_3D***

***DX DY DZ DRX DRY DRZ***

***The nodes belong to the layer***

***DRX DRY DRZ with the average central node of the hull***

***DKT***

***DX DY DZ DRX DRY DRZ***

***The nodes belong to the facet***

***tangent with the average layer of the hull***

***DST***

***DX DY DZ DRX DRY DRZ***

***The nodes belong to the facet***

***tangent with the average layer of the hull***

***Q4G***

***DX DY DZ DRX DRY DRZ***

***The nodes belong to the facet***

***tangent with the average layer of the hull***

***COQUE\_C\_PLAN DX DY DRZ***

***The nodes belong to surface***

***average of the hull***

***COQUE\_D\_PLAN DX DY DRZ***

***The nodes belong to surface***

***average of the hull***

***COQUE\_AXIS***

***DX DY DRZ***

***The nodes belong to surface***

***average of the hull***

***ROAST***

***DX DY DZ DRX DRY DRZ***

***The nodes belong to the facet***

***tangent with the average layer of the hull.***

***2.2.1.2 Meshs support of the matrices of rigidity***

***Modeling Nets***

***Element***

***finished***

***Remarks***

**COQUE\_3D TRIA7**

**MEC3TR7H**

***Meshs not presumedly plane***

**QUAD9**

**MEC3QU9H**

**DKT TRIA3**

**MEDKTR3**

***Plane meshs***

**QUAD4**

**MEDKQU4**

**DST TRIA3**

**MEDSTR3**

***Plane meshs***

**QUAD4**

**MEDSQU4**

**Q4G QUAD4**

**MEQ4QU4**

***Plane meshs***

**COQUE\_C\_PLAN SEG3 METCSE3 *Meshs not presumedly plane***

**COQUE\_D\_PLAN SEG3 METDSE3 *Meshs not presumedly plane***

**COQUE\_AXIS SEG3**

**MECXSE3 *Meshs not presumedly plane***

**ROAST TRIA3**

**MEGRDKT**

***Plane meshs***

***Modeling ROASTS used to model the reinforced concrete structures has the same ones characteristics of grid that modeling DKT with triangles. For the moment, this modeling is available only for mesh TRIA3.***

***Note:***

***In a grid, to transform meshs TRIA7 into meshs QUAD9, one can use operator MODI\_MAILLAGE.***

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### **2.2.1.3 Meshs support of the loadings**

*All the loadings applicable to the facets of the elements used here are treated by discretization direct on the mesh support of the element in displacement formulation. Pressure and other forces surface as well as gravity are examples of loadings applying directly to facets. No special mesh of loading is thus necessary for the faces of the elements plates and hulls.*

*For the applicable loadings on the edges of the elements, one a:*

#### **Modeling Nets**

**Element**

**finished**

**Remarks**

**COQUE\_3D SEG3**

**MEBOCQ3**

**DKT SEG2**

**MEBODKT**

**DST SEG2**

**MEBODST**

**Q4G SEG2**

**MEBOQ4G**

**COQUE\_C\_PLAN POI1**

*Meshs support stub to 1 point*

**COQUE\_D\_PLAN POII**

*Meshs support stub to 1 point*

**COQUE\_AXIS POII**

*Meshs support stub to 1 point*

**ROAST**

*Forces distributed, linear, of traction, shearing, the bending moments applied to edges of structures hull are included in this category of loadings.*

#### **Model 2.2.1.4**

:

**AFFE\_MODELE**

*The assignment of modeling passes through operator AFFE\_MODELE [U4.41.01].*

**AFFE\_MODELE**

#### **Remarks**

**AFFE**

**PHENOMENON:**

**“MECHANICAL”**

**MODELING “COQUE\_3D”**

**“DKT”**

**“DST”**

**“Q4G”**

**“COQUE\_C\_PLAN”**

**“COQUE\_D\_PLAN”**

**“COQUE\_AXIS”**

**“GRID”**

#### **Note:**

*It is advisable to check the number of affected elements.*

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### ***2.2.2 Elementary characteristics: AFFE\_CARA\_ELEM***

*In this part, the operands characteristic of the elements of plates and hulls are described.*

*The documentation of use of operator AFFE\_CARA\_ELEM is [U4.42.01].*

***AFFE\_CARA\_ELEM COQUE\_3D***

***DKT***

***DST***

***Q4G***

***COQUE\_C\_PLAN***

***COQUE\_D\_PLAN***

***COQUE\_AXIS***

***HULL*** .

.

.

.

.

***THICK***

.....

.

***ANGL\_REP***

.....

***A\_CIS***

.

.

***COEF\_RIGI\_DRZ***

.....

·  
*OFFSETTING*

·  
·  
·  
*INER\_ROTA*

·  
·  
*MODI\_METRIQUE*

·  
*AFFE\_CARA\_ELEM*

*ROAST*

*ROAST*

·  
*THICK*

·  
*ANGL\_REP* ·

*OFFSETTING*

·  
*ANGL\_L*

·  
*POUR\_CENT\_L*

·  
*POUR\_CENT\_T*

·  
*SECTION\_L* ·

*The easily affected characteristics on the elements of plate or hull are:*

·  
*the constant THICK thickness on each mesh, since the grid represents only it average layer.*

·  
*the coefficient of correction of transverse shearing A\_CIS for the curved hulls isotropic.*

.  
*the taking into account of the correction of metric **MODI\_METRIQUE** enters average surface and surfaces upper and lower (effective only for the **COQUE\_C\_PLAN**, **COQUE\_D\_PLAN**, **COQUE\_AXIS**).*

.  
*a direction of reference **D** defined by two nautical angles given in the total reference mark, by key word **ANGL\_REP**. The projection of this direction of reference on the tangent level to the hull fixes **X1**, the first direction of the local reference mark. The normal in the tangent plan in fixed one*

*second and the vector product of the two associated vectors makes it possible to define the local trihedron.*

*necessary to the supply of the characteristics nonisotropic material and for the analysis of the efforts generalized, of the state of stress or the generalized and three-dimensional deformations. The user will have to take care that the selected reference axis is not found parallel with normal of certain meshes of the grid. By defect, this direction of reference is axis **X** total reference mark of definition of the grid.*

.  
*a functionality of **DEFI\_GROUP** makes it possible to create a group of meshes automatically of which it normal is included/understood in a given solid angle, of axis direction of reference. This order can be used in preprocessing to affect data material not isotropic or in postprocessing after a calculation of hull.*

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.  
*offsetting (constant for all the nodes of the mesh) OFFSETTING of each one they compared to the mesh support. This distance is measured on the normal of the mesh support. In the excentré case inertias of rotation are obligatorily taken into account and INER\_ROTA is put at YES.*

**Z D**

**y**  
*plan*  
**x1**  
*tangent*

**X**

*The total xy plan is not parallel in the tangent plan*

**Appear 2.2.2-a: Total reference mark and tangent plan**

*For modeling ROASTS, the following geometrical data are necessary to model them tablecloths of reinforcements (see [3]):*

.  
*offsetting (constant for all the nodes of the mesh) OFFSETTING of each one they compared to the mesh support. This distance is measured on the normal of the mesh support which, in practice, is superposable with that of the concrete.*

.  
*direction of reference D defined previously by ANGL\_REP.*

.  
*direction of the reinforcements compared to the X1 vector of the tangent plan. One of the directions ANGL\_L is enough because the grid consists of orthogonal reinforcements between them.*

.  
*percentages of section of reinforcement in direction 1 POUR\_CENT\_L and direction 2 POUR\_CENT\_T which is orthogonal for him.*

.  
*the sum of the sections of reinforcements per unit of width in direction 1 SECTION\_L.*

**Important remark:**

*Orientation of the elements of plates and hulls*



*The direction of the normals to each element is a recurring problem concerning the use of this type of element, for example when loadings of the pressure type are applied, or to define a offsetting or a local reference mark.*

*By defect for the surface elements the orientation is given by the vector product  $12^{\wedge}13$  for a triangle numbered 123 (DKT,...) or 1234567 (COQUE\_3D) and  $12^{\wedge}14$  for a numbered quadrangle 1234 (DKQ,...) or 123456789 (COQUE\_3D). For linear hulls  $N$  is given by the formula of [2.1.1.1](#) paragraph [with](#)  $T$  directed in the direction of course of the mesh on the level of the grid.*

*Generally, these data are accessible while looking in the file from grid, which is not very practical for the user. Moreover it is necessary that it checks the coherence of its grid and to ensure itself*

*that all the meshes have the same orientation well.*

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*The user can automatically modify the orientation of the elements of the grid by imposing one direction of normal, for a grid or part of using grid of modelings of hull and whatever the type of modeling. The reorientation of the elements is done by the means of operator `ORIE_NORM_COQU` of order `MODI_MAILLAGE` [U4.12.05]. The principle is it according to: one defines under `ORIE_NORM_COQU` a direction by the means of a vector and a node belonging to the group of meshes to be reorientated. If the introduced vector is not in the plan of the mesh selected by `MODI_MAILLAGE`, one automatically deduces a direction from it from normal obtained like the vector less given its projection in the field of the mesh. All meshes of the group related with those initially selected will then have the same orientation of normal automatically. In addition an automatic checking of the same orientation of the meshes*

*related is carried out by the means of operator VERI\_NORM of order AFFE\_CHAR\_MECA [U4.25.01].*

### **2.2.3 Materials**

**:  
DEFI\_MATERIAU**

*The definition of the behavior of a material is carried out using operator DEFI\_MATERIAU [U4.43.01].*

**DEFI\_MATERIAU COQUE\_3D  
DKT  
DST  
Q4G  
COQUE\_C\_PLAN  
ROAST  
COQUE\_D\_PLAN  
COQUE\_AXIS  
COMP. LINEAR**

**ELAS  
..  
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.  
ELAS\_FO**

**..  
.  
.  
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.  
ELAS\_ORTHO**

**..  
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.  
ELAS\_COQUE  
.**

•  
•  
  
*ELAS\_COQUE\_FO*

•  
•  
•  
  
*DEFI\_MATERIAU COQUE\_3D*  
*DKT*  
*DST*  
*Q4G*  
*COQUE\_C\_PLAN*  
*ROAST*  
*COQUE\_D\_PLAN*  
*COQUE\_AXIS*  
*COMP. NONLINEAR*

*TRACTION*

• •  
  
•  
  
*ECRO\_LINE*

• •  
  
•  
  
*ECRO\_LINE\_FO*

• •  
  
*CHABOCHE*

.  
*DEFI\_COQU\_MULT*

.  
.  
.  
*DEFI\_MATERIAU COQUE\_3D*

*DKT*

*DST*

*Q4G*

*COQUE\_C\_PLAN*

*ROAST*

*COQUE\_D\_PLAN*

*COQUE\_AXIS*

*BY LAYER*

*All comp.*

..

.  
*C\_PLAN*

*The materials used with the whole of the elements plates or hulls can have elastic behaviors in plane constraints whose linear characteristics are constant or functions of the temperature. The nonlinear behaviors in plane constraints are available for modelings DKT and hulls. For more information on these nonlinearities one can to defer to the paragraph [§2.3.2].*

*The mean composite material structures can be treated currently only by modelings plates, by using DEFI\_COQU\_MULT with material characteristics homogenized. One can also directly introduce the coefficients of rigidity of the matrices of membrane, inflection and shearing with ELAS\_COQUE. These coefficients are given in the reference mark room of the element defined by ANGL\_REP. It should be noted that the terms of shearing are not taken*

*in*

*take into account behavior ELAS\_COQUE that for elements DST and Q4G. They are not taken in take into account elements DKT.*

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*In order to facilitate comprehension, we represented on the figure below the different ones reference marks used.*

**Z**

**Z**

*normal*

*ortho*

*ortho*

**Locate orthotropism**

**4**

*y ortho*

*Defined layer by layer*

**3**

**3**

**2**

**1**

**2**

**1**

**Z**

*X ortho*

## **Stacking**

*X ortho*

*Z*

*Y*

*ortho*

*y ortho*

*X*

*X ortho*

*Skin "SUP"*

*X*

## **Total reference mark**

*ortho*

*Skin MOY'*

*Skin "INF"*

***Sleep***

### ***Appear 2.2.3-a: Reference marks used for the definition of material***

*The following example is extracted from case-test SSLS117B and illustrates the syntax of DEFI\_COQU\_MULT:*

```
MU2=DEFI_COQU_MULT (COUCHE=_F (EPAIS=0.2,  
MATER=MAT1B,  
ORIENTATION=0.0,));
```

*In this example, one defines a multi-layer composite thickness 0.2, the material being defines by MAT1B, and the angle of the 1st direction of orthotropism (longitudinal direction or direction of fibres) being null. One will refer to documentation [U4.42.03] for more details concerning the use of DEFI\_COQU\_MULT.*

### ***2.2.4 Limiting loadings and conditions: AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F***

*The assignment of the loadings and the boundary conditions on a mechanical model is carried out with assistance of operators AFFE\_CHAR\_MECA, if loadings and boundary conditions mechanical on a system are actual values depending on no parameter, or AFFE\_CHAR\_MECA\_F, if these values are functions of the position or the increment of loading.*

*The documentation of use of AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F is [U4.44.01].*

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### *2.2.4.1 Lists key words factor of AFFE\_CHAR\_MECA*

*AFFE\_CHAR\_MECA COQUE\_3D*

*DKT DST*

*Q4G*

*COQUE\_C\_PLAN*

*ROAST*

*COQUE\_D\_PLAN*

*COQUE\_AXIS*

*DDL\_IMPO*

*..*

*.*

*.*

*.*

*.*

*.*

*FACE\_IMPO*

*..*

*.*

*.*

*.*

*.*

*.*

*LIAISON\_DDL*

*..*

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*LIAISON\_OBLIQUE*

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*LIAISON\_GROUP*

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*CONTACT*

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*LIAISON\_UNIF*

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*LIAISON\_SOLIDE*

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*LIAISON\_ELEM*

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*LIAISON\_COQUE*

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*FORCE\_NODALE*

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•

### *DDL\_IMPO*

*Key word factor usable to impose, with nodes or groups of nodes, one or more values of displacement.*

### *FACE\_IMPO*

*Key word factor usable to impose, with all the nodes of a definite face by a mesh or a group of meshes, one or more values of displacements (or certain associated sizes).*

### *LIAISON\_DDL*

*Key word factor usable to define a linear relation between degrees of freedom of two or several nodes.*

*LIAISON\_OBLIQUE key Word factor usable to apply, with nodes or groups of nodes, the same component value of displacement definite per component in an unspecified oblique reference mark.*

### *LIAISON\_GROUP*

*Key word factor usable to define linear relations between some degrees of freedom of couples of nodes, these couples of nodes being obtained while putting in opposite two lists of meshes or nodes.*

### *CONTACT*

*Key word factor usable to notify conditions of contact and of friction between two sets of meshes.*

### *LIAISON\_UNIF*

*Key word factor allowing to impose the same value (unknown) on degrees of freedom of a whole of nodes.*

### *LIAISON\_SOLIDE*

*Key word factor allowing to model an indeformable part of one structure.*

### **LIAISON\_ELEM**

*Key word factor which makes it possible to model the connections of a hull part with a beam part or of a hull part with a pipe part (see [2.2.4.5](#) paragraph).*

### **LIAISON\_COQUE**

*Key word factor making it possible to represent the connection enters of the hulls to means of linear relations.*

### **FORCE\_NODALE**

*Key word factor usable to apply, with nodes or groups of nodes, of the nodal forces, definite component by component in TOTAL reference mark or in an oblique reference mark defined by 3 nautical angles.*

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**AFFE\_CHAR\_MECA**

**COQUE\_3D**

**DKT DST Q4G**

**COQUE\_C\_PLAN**

**ROAST**

**private individuals**

**COQUE\_D\_PLAN**

*COQUE\_AXIS*  
*FORCE\_ARETE*

..  
.  
.

*FORCE\_COQUE*

*total*

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*near*

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*tangent room*

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*GRAVITY*

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*PRES\_REP*

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..

## *ROTATION*

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## *TEMP\_CALCULEE*

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..

.

## *EPSI\_INIT*

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## *FORCE\_ARETE*

*Key word factor usable to apply linear forces to an edge of an element of hull. For the linear elements the equivalent returns to apply a nodal force to the nodes supports of the element. There is not thus no the particular dedicated term. On the other hand, it requires elements of edges.*

## *FORCE\_COQUE*

*Key word factor usable to apply surface efforts (pressure by example) on elements defined on all the grid or one or several meshes or of the groups of meshes. These efforts can be given in the total reference mark or a reference mark of reference defined on each net or groups meshes; this reference mark is built around the normal with the element of hull and a fixed direction (see paragraph [2.2.2](#)).*

## *GRAVITY*

*Key word factor usable for a loading of the gravity type.*

## *PRES\_REP*

*Key word factor usable to apply a pressure to one or more meshes, or of the groups of meshes.*

## *ROTATION*

*Key word factor usable to calculate the loading due to the rotation of structure.*

## *TEMP\_CALCULEE*

*Allows to recover the thermal loading resulting from a thermal calculation linear or not linear. This functionality is useful for the chainings thermomechanical, not which will be approached in paragraph [4](#).*

## *EPSI\_INIT*

*Key word factor usable to apply a loading of deformation initial.*

### **Note:**

*The efforts of pressure being exerted on the elements of plates can apply is by FORCE\_COQUE (near) is by PRES\_REP. The user will have to thus pay attention (in version 5) not to twice apply the loading of pressure for the elements concerned, especially whenever modelings of plates would be mixed with other modelings using PRES\_REP.*

*In addition it should be noted that efforts of pressure, whether it is with FORCE\_COQUE (near) or PRES\_REP are such as a positive pressure acts in the contrary direction with that of the normal with the element. By defect, this normal is dependent on the direction of course of the nodes of an element, it who is not always very easy for the user. Moreover it is necessary that this one makes sure that all these elements are directed same manner. One thus advises to impose the orientation of these elements by the means of operator ORIE\_NORM\_COQU of order MODI\_MAILLAGE (see paragraph [§2.2.2]).*

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**2.2.4.2 Lists key words factor of AFFE\_CHAR\_MECA\_F**

*The key words factor Generals of operator AFFE\_CHAR\_MECA\_F are identical to those of operator AFFE\_CHAR\_MECA introduced above.*

**AFFE\_CHAR\_MECA\_F**

**COQUE\_3D DKT DST Q4G COQUE\_C\_PLAN ROASTS**

**private individuals**

**COQUE\_D\_PLAN**

**COQUE\_AXIS**

**FORCE\_ARETE**

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*Total FORCE\_COQUE*

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*near*

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*tangent room*

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*The loadings of pressure functions of the geometry can be indicated by the means of FORCE\_COQUE (near).*

### **2.2.4.3 Application of a pressure: key word *FORCE\_COQUE***

*The key word factor **FORCE\_COQUE** makes it possible to apply surface efforts to elements of the type hull (DKT, DST, Q4G,...) defined on all the grid or one or more meshes or of the groups meshes. According to the name of the operator called, the values are provided directly (**AFFE\_CHAR\_MECA**) or via a concept function (**AFFE\_CHAR\_MECA\_F**).*

#### ***AFFE\_CHAR\_MECA***

##### ***Remarks***

***AFFE\_CHAR\_MECA\_F***

***FORCE\_COQUE***

***:***

***.***

***ALL:***

***“YES”***

***.***

***Place of application of the loading***

***NET***

***GROUP\_MA***

***Locate***

***FX***

***.***

***Provided directly for***

***total***

***FY***

***AFFE\_CHAR\_MECA, in the form of***

***FZ***

***function for AFFE\_CHAR\_MECA\_F***

***MX***

***MY***

***MZ***

***PLAN “MOY”***

***.***

***Allows to define a torque of efforts on***

***“INF”***

***the average, lower, higher plan or of***

***“SUP”***

***grid (elements DKT and DST)***

***“EMAIL”***

*CLOSE F1*

.

*Provided directly for*

*Locate*

*F2*

*AFFE\_CHAR\_MECA, in the form of  
room*

*F3*

*function for AFFE\_CHAR\_MECA\_F*

*MF1*

*MF2*

*We return in the paragraph corresponding to key word FORCE\_COQUE of the document of use  
operators AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F.*

***Limiting 2.2.4.4 Conditions: key words DDL\_IMPO and LIAISON\_\****

*The key word factor DDL\_IMPO makes it possible to impose, with nodes introduced by one (at least) of  
the words*

*keys: ALL, NODE, GROUP\_NO, MESH, GROUP\_MA, one or more values of displacement (or of  
certain associated sizes). According to the name of the operator called, the values are provided  
directly (AFFE\_CHAR\_MECA) or via a concept function (AFFE\_CHAR\_MECA\_F).*

*The operands available for DDL\_IMPO, are listed below:*

.

*DX DY DZ*

*Blocking on the component of displacement in **translation***

.

*DRX DRY DRZ*

*Blocking on the component of displacement in **rotation***

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#### ***2.2.4.5 Connections hulls with other machine elements***

*These connections must meet the requirements established in [bib4] and that one finds in particular in the connection 3d-BEAM in [R3.03.03].*

*The connections available with the elements of plates and hulls are as follows:*

*.*

*Connection Beam-**Hull**: it is a question of establishing the connection between a node end of an element of*

*beam and a group of meshes of edge of elements of hulls. Theories of beam and of plate know only normal cuts with fibre or the average surface.*

*connections can take place only according to these average fibres or surfaces. The connection beam-hull is **realizable for beams whose neutral fibre is orthogonal with***

***normals with the facets of the plates or the hulls**. To extend to other configurations*

*(a beam arriving perpendicular to the plan of a plate for example) request one*

*feasibility study because the elements of plate or hull do not have rigidity associated with*

*a rotation in the plan perpendicular to the normal on the average surface. The connection is*

*usable by using key word LIAISON\_ELEM: (OPTION: "COQ\_POU") of*

*AFFE\_CHAR\_MECA.*

*.*

*Connection Hull-**Pipe**: it is a question of establishing the connection between a node end of an element of*

*pipe and a group of mesh of edge of elements of hulls. The formulation of the connection*

*hull-pipes is presented in the reference document [R3.08.06]. Theories of pipe*

*and of plate, know only normal cuts with fibre or the average surface.*

*The connections can take place only according to these average fibres or surfaces. The connection*

*hull-pipe is realizable for pipes whose neutral fibre is orthogonal with the normals*

*with the facets of the plates or hulls. The connection is usable by using the key word*

*LIAISON\_ELEM: (OPTION: "COQ\_TUYAU") of AFFE\_CHAR\_MECA.*

*N*

*N normal with the facet of the hull = tangent to the beam*

*Connection hull - pipe*

*Connection plates or hull - beam*

## **Appear 2.2.4.5 - has: Connections hulls with other machine elements**

.  
*Connection **Hull massive 3D**: the connection massive hull-3D is being studied but it will be limited initially with the cases where the normal with the solid is orthogonal with the normal with the one facets of the element of plate or hull (see [bib4]).*

.  
*Connection **between elements of Hulls**: to connect two elements of hulls between them, one uses key word **LIAISON\_COQUE** of **AFFE\_CHAR\_MECA** (**\_F**) (documentation [U4.44.01]). This connection is carried out by means of linear relations. The traditional approach admits that 2 plans with a grid in hulls are cut according to a line which belongs to the grid of structure. In order to prevent that the volume which is the intersection of the 2 hulls is counted twice, one stops the grid of a hull perpendicular to a hull given to the level of the skin higher or lower of the latter. On [2.2.4.5 Figure - B], the connection between the 2 hulls is done by connections of solid body between the nodes in with respect to the A1 segments A2 and B1 B2.*

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A2

B2

A1 B1

## **Appear 2.2.4.5 - B: Connection between elements of hulls**

*Case-tests making it possible to validate these connections are available in the section examples,*

## **2.3 Resolution**

### **2.3.1 Linear calculations: Linear MECA\_STATIQUE and other operators**

*Linear calculations are carried out in small deformations. Several linear operators of resolution are available:*

·  
**MECA\_STATIQUE:**

*resolution of a problem of static mechanics linear ([U4.51.01]);*

·  
**MACRO\_ELAS\_MULT:**

*calculate linear static answers for various cases of loads or modes of Fourier. ([U4.51.02]).*

·  
**MODE\_ITER\_SIMULT:** *calculation of the values and vectors clean by methods of under spaces. ([U4.52.03]).*

·  
**MODE\_ITER\_INV:**

*calculation of the values and vectors clean by the method of iterations opposite ([U4.52.04]).*

·  
**MODE\_ITER\_CYCL:**

*calculation of the clean modes of a structure with cyclic symmetry ([U4.52.05]);*

·  
**DYNA\_LINE\_TRAN:**

*calculation of the transitory dynamic response to an excitation temporal unspecified ([U4.53.02]);*

·  
**DYNA\_TRAN\_MODAL:**

*calculation is carried out by modal superposition or by under*

*structuring ([U4.53.21]);*

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## **2.3.2 Nonlinear calculations: STAT\_NON\_LINE and DYNA\_NON\_LINE**

### **2.3.2.1 Behaviors and assumptions of deformations available**

Following information is extracted from the documentation of use of the operator STAT\_NON\_LINE: [U4.51.03].

**COQUE\_3D DKT DST Q4G COQUE\_C\_PLAN**

**COQUE\_D\_PLAN**

**COQUE\_AXIS**

**COMP\_INCR**

**RELATION**

*All the relations . .*

*.  
(small  
available in constraints  
deformations)  
plane*

*The relations 3D while using:*

*. .*

*.  
ALGO\_C\_PLAN: "DEBORST"*

*DEFORMATION: Coque\_3D into large*

•  
  
“GREEN\_GR”

*displacements and large rotations available with incrémentaux behaviors nonlinear, but into small deformations*

COMP\_ELAS  
RELATION ELAS

(large  
DEFORMATION: '

•  
  
*deformations) GREEN\_GR'*  
TYPE\_CHARGE: 'Following Pressure

•  
  
SUIV'

*All the mechanical nonlinear behaviors of plane constraints of the code are accessible. One distinguishes the incremental relations of behavior (key word factor COMP\_INCR) from the relations nonlinear elastic behaviors (key word factor COMP\_ELAS). The relation of behavior connect the rates of deformation to the rates of constraints.*

*For modeling ROASTS reinforced concrete structures, the nonlinear behaviors correspond to particular incrémentaux behaviors in STAT\_NON\_LINE (COMP\_INCR):*

*GRILLE\_ISOT\_LINE for plasticity with isotropic work hardening,*

*GRILLE\_ISOT\_CINE for plasticity with kinematic work hardening linear Bi,*

*GRILLE\_PINTO\_MEN for the behavior of Pinto Menegotto.*

*Moreover, the behavior of the average concrete layer is given by a law of the type NADAI\_B.*

*The concept RESULT of STAT\_NON\_LINE contains fields of displacements, constraints and variables intern at the points of integration always calculated at the points of gauss:*

*DEPL: fields of displacements.*

*SIEF\_ELGA: Tensor of the constraints by element at the points of integration (COQUE\_3D and DKT) in the local reference mark. For each layer, one stores in the thickness and for each thickness on the points of surface integration. Thus if one wants information on one constraint for layer NC, on level NCN (NCN = -1 so the lower, NCN = 0 if medium, NCN = +1 so higher) for the surface point of integration NG, it will be necessary to look at the value data by the point defined in the option NOT such as*

*: NP = 3\* (NC-*

*1) \*NPG+ (NCN+1) \*NPG+NG where NPG is the total number of points of surface integration of*

*the element of COQUE\_3D (7 for the triangle and 9 for the quadrangle) and of element DKT.*

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*VARI\_ELGA: Field of variables intern (DKT and COQUE\_3D) by element at the points of surface integration. For each point of surface integration, one stores them information on the layers while starting with the first, level "INF". The number of variables represented is worth thus  $2*NCOU*NBVARI$  where NBVARI represents the number of internal variables.*

*It can be enriches by the following fields, calculated in postprocessing by operator CALC\_ELEM:*

*SIEF\_ELNO\_ELGA: activate the calculation of the tensor of the efforts generalized by element with nodes (membrane efforts, bending moments, sharp efforts), in the reference mark user (defined in the paragraph [§2.2.2]).*

*VARI\_ELNO\_ELGA: activate the calculation of the field of internal variables by element with the nodes in the thickness (by layer SUP/MOY/INF in the thickness except indication).*

### **2.3.2.2 Detail on the points of integration**

*For non-linear calculations the method of integration for the elements of plate and hulls is a method of integration by **layers**, of which the number is defined by the user. For each sleep, except modeling ROASTS, one uses a method of Simpson at three points of integration, with medium of the layer and in skins higher and lower of layer. For NR layers the number of points of integration in the thickness is of  $2N+1$ .*

*To treat non-linearities material, one advises to use from 3 to 5 layers in the thickness for a number of points of integration being worth 7, 9 and 11 respectively. For tangent rigidity, one calculates for each layer, in plane constraints, the contribution to the matrices of rigidity of membrane, of inflection and of coupling membrane-inflection. These contributions are added and assembled to obtain the matrix of total tangent rigidity. For each layer, one calculates the state of the constraints and the whole of the internal variables, in the middle of the layer and in skins higher and lower of sleep. This information is available in VARI\_ELGA and SIEF\_ELGA. The behavior plastic does not include/understand the transverse terms of shearing which are treated in an elastic way, because transverse shearing is uncoupled from the plastic behavior.*

*For modeling ROASTS reinforced concrete structures, it has only one point of integration there by sleep.*

### **Geometrical 2.3.2.3 non-linear Behavior**

*Calculations into non-linear geometrical (great displacements and great rotations), available with modeling COQUE\_3D, are carried out using operator STAT\_NON\_LINE, by using it*



key word *COMP\_ELAS*, as illustrated in the following example:

```
STAT_NON_LINE (  
COMP_ELAS (RELATION: "ELAS"  
COQUE_NCOU: 3  
DEFORMATION: "GREEN_GR")  
)
```

or by using an incremental behavior (key word *COMP\_INCR*) in small deformations.

It is possible to apply to the elements of *COQUE\_3D*, the following pressures. This loading has the characteristic to follow the geometry of the structure during its deformation (for example: hydrostatic pressure remains always perpendicular to the deformed geometry). To take in count this type of loading, it is necessary to specify in operator *STAT\_NON\_LINE* information following:

```
STAT_NON_LINE (  
EXCIT (LOAD: near  
TYPE_CHARGE: "SUIV")  
)
```

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The geometrical non-linear behavior of the structures can have instabilities (buckling, snap-through/snap-back...). The determination and the passage of these limiting points, cannot be obtained by imposing the loading, however options of piloting of loading "*DDL\_IMPO*" or "*LONG\_ARC*" of operator *STAT\_NON\_LINE* make it possible to cross these critical points.

### **2.3.2.4 Buckling linear**

*Calculations in linear buckling are similar to the search of Eigen frequencies and modes of vibration. The problem has to solve is expressed in the form:*

*To find  $(\lambda, X)$   $(R, RN)$  such as  $AX = \lambda BX$*

*where  $A$  is the matrix of rigidity*

*$B$   
is the geometrical matrix of rigidity (calculated with option `RIGI_GEOM` of `CALC_MATR_ELEM`)*

*$\lambda$  is the critical load*

*$X$  is the mode of buckling associated with the critical load*

*Operators `MODE_ITER_INV` [U4.52.04] and `MODE_ITER_SIMULT` [U4.52.03] are used to determine the critical load and the mode of associated buckling.*

## **2.4 Additional calculations and postprocessings**

### **2.4.1 Elementary calculations of matrices: operator `CALC_MATR_ELEM`**

*Operator `CALC_MATR_ELEM` (documentation [U4.61.01]) allows to calculate matrices elementary, which is then gatherable by order `ASSE_MATRICE` (documentation [U4.61.22]).*

*The elementary options of operator `CALC_MATR_ELEM` are described below:*

**`CALC_MATR_ELEM COQUE_3D`**

**`DKT DST`**

**`Q4G`**

**`COQUE_C_PLAN`**

**`ROAST`**

**`COQUE_D_PLAN`**

**`COQUE_AXIS`**

**`"AMOR_MECA"`**

**`...`**

**`..`**

**`.`**

“*MASS\_MECA*”

...  
..  
.

“*RIGI\_GEOM*”

.

“*RIGI\_MECA*”

...  
..  
.

“*RIGI\_MECA\_HYST*”

...  
..  
.

.

*AMOR\_MECA: Stamp damping of the elements calculated by linear combination of rigidity and of the mass.*

.

*MASS\_MECA: Stamp of mass.*

.

*RIGI\_GEOM: Stamp geometrical rigidity (for great displacements).*

.

*RIGI\_MECA: Stamp rigidity of the elements.*

.

*RIGI\_MECA\_HYST: Hysteretic rigidity (complex) calculated by the product by one coefficient complexes structural damping of simple rigidity.*

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**2.4.2 Calculations by elements: operator CALC\_ELEM**

*One presents hereafter the options of postprocessing for the elements of plates and hulls. They correspond to the results which a user can obtain after a thermomechanical calculation (internal constraints, displacements, deformations, variables, etc...). For the modelled structures by elements of hulls or beams it is particularly important to know how are presented results of constraints in order to be able to interpret them correctly. Approach adopted in Code\_Aster consists in observing the constraints in a particular reference mark related to the element whose reference axis was defined in the paragraph [§2.2.2]. Indeed, for a structure cylindrical the constraints easiest to interpret are not the constraints in Cartesian reference mark but constraints in cylindrical co-ordinates. Moreover this approach allows larger flexibility in use.*

**OPTIONS COQUE\_3D****DKT****DST****Q4G****COQUE\_C\_PLAN****ROAST****COQUE\_D\_PLAN****COQUE\_AXIS****“SIEF\_ELGA\_DEPL”**

..

.

.

.

.

.

**“SIGM\_ELNO\_DEPL”**

..

.

.

.

.

**“SIGM\_ELNO\_CART”**

*“EQUI\_ELNO\_SIGM”*

..

*“EFGE\_ELNO\_DEPL”* .

..

.

.

.

*“EFGE\_ELNO\_CART”*

*“EPSI\_ELNO\_DEPL”*

..

.

.

.

.

*“DEGE\_ELNO\_DEPL”*

.

.

.

.

.

*“EPOT\_ELEM\_DEPL”*

..

.

.

.

.

*“ECIN\_ELEM\_DEPL”*

..

.

.

·  
“VNOR\_ELEM\_DEPL”

· MEDKTR3

·  
“SIEF\_ELNO\_ELGA”  
· ·

·  
“VARI\_ELNO\_ELGA”  
· ·

·  
“SIGM\_ELNO\_COQU”  
· ·

·  
“VARI\_ELNO\_COQU”  
· ·

·  
NUME\_COUCHE  
· ·

·  
NIVE\_COUCHE  
· ·

·  
*SIEF\_ELGA\_DEPL: Calculation of the efforts generalized by element at the points of integration of*

*the element starting from displacements (use only in elasticity). Locate user.*

*SIGM\_ELNO\_DEPL*

*: Calculation of the constraints by element to the nodes from displacements in a point the thickness (key word NIVE\_COUCHE = INF, SUP or MOY). Use in elasticity. Locate user.*

*SIGM\_ELNO\_CART: Expression of the constraints by element to the nodes in the reference mark total of description of the grid. Nonavailable for the elements of plates and hulls.*

*EQUI\_ELNO\_SIGM: Constraints equivalent to the nodes, calculated in a point of the thickness starting from SIGM\_ELNO\_DEPL or SIGM\_ELNO\_COQU:*

*VMIS: Constraints of Von Mises.*

*VMIS\_SG: Constraints of Von Mises signed by the trace of. PRIN\_1, PRIN\_2, PRIN\_3: Principal constraints.*

*EFGE\_ELNO\_DEPL: Calculation of the efforts generalized by element with the nodes from displacements (use only in elasticity). Locate user.*

*EFGE\_ELNO\_CART: Expression of the efforts generalized by element with the nodes in total reference mark of description of the grid.*

*EPSI\_ELNO\_DEPL: Calculation of the deformations by element to the nodes from displacements, in a point the thickness (use only in elasticity). Locate user.*

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.  
*DEGE\_ELNO\_DEPL: Calculation of the deformations generalized by elements with the nodes to leave displacements. Locate user.*

.  
*EPOT\_ELEM\_DEPL: Calculation of the linear elastic energy of deformation per element to be left displacements.*

.  
*ECIN\_ELEM\_DEPL: Calculation of the kinetic energy by element.*

.  
*VNOR\_ELEM\_DEPL: Projection of a field speed on the normal of the elements hull.*

.  
*SIEF\_ELNO\_ELGA: Option of activation of the calculation of the tensor of the efforts generalized (see paragraph [§2.3.2]) by element with the nodes, in the reference mark user, by integration of constraints SIEF\_ELGA.*

.  
*VARI\_ELNO\_ELGA: Option of activation of the calculation of the field of variables intern (see paragraph [§2.3.2]) by element and layer with the nodes. For each point of integration surface, one stores information on the layers while starting with the first, level "INF". The number of variables represented is worth thus  $3 \cdot NCOU \cdot NBVARI$  where *NBVARI* represent the number of internal variables.*

.  
*SIGM\_ELNO\_COQU: Extraction of the stress field in a point in the thickness by element and by layer (in skins SUP, MOY and INF) with the nodes. Reference mark defined by the user with ANGL\_REP. This stress fields surface can then be visualized.*

.  
*VARI\_ELNO\_COQU: Calculation of the field of variables intern in a point thickness (in skins SUP, MOY and INF, to see key words NUME\_COUCHE and NIVE\_COUCHE). Reference mark defined by the user with key word ANGL\_REP of AFFE\_CARA\_ELEM.*



*NUME\_COUCHE: In the case of a multi-layer material (composite or hull in plasticity), whole value ranging between 1 and numbers it layers, necessary to specify the layer where one wants to carry out elementary calculation.*

*NIVE\_COUCHE: For layer N, one can specify the ordinate where one wishes to carry out it elementary calculation. A calculation in internal skin is indicated by “INF”, in external skin by “SUP” and on the average layer by “MOY” (according to the direction of the normal).*

*PLAN: For option EFGE\_ELNO\_DEPL one can specify the plan in which one wishes to have it calculation. This possibility is interesting in the event of offsetting of the elements of plate. One calculation in the plan of the grid is indicated by “EMAIL” (defect), a calculation in internal skin is indicated by “INF”, in external skin by “SUP” and on the average layer by “MOY”.*

### **2.4.3 Calculations with the nodes: operator CALC\_NO**

**OPTIONS COQUE\_3D**

**DKT**

**DST**

**Q4G**

**COQUE\_C\_PLAN**

**ROAST**

**COQUE\_D\_PLAN**

**COQUE\_AXIS**

**“FORC\_NODA”**

..

.

.

.

.

**“REAC\_NODA”**

..

.

.

.

.

**\_NOEU\_**

..

.

.

.

.

For the elements of plates and hulls, operator *CALC\_NO* (documentation [U4.81.02]) allows only the calculation of the forces and reactions (calculation of the fields to the nodes by moyennation, option *\_NOEU\_*):

starting from the constraints, balance: *FORC\_NODA* (calculation of the nodal forces from constraints at the points of integration, element by element),

then by removing the loading applied: *REAC\_NODA* (calculation of the nodal forces of reaction with the nodes, the constraints at the points of integration, element per element):

$REAC\_NODA = FORC\_NODA - \text{loadings applied,}$

useful for checking of the loading and calculations of resultants, moments, etc

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#### **2.4.4 Calculations of the elementary fields: operator *CALC\_CHAM\_ELEM***

Operator *CALC\_CHAM\_ELEM* (documentation [U4.81.03]) allows to calculate fields elementary starting from already calculated fields of type *CHAM\_NO\_\** or *CHAM\_ELEM\_\**.

**OPTIONS COQUE\_3D**

**DKT**

**DST**

**Q4G**  
**COQUE\_C\_PLAN**  
**ROAST**  
**COQUE\_D\_PLAN**  
**COQUE\_AXIS**  
"EFGE\_ELNO\_DEPL" ·

· ·  
·  
·  
·  
·

*EFGE\_ELNO\_DEPL: Calculation of the efforts generalized by element with the nodes from displacements. Locate user. See the option PLAN for the definition of the plan of calculation.*

*For the modelings of plates and hulls, only the efforts generalized for a field of displacement are available.*

#### **2.4.5 Calculations of quantities on whole or part of the structure: operator POST\_ELEM**

*Operator POST\_ELEM (documentation [U4.81.22]) allows to calculate quantities on all or part of the structure. The calculated quantities correspond to particular options of calculation of affected modeling.*

**OPTIONS Operator**  
**COQUE\_3D**  
**DKT**  
**DST**  
**Q4G**  
**COQUE\_C\_PLAN**  
**ROAST**  
**COQUE\_D\_PLAN**  
**COQUE\_AXIS**  
"MASS\_INER" POST\_ELEM

· ·  
·  
·  
·

"ENER\_POT" POST\_ELEM

· ·  
·  
·

•

**“ENER\_CIN” POST\_ELEM**

••

•

•

•

•

•

*MASS\_INER: calculation of the geometrical characteristics (volume, centre of gravity, stamps of inertia) for the elements plates and curves.*

•

*ENER\_POT: calculation of the potential energy of deformation due to balance from displacements in linear mechanics of the continuous mediums (2D and 3D) and in mechanics linear for the elements of structures, or the energy dissipated thermically with balance in linear thermics starting from the temperatures (cham\_no\_TEMP\_R).*

•

*ENER\_CIN: calculation of the kinetic energy starting from a field speed or one field of displacement and a frequency (only for the elements of structure and them elements 3D).*

**2.4.6 Values of components of fields of sizes: operator POST\_RELEVE\_T**

*Operator POST\_RELEVE\_T (documentation [U4.81.21]) allows, on a group of nodes, to extract values or to carry out calculations:*

•

*to extract from the values of components of fields of sizes;*

•

*to carry out calculations of averages and invariants:*

*Averages,*

*Resultants and moments of vector fields,*

*Invariants of tensorial fields,*

*Directional trace of fields,*

*Of expression in the TOTAL reference marks, LOCAL, POLAR, USER or CYLINDRICAL*

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*The produced concept is of type counts.*

*To use POST\_RELEVE\_T, it is necessary to define three concepts:*

.

**a place:** *the option NODE (example: N01 N045) or option GROUP\_NO (example: SUPPORT);*

.

**an object:** *with the choice, the option RESULT (SD result: EVOL\_ELAS,...) or the option CHAM\_GD (CHAM\_NO: DEPL,... or CHAM\_ELEM: SIGM\_ELNO\_DEPL,...) ;*

.

**a nature:** *with the choice, the option “EXTRACTION” (value,...) or the “AVERAGE” option (average, maximum, mini,...).*

### **Important remark:**

*If one comes from an interface with a maillor (PRE\_GIBI, PRE\_IDEAS, PRE\_GMSH), the nodes are arranged by numerical order. It is necessary to reorder the nodes along the line of examination. The solution is to use operator DEFI\_GROUP with option NOEU\_ORDO. This option makes it possible to create an ordered GROUP\_NO containing the nodes of a whole of meshes made of segments (SEG2ou SEG3).*

*An example of extraction of component is given in case-test SSNL503 (see description with [paragraph \[§2.5.3\] page 34](#)):*

```
TAB_DRZ=POST_RELEVE_T (ACTION=_F (  
GROUP_NO = “Of,  
ENTITLE = “TB_DRZ”,  
RESULT = RESUL,
```

```
NOM_CHAM = "DEPL",  
NOM_CMP = "DRZ",  
TOUT_ORDRE = "YES",  
OPERATION = "EXTRACTION"  
)  
)
```

*The purpose of this syntax is:*

- *to extract:*  
*OPERATION = "EXTRACTION"*
- *on the group of nodes D:*  
*GROUP\_NO = "Of*  
·  
*component DRZ of displacement: NOM\_CHAM = "DEPL", NOM\_CMP = "DRZ",*  
·  
*for every moment of calculation:*  
*TOUT\_ORDRE = "YES"*

#### ***2.4.7 Impression of the results: operator IMPR\_RESU***

*Operator IMPR\_RESU allows to write the grid and/or the results of a calculation on listing with the format*

*"RESULT" or on a file in a displayable format by external tools for postprocessing with Aster: format RESULT and ASTER (documentation [U4.91.01]), format CASTEM (documentation [U7.05.11]), format ENSIGHT documentation [U7.05.31]), format IDEAS (documentation [U7.05.01]), format MED (documentation [U7.05.21]) or format GMSH (documentation [U7.05.32]).*

*Currently this procedure makes it possible to write with the choice:*

- *a grid,*
- *fields with the nodes (of displacements, temperatures, clean modes, modes statics,...),*
- *fields by elements with the nodes or the points of GAUSS (of constraints, efforts generalized, of variables intern...).*

*Elements of plate and hull being treated same manner that other finite elements, us*

*let us return the reader to the notes use corresponding to the format of exit which it wishes to use.*

*Instruction manual*

*U2.02 booklet: Elements of structure*

*HT-66/02/003/A*

---

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*Version*

6.3

*Titrate:*

*Note of use of the elements plates and hulls*

*Date:*

21/06/02

*Author (S):*

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## **2.5 Examples**

*The case-tests selected here are traditional case-tests resulting from the literature and which are usually used to validate this type of elements.*

*It is pointed out that modelings DKT correspond to the theory of Coils-Kirchhoff and them DST modelings, Q4G with the theory with transverse energy of shearing (Reissner). Results for modeling COQUE\_3D are presented only for one theory with energy of shearing transverse.*

### **2.5.1 Analyze static linear**

**SSLS20**

**Titrate::** *Cylindrical hull pinch on free board*

*y*

*F*

*F*

*D*

*With*

*D*

**Documentation V: [V3.03.020]**

*C*

*With*

*C*

*X*

*B*

*B*

***Modelings:***

*L*

*SSLS20A DKT*

*F*

*SSLS20B COQUE\_3D*

*MEC3QU9H*

*Z*

*R*

*L*

*SSLS20C COQUE\_3D*

*MEC3TR7H*

*eighth of cylinder*

*Length*

*L = 10.35 m*

*Ray*

*R = 4.953 m*

*Thickness*

*T = 0.094 m*

***SSLS100***

***Titrate:*** *Plate circular embedded subjected to a pressure*

*y*

*uniform.*

*C*

*B*

***Documentation V: [V3.03.100]***

*E*

*F*

***Modelings:***



*SSLS100K*  
*COQUE\_3D*  
*MEC3QU9H*  
*O*  
*D With xSSLS100L COQUE\_3D MEC3TR7H*  
*SSLS100B DKT*  
*1/4 of plate*

*SSLS100E DKQ*  
*Ray*  
*R = 1 m*

*SSLS100F DST*  
*Thickness*  
*T = 0.1 m*  
*SSLS100G DSQ*  
*SSLS100H Q4G*  
*SSLS100I, J*  
*COQU\_AXIS*

***SSLS101***  
***Titrate: Plate circular posed subjected to a pressure***  
*y*  
*uniform.*  
*C*

*B*  
***Documentation V: [V3.03.101]***  
*E*

*F*  
***Modelings:***  
*SSLS101J*  
*COQUE\_3D*  
*MEC3QU9H*  
*O*  
*SSLS101I*  
*COQUE\_3D*  
*MEC3TR7H*  
*D*  
*With*

*X SSLS101B DKT*

*1/4 of plate*

*SSLS101E DKQ*

*Ray*

*R = 1 m*

*SSLS101F DST*

*Thickness*

*T = 0.1 m*

*SSLS101G DSQ*

*SSLS101H Q4G*

*Instruction manual*

*U2.02 booklet: Elements of structure*

*HT-66/02/003/A*

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*Author (S):*

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**SSLS104**

**Titrate:** *Cylindrical hull pinch with diaphragm.*

*y*

*F*

*F*

*B*

**Documentation V:**

*C*

*B*

*[V3.03.104]*

*With*

*C*

*D*

*With*

*X*

***Modelings:***

*D*

*SSLS104B*

*COQUE\_3D*

*MEC3QU9H*

*L*

*SSLS104C*

*COQUE\_3D*

*MEC3TR7H*

*F*

*Z*

*R*

*SSLS104A*

*DKT*

*L*

*eighth of cylinder*

*Length*

*L = 600*

*Ray*

*R = 300*

*Thickness*

*T = 3*

***SSLS105***

***Titrate: Doubly gripped hemisphere.***

*Z*

*Z*

*C*

*C*

***Documentation V: [V3.03.105]***

***Modelings:***

y

**B**

y

**B**

*SSLS105B*

*COQUE\_3D*

*MEC3QU9H*

*With*

*2KN*

*SSLS105?*

*COQUE\_3D*

*MEC3TR7H*

*With*

*SSLS105A*

*DKT*

*2KN*

*X*

*X*

*Ray*

*R = 10. m*

*Thickness*

*T = 0.04 m*

***SSLS107***

***Titrate: Cylindrical panel subjected to its own weight.***

*Z*

*D*

***Documentation V: [V3.03.107]***

*With*

***Modelings:***

*Free*

*C*

*SSLS107A*  
*COQUE\_3D*  
*MEC3QU9H*  
*X*

*SSLS107B*  
*COQUE\_3D*  
*MEC3TR7H*  
*y*  
*B*

*L*  
*R*

*Length*

*L = 6. m*  
*Ray*  
*R = 3. m*  
*Thickness*  
*T = 0.03 m*  
*Angular section = 40°*

***SSLS108***  
***Titrate: Helicoid hull under concentrated loadings.***  
*Y*

***Documentation V: [V3.03.108]***

*FY*  
*L*  
***Modelings:***

*C*  
*H*  
*SSLS108A*  
*COQUE\_3D*  
*MEC3QU9H*  
*O*  
*SSLS108B*  
*COQUE\_3D*  
*MEC3TR7H*  
*B*  
*With*

X

Z

B

**Note:**

*Disadvised use with DKT/DKQ, without*

*FZ*

*transverse shearings.*

*Instruction manual*

*U2.02 booklet: Elements of structure*

*HT-66/02/003/A*

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*Other case-tests are more briefly described in the following table:*

**Name Modeling**

**Remarks**

*hpla100a*

*2D\_AXIS*

**Titrate:** *Heavy thermoelastic hollow roll in uniform rotation.*

*hpla100b*

*COQUE\_AXIS*

**Documentation V:** *[V7.01.100]*

*hpla100c*

*COQUE\_3D*

*The purpose of this test is to test the second corresponding members*

*with the effects of gravity and an acceleration due to a rotation*

*hpla100d*

*COQUE\_3D*

*uniform.*

*hpla100e*

*HULL*

*The analytical solutions for the COQUE\_3D include the variation of*

*hpla100f*

*HULL*

*metric in the thickness of the hull. Analytical solutions for*

*the plates are without correction of metric*

*hsls01a*

*DKT/DST/Q4G*

***Titrate:** Embedded thin section subjected to a heat gradient in*

*the thickness.*

***Documentation V: [V7.11.001]***

*hsls01b*

*COQUE\_3D*

*hsns100a*

*COQUE\_3D/DKT*

***Titrate:** Plate subjected to a variation in temperature in*

*the thickness.*

*hsns100b*  
*COQUE\_3D/DKT*  
**Documentation V:** [V7.23.100]

*This case-test makes it possible to test two ways of imposing the field thermics. The results obtained has some and B must be identical, but the reference solutions obtained are numerical.*

*ssl102a*  
*COQUE\_C\_PLAN*  
**Titrate:** *Fixed beam subjected to unit efforts*

**Documentation V:** [V3.01.102]

*ssls501a*  
*COQUE\_D\_PLAN*  
**Titrate:** *Roll infinitely long subjected to two lines of loads.*

**Documentation V:** [V3.03.501]

*ssls114a*  
*COQUE\_3D*  
**Titrate:** *Setting under pressure of a cylindrical quarter of binding ring.*

*ssls114b*  
*COQUE\_3D*  
**Documentation V:** [V3.03.114]

*ssls114c*  
*DKT/DST*  
*Analytical reference solution. Allows to test the term of*

*pressure and orientation of the normals. One tests the results in*

*ssls114d*  
*DKQ/DSQ*  
*radial displacement and in radial constraints.*



*ssls114i*  
*COQUE\_AXI*

*ssls114j*  
*COQUE\_C\_PLAN*

*ssls114k*  
*COQUE\_D\_PLAN*

*Instruction manual*  
*U2.02 booklet: Elements of structure*  
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Titrate:

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Date:

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Author (S):

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## **2.5.2 Modal analysis in dynamics**

**Name Modeling**

**Remarks**

**Titrate:** *Thin square plate free or embedded on an edge*

**Documentation V:** [V2.03.001]

*sdl01a*

**DKT**

*It is of a modal calculation and a harmonic calculation of answer. For*

*modal calculation, it acts to calculate the clean modes of inflection*

*of a thin square plate free or embedded on an edge.*

*sdl01b*

**DKT**

*has - Edges of the plate directed according to axes' of the reference mark.*

*B - Unspecified orientation of the plate and harmonic answer for*

*the embedded plate.*

*sdls01c*

*DKT*

*C - Modal calculation by traditional dynamic under-structuring and*

*cyclic.*

*D - Modal calculation following a under-structuring of Guyan.*

*E - Edges of the plate directed according to axes' of the reference mark.*

*sdls01d*

*DKT*

*F - Edges of the plate directed according to axes' of the reference mark.*

*G - Unspecified orientation of the plate and harmonic answer for*

*the embedded plate.*

*H - Unspecified orientation of the plate and harmonic answer for*

*sdls01e*

*COQUE\_3D*

*the embedded plate.*

.

*For A and B the precision on the Eigen frequencies is lower*

*to 1% until the sixth mode of inflection*

*sdls01f*

*COQUE\_3D*

.

*For C in under-structuring, the quality of the results can be*

*improved by the use of a finer grid of substructure.*

.

*For D, it is necessary in order to obtain an accuracy of 1% on*  
*sdl01g*

*COQUE\_3D*

*Eigen frequencies to also condense on the nodes medium*

*edges.*

.

*For E, F, G and H, the precision on the Eigen frequencies is*

*lower than 1% until the sixth mode of inflection for*  
*sdl01h*

*COQUE\_3D*

*elements quadrangle and lower than 2% for the elements*

*triangle.*

*The element of hull MEC3QU9H powerful is compared with the element*  
*DKT which is itself more powerful than element MEC3TR7H.*

*Instruction manual*

*U2.02 booklet: Elements of structure*

*HT-66/02/003/A*

---

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*Titrate:*

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### **2.5.3 Analyze static nonlinear material**

#### **SSNL501**

**Titrate:** *Fixed beam subjected to a uniform pressure.*

Z

y

**Documentation V:** [V6.02.501]

#### **Modelings:**

X

SSNL501E

COQUE\_3D

MEC3QU9H

SSNL501D

COQUE\_3D

MEC3TR7H

SSNL501B

DKT

SSNL501C

DKQ

SSNL501A

COQUE\_C\_PLAN

*Other case-tests are more briefly described in the following table:*

#### **Name Modeling**

#### **Remarks**

ssnp15a

3D

**Titrate:** *Square plate in traction-shearing - Von Misès*

*(isotropic work hardening).*

*ssnp15b*  
*C\_PLAN*  
**Documentation V: [V6.03.015]**

*A plate, made up of a plastic material with work hardening*  
*ssnp15c*  
*DKT*  
*isotropic linear, is subjected to a tractive effort and an effort of*  
  
*shearing. Even if the test validates the law of behavior rather than*

*the elements to which it applies, it makes it possible to test them*  
*ssnp15d*  
*COQUE\_3D*  
*values of the constraints, the efforts and the deformations in*  
  
*reference mark defined by user (ANGL\_REP).*

*ssnv115a*  
*D\_PLAN*  
**Titrant:** *Iron corrugated in nonlinear behavior.*

**Documentation V: [V6.04.115]**  
*ssnv115b*  
*DKT*

*This test validates the nonlinear behaviors in*  
  
*modelings of plates or thin hulls. Modeling A*

*ssnv115c*

*DKT*

*(2D D\_PLAN) is used as reference. The values of displacements are*

*tested.*

*ssnv115d*

*COQUE\_3D*

*Modeling COQUE\_D\_PLAN reveals variations on*

*side displacements of sheet of about 13% compared to*

*ssnv115e*

*COQUE\_3D*

*other modelings. This is due to the method of integration in*

*the thickness which utilizes only 5 points of Gauss for this*

*modeling, compared with 19 points for elements DKT and DKQ and*

*ssnv115f*

*COQUE\_D\_PLAN*

*8 points for modeling D\_PLAN.*

*Instruction manual*

*U2.02 booklet: Elements of structure*

*HT-66/02/003/A*

---

**Code\_Aster** ®

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6.3

Titrate:

*Note of use of the elements plates and hulls*

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## **2.5.4 Analyze static nonlinear geometrical**

### **SSNV138**

**Titrate:** Plate cantilever in great rotations subjected to one moment.

X

y

**Documentation V:** [V6.04.138]

**Mr. Modélisations:**

X SSNV138 COQUE\_3D

MEC3QU9H

SSNV138 COQUE\_3D

MEC3TR7H

**Note:**

Greatest rotation reached is slightly lower than . The results obtained are very satisfactory, the variation maximum is lower than 0.01%. It is necessary to increase the value of COEF\_RIGI\_DRZ (10th-5 by defect) with 0.001 in order to be able to increase the value of the swing angle which one can reach.

### **SSNV139**

**Titrate:** Plate skews.

y

**Documentation V:** [V6.04.139]

**Modelings:**

SSNV139 COQUE\_3D

MEC3QU9H

SSNV139 COQUE\_3D

MEC3TR7H

X

P

Z



X

**SSNL502**

*Titrate: Beam in buckling.*

X

y  
**Documentation V: [V6.02.502]**

**Modelings:**

P

SSNL502 COQUE\_3D

MEC3QU9H

SSNL502 COQUE\_3D

MEC3TR7H

Z

**SSNS501**

*Titrate: Great displacements of a cylindrical panel.*

Z

**Documentation V: [V6.05.501]**

**Modelings:**

SSNS501 COQUE\_3D

MEC3QU9H

SSNS501 COQUE\_3D

MEC3TR7H

y

X

*Instruction manual*

*U2.02 booklet: Elements of structure*

*HT-66/02/003/A*

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*Titrate:*

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*Date:*

21/06/02

*Author (S):*

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*Other case-tests are more briefly described in the following table:*

*Name Modeling*

*Remarks*

*ssnv140a*

*COQUE\_3D*

***Titrate:*** *Embedded cylindrical panel subjected to a surface force.*

***Documentation V: [V6.04.140]***

*ssnv140b*

*COQUE\_3D*

*This force is constant for modeling has and following in*

*modeling B. The goal of this case-test is to check modeling Geometrical non-linear COQUE\_3D by using the algorithm of setting with day of large rotations 3D GREEN\_GR of STAT\_NON\_LINE and of to check the treatment of the following pressures. Data of it problem correspond to a thin hull  $h/L=0.625\%$  what is severe for the finite element triangle MECQTR7H (case of blocking with transverse shearing).*

*ssnv141a*

*COQUE\_3D*

***Titrate:*** *Segment of a sphere pinch.*

***Documentation V: [V6.04.141]***

*The data of this problem correspond to a thin hull  $h/L=0.4\%$  what is severe for the finite element triangle MECQTR7H (case of blocking with transverse shearing). It is necessary to increase value of the COEF\_RIGI\_DRZ which allots a rigidity around the normal elements of hull which is worth by defect the 10-5 smallest rigidity of inflection around the directions in the plan of the be able hull in order to to increase the value of the swing angle which one can reach. values of this coefficient up to 10-3 remain licit.*

*ssnv144a*

*COQUE\_3D*

***Titrare:*** *Bend in cross-bending, elastic, embedded on dimensioned and subjected*

*with a linear force equivalent to one bending moment.*

***Documentation V:*** *[V6.04.144]*

*The goal of this case-test is to check that, for elements COQUE\_3D, quasi-static solutions into linear geometrical (VMIS\_ISOT\_LINE in STAT\_NON\_LINE) and into nonlinear geometrical (GREEN\_GR in STAT\_NON\_LINE) are close to the linear static solution (MECA\_STATIQUE) in the field of the small disturbances.*

*ssnv145a*

*COQUE\_3D*

***Titrare:*** *Plate cantilever in great rotations subjected has a pressure*

*following.*

***Documentation V:*** *[V6.04.145]*

*ssnv145b*

*COQUE\_3D*

*The goal of this case-test is to check modeling COQUE\_3D (mesh*

*TRIA7, QUAD9) in the presence of pressure of a following type.*

*Instruction manual*

*U2.02 booklet: Elements of structure*  
*HT-66/02/003/A*

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**Code\_Aster** ®

*Version*

6.3

*Titrate:*

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*Date:*

21/06/02

*Author (S):*

*A. ASSIRE, P. MASSIN, F. LEBOUVIER* Key

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**2.5.5 Analyze in buckling of Euler**

**SSLS110**

***Titrate:*** *Stability of a compressed square plate.*

***Documentation V:*** [V3.03.110]

***Modelings:***

*SSLS110 COQUE\_3D*

*MEC3QU9H*

*SSLS110 COQUE\_3D*

*MEC3TR7H*

**SDLS504**

***Titrate:*** *Side buckling of a beam (discharge).*

*y, v*

***Documentation V:*** [V2.03.504]

*P*

***Modelings:***

*SDLS504 COQUE\_3D*

*MEC3QU9H*

*X, U*  
*Z, W*  
*SDLS504 COQUE\_3D*  
*MEC3TR7H*

***SDLS505***  
***Titrate: Buckling of a cylindrical envelope under***  
***Z, W***  
***external pressure.***  
***NR***

***Documentation V: [V2.03.505]***

***Modelings:***  
*SDLS505 COQUE\_3D*  
*MEC3QU9H*  
*SDLS505 COQUE\_3D*  
*MEC3TR7H*

*y, v*  
***P***  
***L***  
*X, U*  
***R***

*Instruction manual*  
*U2.02 booklet: Elements of structure*  
*HT-66/02/003/A*

---

***Code\_Aster*** ®

*Version*  
*6.3*

*Titrate:*  
*Note of use of the elements plates and hulls*

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*21/06/02*  
*Author (S):*  
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*:*  
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## **2.5.6 Connections hulls and other machine elements**

*SSLX100*

***Titrate: Mix 3D-Hull-Beam in inflection.***

*y*

***hull thickness 1***

***beam of section***

*M2*

***rectangular***

*B*

*C2*

***Documentation V: [V3.05.100]***

*has*

*O*

*M*

*C*

*D*

*X*

*M1*

*With*

***Modelings:***

*C1*

***F = - 1.***

*NR*

*M4*

*L1*

*Z*

*L2*

*L3*

*y*

*SSLX100A*

*3D*

*1*

*MECA\_HEXA20*

*Z*

*B*

*DKT*

*4*

*MEDKTR3*

*has*

**beam of section**

*POU\_D\_E 2*

*POU\_D\_E*

**rectangular**

*L1 = L2 = L3 = 10 mm*

*B = 1 mm*

*= 3 mm have*

*SSLX100B*

*3D*

*1*

*MECA\_HEX20*

*DKT*

*4*

*MEDKTR3*

*POU\_D\_E 2*

*POU\_D\_E*

*SSLX100C*

*3D*

*1*

*MECA\_HEX20*

*DKT*

*4*

*MEDKTR3*

*COQUE\_C\_PLAN*

*1*

*MECPSE3*

*The axial arrows, constraints, deformations are tested and bending moments in 4 points of the axis of beam.*

*SSLX102*

***Titrate: Piping bent in inflection.***

*With*

***Documentation V: [V3.05.102]***

***Modelings:***

*B*

*SSLX102A*

*DKT and PIPE*  
(*connection COQUE\_TUYAU*)

*C*  
*D*  
*SSLX102D*  
*HULL and BEAM*  
*Mz*

*Instruction manual*  
*U2.02 booklet: Elements of structure*  
*HT-66/02/003/A*

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*Note of use of the elements plates and hulls*

*Date:*  
21/06/02  
*Author (S):*  
A. ASSIRE, P. MASSIN, F. LEBOUVIER Key

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*SSLX101A*  
**Titrate:** *Pipe right modelled in hulls and beams*  
*[V3.05.101].*

*y*  
  
*x1*  
**Documentation V:** *[V3.05.101]*

*P2*  
**Modelings:**  
*SSLX101A*  
*DIS\_TR*  
*POII*  
*DKT*



*MEDKQU4  
P1  
POU\_D\_E 2  
SEG2  
X*

*Z  
Embedding of the hull on the P1 edge. Inflection and  
traction in x1. Variation from 3 to 5% on displacements  
and rotations in P2 with the analytical solution, due to  
grid hull with plane elements.*

*SSLX101B  
DKT  
MEDKQU4,  
METUSEG3  
PIPE  
METUSEG3,  
MEDKQU4  
DIS\_TR  
POII*

*This modeling aims to test the connection  
hull pipe in the presence of unit loadings:  
traction, inflection and of torsion. The reference solution  
is analytical (RDM). The variation with the solution  
numerical is explained by the fact that the grid in  
hulls actually consists of plane elements  
(facets). The geometry of the pipe is thus itself  
approached.*

*SSLX102A  
DKT  
MEDKQU4,  
METUSEG3  
  
PIPE  
MEDKQU4,  
METUSEG3*

*Modeling A utilizes the connection  
coque\_tuyau, the solution obtained (2.7% of variation in  
cross-bending, and 0.4% in inflection except plan, by report/ratio*

*with the reference: grid any hulls (modeling D)  
allows to test the correct operation of  
connection coque\_tuyau.*

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### **3 Thermics**

***For the resolution of chained thermomechanical problems, one must use for thermal calculation finite elements of thermal hull [R3.11.01]. These elements are elements plates, or linear in the case of structures of revolution or invariant structures along an axis. curve of the structure is not taken into account in itself. The metric one of the tangent plan of each element is calculated by supposing that all the tops are coplanar. These elements suppose a distribution a priori parabolic of temperature in the thickness, which results from one asymptotic development in linear thermics for a low thickness of hull, when them variations in temperatures are not too important. It is it should be noted that a model based on one development of the richer field of temperature in the thickness sees its terms of a higher nature to two to converge towards zero when the hull is thin. One cannot thus deal with the problems of thermal shocks with strong variation of the profile of temperature in the thickness with these hulls. methods of use of these elements are presented in [U1.22.01].***

#### **3.1**

##### ***Definition of the problem***

### **3.1.1 Space discretization and assignment of a modeling**

**: operator**

**AFFE\_MODELE**

#### **3.1.1.1 Degrees of freedom**

*The degrees of freedom are the temperatures TEMP (temperature on the average surface of the hull), TEMP\_INF (temperature on the lower surface of the hull), and TEMP\_SUP (temperature on upper surface of the hull).*

#### **3.1.1.2 Meshes support of the matrices of rigidity**

**Modeling**

**Net**

**Nature of the mesh**

**Finite element Remarks**

**HULL QUAD9**

*plane*

**THCOQU9**

*nodes with 3 co-ordinates X, y, Z*

**QUAD8**

*plane*

**THCOQU8**

**QUAD4**

*plane*

**THCOQU4**

**TRIA7**

*plane*

**THCOTR7**

**TRIA6**

*plane*

**THCOTR6**

**TRIA3**

*plane*

**THCOTR3**

*Not supposed COQUE\_PLAN SEG3 planes THCPSE3*

*nodes with 2 co-ordinates X, y*

*Not supposed COQUE\_AXIS SEG3 planes THCASE3*

*nodes with 2 co-ordinates X, y*

*For THCOTR<sub>i</sub>, only the 3 tops are exploited to define the local geometry (tangent plan, normal). For THCOQU<sub>i</sub>, one considers that the element is plane and its tangent plan is defined by*

*defect by 3 of the 4 tops of the element.*

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### ***3.1.1.3 Meshs support of the loadings***

***Modeling Nets***

***Element***

***finished Remarks***

***HULL SEG2***

***THCOSE2***

***with TRIA3 and QUAD4***

***HULL SEG3***

***THCOSE3***

***with TRIA6,7 and QUAD8, 9***

*All the loadings applicable to the facets of the elements of hull are treated by discretization direct on the mesh support of the element in temperature formulation. No mesh of loading is not thus necessary for the faces of the elements of hulls.*

*For the applicable loadings on the edges of the elements of hull, a mesh support of the type SEG2 (element THCOSE2) or SEG3 (element THCOSE3) must be used.*

*For the imposed temperatures the meshs support are meshs reduced to a point.*

### ***Model 3.1.1.4***

:  
***AFFE\_MODELE***

*The assignment of modeling passes through operator AFFE\_MODELE [U4.41.01].*

***AFFE\_MODELE***

***Remarks***

*AFFE*

*PHENOMENON:*

*“THERMAL”*

*MODELING “COQUE\_3D”*

*“COQUE\_C\_PLAN”*

*“COQUE\_D\_PLAN”*

*“COQUE\_AXIS”*

***3.1.2 Elementary characteristics: AFFE\_CARA\_ELEM***

*In this part, operands characteristic of the elements of plates and hulls in thermics are described. The documentation of use of operator AFFE\_CARA\_ELEM is [U4.42.01].*

***AFFE\_CARA\_ELEM HULL***

***COQUE\_PLAN***

***COQUE\_AXIS***

***Remarks***

*HULL*

*THICK*

*..*

*.*

*The characteristics assigned to materials are the same ones as for a mechanical calculation. It is with to note that it is not useful to define a particular reference mark for the analysis of the results of calculation thermics because those are limited to the fields of temperature, scalar size, independent of reference frame used.*

### **3.1.3 Materials**

:  
**DEFI\_MATERIAU**

**DEFI\_MATERIAU HULL**

**COQUE\_PLAN**

**COQUE\_AXIS**

**Remarks**

**THER**

..

.

**THER\_FO**

..

.

*The materials used with elements plates or hulls in thermics can have linear characteristics thermal constant or dependent on the increment of loading.*

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### **3.1.4 Limiting loadings and conditions: AFFE\_CHAR\_THER and AFFE\_CHAR\_THER\_F**

*The assignment of the loadings and the boundary conditions on a thermque model is carried out with the*

*assistance*

*operators AFFE\_CHAR\_THER, if loadings and boundary conditions mechanical on one system are actual values depending on no parameter, or AFFE\_CHAR\_THER\_F, if these values are functions of the position or the increment of loading.*

*The documentation of use of AFFE\_CHAR\_THER and AFFE\_CHAR\_THER\_F is [U4.44.02].*

### ***3.1.4.1 Lists key words factor of AFFE\_CHAR\_THER***

*The affected values of the loadings are real and do not depend on any parameter.*

***AFFE\_CHAR\_THER***  
***HULL COQUE\_PLAN***  
***COQUE\_AXIS Remarks***  
***Generals***  
***TEMP\_IMPO . . .***

***AFFE\_CHAR\_THER***  
***HULL COQUE\_PLAN***  
***COQUE\_AXIS Remarks***  
***private individuals***  
***FLUX\_REP***

***. . .***  
***on the faces and the edges***  
***surface elements***  
***· EXCHANGE***

***. . .***  
***on the faces and the edges***  
***surface elements***

***TEMP\_IMPO: Key word factor usable to impose, on nodes or groups of nodes, a temperature.***

***FLUX\_REP: Key word factor usable to apply normal flows to a face of hull thermics defined by one or more meshes or of the groups of meshes of the triangle type or quadrangle.***

***EXCHANGE: Key word factor usable to apply conditions of exchange with one***

*outside temperature with a face of hull, defined by one or more meshes or groups  
meshes of the triangle type or quadrangle.*

### ***3.1.4.2 Lists key words factor of AFFE\_CHAR\_THER\_F***

*The affected values of the loadings can be a function of the total co-ordinates and time,  
or of the temperature in nonlinear thermics (except in hulls).*

***AFFE\_CHAR\_THER\_F***

***HULL COQUE\_PLAN COQUE\_AXIS Remarks***

***Generals***

***TEMP\_IMPO***

***..***

***.***

***AFFE\_CHAR\_THER\_F***

***HULL COQUE\_PLAN COQUE\_AXIS Remarks***

***private individuals***

***FLUX\_REP***

***.***

***.***

***.***

***on the faces and the edges of  
surface elements***

***EXCHANGE***

***.***

***.***

***.***

***on the faces and the edges of  
surface elements***

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## **3.2 Resolution**

### **3.2.1 Transitory calculations: operator *THER\_LINEAIRE***

**Option of calculation**

**HULL COQUE\_PLAN**

**COQUE\_AXIS**

**Remarks**

**transient**

**CHAR\_THER\_EVOL**

.

*It is here about the treatment of the problems of thermics evolutionary.*

## **3.3**

**Additional calculations and postprocessings**

### **3.3.1 Calculations in postprocessing**

*One presents hereafter the options of postprocessing for the elements of plates and hulls*

**OPTIONS**

**HULL COQUE\_PLAN COQUE\_AXIS Remarks**

**elementary**

**“FLUX\_ELNO\_TEMP”**

•  
“*FLUX\_ELGA\_TEMP*”

•  
“*NIVE\_COUCHE*”

•  
*FLUX\_ELNO\_TEMP*: This option carries out the calculation of heat flow to the nodes from the temperature.

•  
*FLUX\_ELGA\_TEMP*: This option carries out the calculation of heat flow at the points of integration starting from the temperature.

•  
*NIVE\_COUCHE*: Option which specifies for layer N the ordinate where one wishes to have the field of temperature. A calculation in internal skin is indicated by “*INF*”, in external skin by “*SUP*” and on the average layer by “*MOY*”.

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***3.4 Examples***

*One gives here the list of the case-tests available for the thermal hulls. They are case-tests of stationary thermics. The results are correct for the whole of these case-tests, whatever the element used.*

**Name**  
**Modeling Element**  
**Remarks**

*tplp301a*

*HULL*

*THCOTR3*

**Titrate:** *Plate with imposed temperature distributed sinusoidalement on a side.*

**Documentation:** *[V4.05.301]*

*tplp302a HULL*

*THCOTR6*

**Titrate:** *Rectangular plate with temperature imposed on the sides.*

**Documentation:** *[V4.05.302]*

*tpls100a*

*HULL*

*THCOTR6/THCOTR3*

**Titrate:** *Infinite plate subjected to a couple of flow*

*tpls100b*

*COQUE\_PLAN*

*THCPSE3*

*of heat antisymmetric stationary on its two half-faces.*

**Documentation:** *[V4.03.100]*

*Conduction is linear, homogeneous and isotropic.*

*tpls101a*

*HULL THCOTR6/THCOSE3*

**Titrate:** *Infinite plate subjected to a couple of*

*tpls101b*

*THCOQU4/THCOSE2*

*thermal conditions with outside,*

*tpls101c*

*THCOQU8/THCOSE3*

*symmetrical compared to the average layer.*

*tpls101d*  
*THCOQU9/THCOSE3*

*tpls101e*  
*THCOTR7/THCOSE3*

**Documentation:** [V4.03.101]

*Conduction is linear, homogeneous and isotropic.*

*tpls302a*  
*HULL THCOQU8/THCOSE3*

**Titrate:** *Rectangular plate with convection and*

*tpls302b*  
*THCOQU4/THCOSE2*

*imposed temperature*

*tpls302c*  
*THCOQU9/THCOSE3*

*tpls302d*  
*THCOTR7/THCOSE3*

**Documentation:** [V4.03.302]

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**4 Chaining**

***thermomechanics******4.1 Formalism***

*For the resolution of chained thermomechanical problems, one must use for thermal calculation finite elements of thermal hull [R3.11.01] whose field of temperature is recovered like input datum of the Code \_Aster for mechanical calculation. It is necessary thus that there is compatibility between thermal field given by the thermal hulls and that recovered by the mechanical hulls. It the last is defined by the knowledge of 3 fields TEMP\_SUP, TEMP and TEMP\_INF given in skins lower, medium and higher of hull. The table below indicates these compatibilities:*

***Modélisation Maille Element Nets Element Modeling******THERMICS******MECHANICS******HULL QUAD9******THCOQU9******QUAD9******MEC3QU9H******COQUE\_3D******HULL QUAD8******THCOQU8******HULL QUAD4******THCOQU4******QUAD4******MEDKQU4******DKT******MEDSQU4******DST******MEQ4QU4******Q4G******HULL TRIA7******THCOTR7******TRIA7******MEC3TR7H******COQUE\_3D******HULL TRIA6******THCOTR6******HULL TRIA3******THCOTR3******TRIA3******MEDKTR3***

DKT  
MEDSTR3  
DST  
COQUE\_PLAN SEG3 THCPSE3  
SEG3 METDSE3  
COQUE\_D\_PLAN  
SEG3  
METCSE3  
COQUE\_C\_PLAN  
COQUE\_AXIS SEG3 THCASE3  
SEG3 MECXSE3  
COQUE\_AXIS

**Note:**

.

*Nodes of the thermal elements of hulls and plates or hulls mechanics must correspond. Grids for thermics and mechanics the same number and the same type of meshes will thus have.*

.

*The elements of thermal hulls surface are treated like plane elements by projection of the initial geometry on the level defined by the first 3 tops. For the chaining of calculations with mechanical curved elements it is thus necessary that the geometry of the plate is not too distant from that of the hull. When structure is curved, that thus requires for thermal calculation to net it way sufficient fine in order to have correct results in preparation for the part mechanics. Only the linear elements of thermics are associated perfectly corresponding linear elements in mechanics fascinating bus of account curve of the structure with a grid.*

.

*The chaining with multi-layer materials is not available for the moment.*

.

*The thermomechanical chaining is also possible if one knows, analytically or by experimental measurements, variation of the field of temperature in the thickness of the structure or certain parts of the structure. In this case one works with one chart of temperature defined a priori; the field of temperature is not given any more by three values TEMP\_INF, TEMP and TEMP\_SUP of thermal calculation obtained by EVOL\_THER. Operator DEF1\_NAPPE allows to create such profiles of temperatures with to leave the data provided by the user. These profiles are affected by the order CREA\_CHAMPS and CREA\_RESU (cf the case-test hsns100b). It will be noted that it is not necessary for mechanical calculation that the number of points of integration in the thickness is equal to the number of points of discretization of the field of temperature in the thickness. The field of temperature is automatically interpolated at the points*

*of integration in the thickness of the elements of plates or hulls.*

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## **4.2 Examples**

### **HPLA100**

**Titrate:** *Heavy thermoelastic hollow roll in*

*Z*

*uniform rotation*

**Documentation:** [V7.01.100]

*IH*

*Re*

### **Modelings:**

**HPLA100A**

*Interior ray IH = 19.5 mm*

*Thermics*

**PLAN**

32

**THPLQU8**

*External ray Re = 20.5 mm*

*Mechanics*

**AXIS**

32

**MEAXQU8**

*Not F*

*R = 20.0 mm*

*Thickness*

*H = 1.0 mm*

*HPLA100B*

*Height*

*L = 10.0 mm*

*Thermics*

*COQUE\_PLAN*

*10 THCPSE3*

*R*

*Mechanics*

*COQUE\_AXIS*

*10 MECXSE3*

*HPLA100C*

*Thermics*

*HULL*

*32*

*THCOQU9*

*Z*

*Mechanics*

*COQUE\_3D*

*32*

*MEC3QU9H*

*J*

*D*

*C*

*HPLA100D*

*Thermics*

*HULL*

*64*

*THCOTR7*

*H*

*+*

*Mechanics*

*COQUE\_3D*

*64*

*MEC3TR7H*

*R*

*With*



*B*  
*HPLA100E*  
*F*  
*Thermics*  
*HULL*  
*200*  
*THCOQU4*

*Mechanics*  
*HULL*  
*200*  
*MEDKQU4*

*It is a question of studying a thermal phenomenon of dilation HPLA100F where the fields of temperature are calculated with Thermique*

*HULL*  
*400*  
*THCOTR3*

*THER\_LINEAIRE by a stationary calculation:*

*Mechanics*  
*HULL*  
*400*  
*MEDKTR3*

*- thermal dilation:*

*(T) T*  
*-*  
*= 5*  
*.*  
*0*  
*++ .*  
*2 +*  
*- /*  
*ref. ()*  
*(T T*  
*S*  
*I)*  
*(T T*  
*S*  
*I) (R*  
*) R H*

*with:  $T_s = 0.5 \text{ }^\circ\text{C}$ ,  $T_i = -0.5 \text{ }^\circ\text{C}$ ,  $T_{ref} = 0. \text{ }^\circ\text{C}$*

$T_s = 0.1 \text{ } ^\circ \text{C}$ ,  $T_i = 0.1 \text{ } ^\circ \text{C}$ ,  $T_{ref} = 0. \text{ } ^\circ \text{C}$

*One tests the constraints, the efforts and moments bending in L and Mr. the results of reference are analytical. For modelings COQUE\_3D one takes in account variation of metric with the thickness of hull. Very good results whatever the type of element considered.*

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## **5**

### **Conclusion and councils of use**

*In the following table, a summary of the possibilities offered by modelings plates and hulls is described.*

*Modeling -! DKT DST Q4G COQUE\_3D COQUE\_AXIS*

*Applicability*

*COQUE\_D\_PLAN*

*COQUE\_C\_PLAN*

*Linear statics: Isotropic material*

**X**

**X**

**X**  
**X**  
**X**  
*Orthotropic, composite material*  
**X X**

*Non-linear statics material*  
**X**

**X**  
**X**  
*Geometrical non-linear statics*

**X**  
*Analyze dynamic*  
**X**  
**X**  
**X**  
**X**  
**X**  
*Buckling of Euler*

**X**

*On the figure below the field of application of the plates and hulls is schematized.*

*Thin hulls*  
*Thick hulls*  
*DKT, DKQ*  
*DST, DSQ, Q4G*  
*Plane elements*  
*h/L*  
*0.05 (1/20)*  
*0.1 (1/10)*  
*Curved elements*  
*COQUE\_3D, COQUE\_AXIS,*

*COQUE\_C\_PLAN, COQUE\_D\_PLAN*

### ***Appear 5-a: Fields of application of the plates and the hulls***

*Some recommendations concerning the field of application of these elements:*

.

***Mean structures:*** for these structures, whose  $h/L$  report/ratio is lower than  $1/20$ , effects of transverse shearing can be neglected and the theory of Kirchhoff applies. One advises to use for this type of structure of the elements plates *DKT-DKQ* or the elements of hull curve (*COQUE\_3D, \_AXIS, \_C\_PLAN, \_D\_PLAN*). **It is advised to use them preferably elements *DKT* and *DKQ*** which give very good results on displacements and more approximate on the constraints (to be recommended for the vibratory analyses). Even if one must to use a great number of these elements, the execution times remain reasonable compared with those of the curved elements.

.

***Thick structures:*** for these structures, one will use elements of *DST* plate, *DSQ* and *Q4G* who take account of transverse shearing with a factor of correction of shearing  $K = 5/6$  (theory of Reissner) or **preferably of the elements of curved hull**. It makes it possible to pass of a theory of Hencky-Mindlin-Naghdi for  $k=1$ , with a theory of Reissner for  $k=5/6$ . One value of  $K = 5/6$  is advised. By defect the coefficient of shearing is put at  $5/6$ . This preference rests on the fact that elements *DST, DSQ* and *Q4G* estimate them relatively badly efforts compared to the curved elements of hull, like one could notice it on certain cases tests of the paragraph [§2.5].

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*Elements DKT, DKQ, DST, DSQ and Q4G are plane elements, they do not take into account curve of the structures, it is thus necessary to refine the grid if the curve is important if one wants to avoid the parasitic inflections.*

*Variation of metric of the geometry (i.e. its radius of curvature) according to sound thickness is taken into account:*

*.  
automatically for modeling COQUE\_3D*

*.  
defined by the user for modelings COQUE\_AXIS, COQUE\_D\_PLAN and COQUE\_C\_PLAN.*

***The optimal machine element in statics according to the whole of the case-tests of the paragraph [§2.5] is the element of hull with 9 nodes MEC3QU9H, which makes it possible to obtain good displacements and good constraints thanks to its P2 interpolation out of membrane. It is a general-purpose element which can be at the same time used to represent very mean structures (h/L 1/100) or thicker. Like, in addition, the element of hull with 7 nodes MEC3TR7H is less powerful, it is advised with the user to net his structure in hulls with the greatest possible number quadrangles.***

*.  
**Non-linearity material:** nonlinear behaviors (plasticity, etc) in plane constraints are available for the elements of hull curves (COQUE\_3D, COQUE\_AXIS, COQUE\_C\_PLAN, COQUE\_D\_PLAN) and the elements plates DKT-DKQ only. The plastic behavior does not take the terms of transverse shearing which are treated in an elastic way, because it transverse shearing is uncoupled from the plastic behavior. For a good representation progression of plasticity through the thickness, one advises to use for integration numerical 3 to 5 layers in the thickness for a number of points of being worth gauss respectively 3, 5 and 11.*

*.  
**Geometrical non-linearity:** nonlinear behaviors (great displacements large rotations) in plane constraints are available for the elements of curved hull COQUE\_3D only.*

*.  
**Buckling of Euler:** this type of analysis is available with the elements of curved hull COQUE\_3D only.*

*Elements corresponding to the machine elements exist in thermics; couplings thermomechanical are thus available at the same time for the elements of plates and hulls. For the moment these couplings are not possible for multi-layer materials.*

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***Instruction manual  
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***Note of use of elements TUYAU\_\****

***Summary:***

***This document is a note of use for modelings TUYAU\_3M and TUYAU\_6M.***

***Finite elements TUYAU\_3M and TUYAU\_6M correspond to linear elements of right piping or curve. The kinematics of the elements PIPE combines at the same time a kinematics of beam, which describes it overall movement of the line of piping, and a kinematics of hull, which brings the description of swelling, of the ovalization and the warping of the cross section.***

***These modelings are usable for problems of relatively thick three-dimensional pipings, in linear mechanical analysis or not linear and small displacements.***

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## 1 Introduction

*Finite elements TUYAU\_3M and TUYAU\_6M correspond to linear elements of piping right-hand side or curve. They are based on a kinematics of beam of Timoshenko for displacements and rotations of average fibre and on a kinematics of hull for the deformations of transverse section (ovalization, warping, swelling). These transverse deformations are broken up into Fourier series. Modeling TUYAU\_3M takes into account 3 modes with maximum, while modeling TUYAU\_6M takes into account 6 modes of Fourier.*

*These modelings are usable for problems of three-dimensional pipings relatively thick, only in linear mechanical analysis or not linear and small displacements. Currently, no calculation of thermics or acoustics is possible.*

*This document presents the possibilities of modeling PIPE available in version 6 of Code\_Aster. One initially presents the possibilities of this type of modeling, then one briefly points out the formulation of the finite elements and their differences with modelings beam. One also gives the list of the options available for each element. One finishes by the presentation of some academic case-tests and finally one gives some councils of use.*

*The right or curved pipe sections are gathered under modelings TUYAU\_3M and TUYAU\_6M. The options of calculations are defined in this document. Current possibilities of these elements pipes are as follows:*

- .  
*right or curved lines of piping,*
- .  
*linear element with 3 nodes (SEG3) or 4 nodes (SEG4),*
- .  
*relatively thick pipe:  $e/R < 0.2$  where  $E$  represents the thickness and  $R$  the ray of the section transverse,*
- .  
*internal pressure, cross-bendings and anti-plane, torsion and extension,*
- .  
*small displacements,*
- .  
*elastoplastic in plane constraints, or not linear behavior incremental unspecified,*
- .  
*the transverse section can become deformed by:*
- *swelling due to the internal pressure or the effect Poisson,*

-  
ovalization due to the inflection,  
-

warping due to the inflections combined in the plan and except plan.

Compared with modeling TUYAU\_3M, modeling TUYAU\_6M allows the best approximation of the behavior of the cross section if this one becomes deformed according to a mode raised, for example in the case of thin tubes where the thickness report/ratio on ray of cross section is  $< 0.1$ , and in the case of plasticity.

Modeling TUYAU\_3M has 21 DDL per node (6 DDL of beam and 15 DDL of hull), tandis that modeling TUYAU\_6M has 39 DDL per node (6 DDL of beam and 33 DDL of hull).

For modeling TUYAU\_3M, one can use meshes SEG3 and SEG4.

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2

**Capacities of modeling**

2.1

**Recall of the formulation**

**2.1.1 Geometry of the elements pipes**

We point out here the methods and the modelings implemented for the elements pipes and which are presented in the reference document [R3.08.06].

*For the elements pipes one defines an average, right fibre or curve (X defines the co-ordinate curvilinear) and a section dig of circular type. This section must be small compared to length of piping. The figure [Figure 2.1.1-a] illustrates the two various configurations. One locate local oxyz is associated average fibre.*

*R  
H  
X  
X  
O  
y  
O  
L  
Z  
Z  
y*

*$R \ll L$   
Average fibre*

***Appear 2.1.1-a: Right pipe or curve***

### ***2.1.2 Formulation of the elements pipes***

*The kinematics of the pipe [Figure 2.1.2-a] is composed of a kinematics of hull which brings description of ovalization, swelling and warping, and a kinematics of beam which described the overall movement of the line of piping. Displacement U [Figure 2.1.2-b] of one not material of the pipe of a macroscopic part beam is composed (UP) and of a part additional local hull (US):  $U = UP + US$*

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*M*

*M*

*inflection-torsion of a right beam*

*In theory of the beams*

*increased*

*theory of the hulls*

*U*

*W*

*v*

*v*

*W*

*Cross*

*Transverse section*

*Cross*

*Transverse section*

*warping*

*ovalization*

### ***Appear 2.1.2-a: Decomposition of displacement in fields of beam and hull***

*The formulation of the elements rests on:*

***The theory of the beams*** for the kinematics of average fibre. If one makes the complete assumption of theory of the beams: cross-sections associated displacements of beam (UP), which are perpendiculars with **average fibre** of reference [Figure 2.1.2-b] remain perpendicular to fibre average after deformation. The cross-section does not become deformed. This will be true on average in the element PIPE. One uses the theory of the beams only to describe the movement of fibre average: the average fibre of the pipe is equivalent to average fibre of a beam. This kinematics makes it possible to describe the overall movement of the line of piping.

***The theory of the hulls*** to describe the transverse deformation of the sections around fibre average. Kinematics of the transverse sections: the cross-sections which are perpendicular to **surface average** reference remain right. Material points located on the normal at surface not deformed average remain on a line in the deformed configuration. The formulation used is a formulation of the type LOVE\_KIRCHHOFF without transverse shearing for the description of behavior of the transverse sections. The thickness of the hull remains constant. Surface average of the pipe, located at mid thickness, is equivalent to the average surface of a hull. This kinematics of hull brings the description of swelling, the ovalization and the warping of cross section.

*R*

*Section*

*ext.*

*X*

*y*

*O*

*o'*

*y*

*E*

*L*

*Z*

*Surface average*

*Z*

*Average fibre*

*, ws X, custom*

*, vs*

*o'*

*X, up*

*O*

*py*

*p*

*p*

*+*

*Z*

*X*

*y, vp*

*X*

*Z, wp*

*y*

*Z*

***Appear 2.1.2-b: Fibre and average surface in the case of a right pipe***

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*Additional displacements (Custom) of the surface of the pipe are approximated by a series of Fourier until the order M (M=3 for modeling TUYAU\_3M and M=6 for modeling TUYAU\_6M).*

*M**M**S* $U(X, \theta) = I$  $U(X) \cos m \theta +$  $u_0(X) \sin m \theta$ *m**m**m=2**m=2**M**M**S* $v(X, \theta) = I$  $W(X) \sin m \theta +$  $w_0(X) \cos m \theta +$  $v_0(X) \cos m \theta$ *m**m**m=2**m**m**iv X m -**m**m**m=2**m=2*

*M**M**S*

$$W(X, \cdot) = w_0 + I$$

$$W(X) \cos m +$$

$$w_0(X) \sin m$$

*m**m*

$$m=2$$

$$m=2$$

*Where*

*custom:* represent the axial displacement of average surface in the local reference mark *X*

*vs:* represent orthoradial displacement average surface in the local reference mark *X*

*ws:* represent the radial displacement of average surface in the local reference mark *X*

*w0:* represent swelling

*These elements thus utilize locally:*

*6 variables kinematics for the beam formulation: up displacements, vp and wp according to fibre of reference and rotations around the local axes,*

*3 variables kinematics for the hull formulation: additional displacements custom, vs and ws in the reference mark of average surface,*

*4 constraints in the thickness of pipe noted SIXX (sxx), SIYY (sff), SIXY (sxf), and SIXZ (sxz). Constraint SIZZ (szz) is null (assumption of plane constraints). Constraints of shearing transverses are null (assumption of Coils Kirchoff),*

*4 deformations in the thickness of pipe noted EPXX (exx), EPYY (EFF), EPXY (exf), and EPXZ (sxz). Deformation EPZZ (ezz) is null for the beam part.*

***Important remark:***

*The kinematics of beam is based on the assumption of Timoshenko [R3.08.03]. The element pipe is not "exact" with the nodes for loadings or torques concentrated at the ends, it is necessary to net with several elements to obtain correct results.*

*According to average fibre, these elements are of isoparametric type. It results from it that them displacements vary like polynomials of order 2 following X for the elements with 3 nodes and*

*of order 3 per 4 nodes.*

## **2.2**

### ***Comparison with other elements***

#### ***2.2.1 Differences between the elements pipes***

*The elements pipes TUYAU\_3M and TUYAU\_6M are linear elements:*

.

*TUYAU\_3M with three or four nodes*

.

*TUYAU\_6M with four nodes*

*These elements are different only on the level from the approximation from the field from displacement additional HULL, which is made by a decomposition in Fourier series:*

.

*TUYAU\_3M until order 3*

.

*TUYAU\_6M until order 6*

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*Consequently the number of DDL is different:*

.

*TUYAU\_3M 21 per node (6 DDL of beam and 15 DDL of hull)*

.

*TUYAU\_6M 39 per node (6 DDL of beam and 33 DDL of HULL)*

*Compared with modeling TUYAU\_3M, modeling TUYAU\_6M allows the best approximation of the behavior of the cross section if this one becomes deformed according to a mode raised, for example in the case of thin tubes where the thickness report/ratio on ray of cross section is  $< 0.1$ , and in certain cases in plasticity.*

### ***2.2.2 Differences between the elements pipes and the elements beams***

*Like the finite elements PIPE, the finite elements BEAM also form part of the class of linear finite elements. One compares in this part the applicable formulations and loadings for these two classes of elements.*

*On the level of the **formulation**:*

.

#### ***Element BEAM:***

*The formulation is based on an exact resolution of the equations of the continuous model carried out for each element of the grid. Several types of elements of beam are available:*

-

*POU\_D\_E: transverse shearing is neglected, as well as the inertia of rotation. This assumption is checked for strong twinges (Assumption of Euler),*

-

*POU\_D\_T, POU\_C\_T: transverse shearing and all the terms of inertia are taken in count. This assumption is to be used for weak twinges (Assumption of Timoshenko).*

*These elements use meshes of the type SEG2 with 6 DDL by nodes, 3 displacements and three rotations. The formulation of these elements is presented in the reference document [R3.08.01]. The section is constant, the only possible behavior of the transverse sections is the translation and rotation for the whole of the points of the section. The section perhaps of an unspecified form constant or variable over the length.*

.

#### ***Element PIPE:***

*The formulation combines at the same time a beam formulation based on the assumption of Timoshenko and a hull formulation based on the assumption of Love\_Kirchhoff allowing to model phenomena of swelling, ovalization and warping. The hollow section, of form circular, is constant over the entire length of the element. The element is not “exact” for the nodes for loadings or torques concentrated at the ends, it is necessary*

*thus to net with several elements to obtain correct results.*

*These elements use meshes of the type SEG3 or SEG4 with, for the kinematics of beam 6 DDL by nodes, 3 displacements and three rotations, and for the kinematics from hull, 15 or 33 DDL to typify displacement.*

*On the level of the **applicable loadings**:*

.

### **Element BEAM:**

*The possible loadings are the loadings of extension, inflection and torsion. internal loading of pressure for the hollow sections does not exist (the section is indeformable).*

.

### **Element PIPE:**

*The element PIPE admits the traditional loadings of beam as well as the application of one internal pressure.*

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## **3 Description of the command sets**

### **3.1**

## ***Assignment of a modeling and space discretization***

*In this part, one describes the choice and the assignment of one of two modelings PIPE as well as degrees of freedom and associated meshes. The majority of described information are extracted from documentation of use [U3.11.06]: Modelings TUYAU\_3M and TUYAU\_6M.*

### ***3.1.1 Degrees of freedom***

*The degrees of freedom are, in each node of the mesh support:*

- 
- six components of displacement of average fibre (three translations and three rotations),*
- 
- three degrees of freedom corresponding to modes 0 and 1,*
- 
- for each mode of Fourier, 6 degrees of freedom (U corresponds to warping, V and W with ovalization: V with displacement orthoradial, W with radial displacement, I means “in plane” and O mean “out of plane”).*

#### ***Element***

***Degrees of freedom to each node top***

#### ***Remarks***

*TUYAU\_3M DX DY DZ*

*Value of the component of displacement in imposed translation on the specified nodes*

*DRX*

*DRY*

*DRZ*

*Value of the component of displacement in rotation imposed on specified nodes*

*W0*

*W11*

*W01*

*DDL of swelling and mode 1 on W*



*UI2 VI2 WI2 UO2 VO2 WO2*  
*DDL related to mode 2*

*UI3 VI3 WI3 UO3 VO3 WO3*  
*DDL related to mode 3*

*TUYAU\_6M DX DY DZ*

*Value of the component of*  
*displacement in imposed translation*  
*DRX*  
*DRY*  
*DRZ*

*Value of the component of*  
*displacement in imposed rotation*  
*W0*  
*W11*  
*WO1*

*DDL of swelling and mode 1 on W*

*UI2 VI2 WI2 UO2 VO2 WO2*  
*DDL related to mode 2*

*UI3 VI3 WI3 UO3 VO3 WO3*  
*DDL related to mode 3*

*UI4 VI4 WI4 UO4 VO4 WO4*  
*DDL related to mode 4*

*UI5 VI5 WI5 UO5 VO5 WO5*  
*DDL related to mode 5*

*UI6 VI6 WI6 UO6 VO6 WO6*

*DDL related to mode 6*

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### ***3.1.2 Net support of the matrices of rigidity***

*The meshes support of the finite elements, in displacement formulation, are segments with 3 or 4 nodes.*

#### ***Modeling Nets Element***

***finished***

***Remarks***

*TUYAU\_3M SEG3 METUSEG3*

*Linear mesh*

*SEG4*

*MET3SEG4*

*Linear mesh*

*TUYAU\_6M SEG3 MET6SEG3*

*Linear mesh*

*The meshes SEG4, which have cubic functions of forms, were developed to solve one simple problem of beam in inflection. For this simple example, the exact solution is obtained with the assistance of only one element with mesh SEG4.*

*For more complex problems, the experiment shows that one can net much more coarsely with meshes SEG4. For example one needs about fifteen elements SEG3 to obtain a correct solution for an elbow in inflection whereas one needs of it half with elements SEG4.*

**Note:**

*One can use operator MODI\_MAILLAGE to build meshes SEG4 from meshes SEG3.*

**3.1.3 Net support of the loadings**

*All the loadings applicable to the elements used are treated by direct discretization on net support of the element in displacement formulation. Linear pressure and other forces as well as gravity are examples of loadings applying directly to the element. No special mesh of loading is thus necessary.*

**3.1.4 Model**

**:  
AFFE\_MODELE**

*The assignment of modeling passes through operator AFFE\_MODELE [U4.41.01]. It is pointed out that only the mechanical phenomenon is available with the element PIPE.*

**AFFE\_MODELE**

**TUYAU\_3M  
Remarks**

**TUYAU\_6M**

**AFFE**

**PHENOMENON:  
"MECHANICAL"**

**MODELING "TUYAU\_3M"**

**MODELING "TUYAU\_6M"**

*On the level of the choice of modeling PIPE, one can note that the use of a decomposition in Fourier series to order 6 (element TUYAU\_6M) improve the approximation of the behavior of cross section if this one becomes deformed according to a raised mode, for example in mean cases of tubes where the thickness report/ratio on ray of the cross section is  $< 0.1$ , and in case of plasticity*

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**3.2**

***Elementary characteristics: AFFE\_CARA\_ELEM***

*In this part, the operands characteristic of the element pipe are described. Documentation of use of operator AFFE\_CARA\_ELEM is [U4.42.01].*

***AFFE\_CARA\_ELEM***

***TUYAU\_3M***

***Remarks***

***TUYAU\_6M***

***BEAM***

.

***SECTION:***

***“CIRCLE”***

.  
*% constant section*

.  
*% section Variable*

.  
*MODI\_METRIQUE*

.  
*TUYAU\_NCOU tncouch*

.  
*TUYAU\_NSEC tnsec*

.  
*ORIENTATION*  
*“GENE\_TUYAU”*

.  
*Definition of a generator. By*  
*defect, a generator is created*

*PRECISION*

.  
*CRITERION*

.  
*The characteristics which it is possible to affect on the elements PIPE, are:*

.  
*SECTION: “CIRCLE”*

*The section is defined by its ray “R” external and its thickness “EP”, on each mesh*  
*since the grid is represented by average fibre of the pipe.*

.  
*TUYAU\_NCOU: tncouch*

*It is the number of layers to be used for the integration of the relations of behavior not*  
*linear in the thickness of the right pipe sections. In linear elasticity, one to two*  
*layers are enough, into nonlinear one advises to put between 3 and 5 layers. The number of*  
*not Gauss is equal to twice the number of layers plus one ( $2 * tncouch + 1$ ), which makes*  
*that time CPU increases quickly with the number of the layers.*

.  
*TUYAU\_NSEC: tnsec*

*It is the number of angular sectors to use for the integration of the relations of nonlinear behavior in the circumference of the right pipe sections. By defect it a many sectors are worth 16. One advises to put 32 sectors into nonlinear for precise results (attention with the increase in time CPU with the number of sectors).*

### **ORIENTATION (“GENE\_TUYAU”)**

*One defines from one of the nodes ends of the line of piping a continuous line traced on the pipe. The operands **PRECISION** and **CRITERION** make it possible to define the precision for the construction of the generator and the limit enters a right pipe section and one curved element.*

#### **Note:**

*The directing vector of the line thus defined should not be colinéaire with average fibre of bend with the node end considered, by using the key word **INFORMATION: 2** one can check if it definite vector is correct.*

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### **3.2.1 Operand**

#### **MODI\_METRIQUE**

*Operand **MODI\_METRIQUE** makes it possible to define for the elements **PIPE** the type of integration in the thickness:*

·  
*MODI\_METRIQUE: “NOT” resulted in assimilating in integrations the ray to the ray means. This is thus valid for the pipes low thickness (relative with the ray),*

·  
*MODI\_METRIQUE: “YES” implies a complete integration, more precise for thick pipings, but being able in certain cases to lead to oscillations of solution.*

### **3.2.2 Generator and concept of local reference mark: key word *ORIENTATION***

*The generator traced throughout piping makes it possible to define the origin of the angles [Figure 2.1.2-b]. This is used:*

·  
*to interpret the degrees of freedom of ovalization;*

·  
*to choose the place of extraction of the constraints (option *SIGM\_ELNO\_TUYO*) and the variables interns (option *VARI\_ELNO\_TUYO*).*

· ·  
*Generating line*

2

·

·

· ·

1

#### ***Appear 3.2.2-a: Representation of two noncoplanar elbows connected by a right pipe.***

*For a transverse section end of the line of piping [Figure 3.2.2-b], the user defines in *AFFE\_CARA\_ELEM* under the key word *ORIENTATION* a vector of which projection on the section transverse end defines a unit vector origin  $zI$ .*

*Syntax is as follows:*

```
AFFE_CARA_ELEM (...
ORIENTATION: (GROUP_NO: END
CARA: “GENE_TUYAU”
VALE: (X, y, Z));
```

*where: END is the node centers transverse section end;*

*(X, y, Z) contains the 3 components of the vector directing the generator of the pipe, to project on the transverse section end. This vector must be defined in a node or a group\_no end of the pipe. The geometry is then built automatically for all the elements related of PIPE.*

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*The intersection between the direction of this vector and the average surface of the elbow determines the trace of*

*generator on this section. One calls  $x1$ ,  $y1$ ,  $z1$  the direct trihedron associated this section where  $x1$  is it unit vector perpendicular to the transverse section. The intersection enters the transverse section and right-hand side resulting from the center of this section directed by  $zk$  is the trace of a generator represented  $Ci$*

*below. For the whole of the other transverse sections, the trihedron  $xk$ ,  $yk$ ,  $zk$  are obtained either by rotation of the trihedron  $xk-1$ ,  $yk-1$ ,  $zk-1$  in the case of the bent parts, is by translation of the trihedron  $xk-1$ ,  $yk-1$ ,  $zk-1$  for the right parts of piping.*

 $x2$  $y2$  $z2$  $z1$  $y1$  $x1$ 

### **Appear 3.2.2-b: Representation of the generator of reference**

*The origin of the commune to all the elements is defined compared to the trace of this generator on the transverse section. The angle enters the trace of the generator and the current position on the section*

*transverse is located by the angle. The local reference mark of the right and bent pipe is thus defined by the option*

*ORIENTATION (“GENE\_TUYAU”) of the order AFFE\_CARA\_ELEM which makes it possible to define the first*

vector  $zk$  at an end.

Z

Trace

the generator

y

X

Surface average

### **Appear 3.2.2-c: Locate local element XYZ**

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### **3.2.3 Example of assignment of characteristic**

This example is a piping comprising two elbows (problem of Hoovgaard resulting from the test SSSL101C).

5

E

Modeling PIPE (SEG3)

D

4

Z

With

F

B

y

5

10

G

4

Boundary conditions: Points C and H

H

- DDL of Beam:  $DX = DY = DZ = DRX = DRY = DRZ = 0$

- DDL of Hull:  $UIm = VIm = Wim = 0$  ( $m=2,3$ )

C

$UOm = VOm = WOm = 0$  ( $m=2,3$ )

X

$WII = WOI = WO = 0$

.  
diameter external of the pipe: 0.185 m

.  
thickness of the pipe: 6.12 m

.  
radius of curvature of the elbows: 0.922 m

MODELE=AFFE\_MODELE (MAILLAGE=MAILLAGE,  
AFFE=\_F (ALL = "YES",  
PHENOMENON = "MECHANICAL",  
MODELING = "TUYAU\_3M")  
)

CARELEM=AFFE\_CARA\_ELEM (MODELE=MODELE,  
POUTRE=\_F (GROUP\_MA = "TOUT\_ELT",  
SECTION = "CIRCLE",  
CARA = ("R", "EP",),  
VALE = (0.0925, 0.00612,)),  
ORIENTATION=\_F (GROUP\_NO = "It,  
CARA = "GENE\_TUYAU",  
VALE = (1. , 0. , 0. ,))  
)

### **3.3 Materials**

**DEFI\_MATERIAU**

*The definition of the behavior of a material is carried out using operator DEFI\_MATERIAU [U4.43.01]. There is no particular constraint which had with the use of the elements PIPE.*

*The materials used with the whole of modelings can have elastic behaviors in plane constraints whose linear characteristics are constant or function of the temperature. The nonlinear behaviors in plane constraints are available for modelings pipes. For more information on these nonlinearities one can refer to [§ 2.6].*

### **DEFI\_MATERIAU**

#### **TUYAU\_3M TUYAU\_6M**

#### **Remarks**

*ELAS, ELAS\_FO,*

*.  
.*

*all them*

*ECRO\_LINE,*

*materials*

*TRACTION,...*

*available in*

*C\_PLAN*

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### **3.4 Limiting loadings and conditions**

**: AFFE\_CHAR\_MECA and  
AFFE\_CHAR\_MECA\_F**

*One points out that it is not possible to carry out thermal calculations, however the assignment of temperature is possible, using operator CREA\_CHAMP. (see paragraph [§3.4.4]).*

*The assignment of the loadings and the boundary conditions on a mechanical model is carried out with assistance of operators AFFE\_CHAR\_MECA, if loadings and boundary conditions mechanical on a system are actual values depending on no parameter, or AFFE\_CHAR\_MECA\_F, if these values are functions of the position or the increment of loading.*

*The documentation of use of AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F is [U4.44.01].*

#### **3.4.1 List key words factors of AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F**

*The key words factors available for these two operators are gathered in the two tables following.*

**AFFE\_CHAR\_MECA TUYAU\_3M**

**Drank, remarks and examples**

**TUYAU\_6M**

**DDL\_IMPO**

.

**Drank:** *to impose, with nodes or groups of nodes, one or of the values of displacement*

*Mode 0 (swelling) and:*

-  
*modes 1 to 3 for TUYAU\_3M*

-  
*modes 1 to 6 for TUYAU\_6M*

**Example:** *SDLL14, SLL101, SSLX102, SSNL106,...*

**LIAISON\_DDL**

.

**Drank:** *to define a linear relation between degrees of freedom from two or several nodes*

**LIAISON\_OBLIQUE**

.

**Drank:** *to apply, with nodes or groups of nodes, even component value of displacement definite by component in an unspecified oblique reference mark*

## *LIAISON\_GROUP*

.

**Drank:** *to define linear relations between certain degrees of freedom of couples of nodes, these couples of nodes being obtained while putting in opposite two lists of meshes or of nodes*

## *LIAISON\_UNIF*

.

**Drank:** *to impose the same value (unknown) on degrees of freedom of a whole of nodes*

**Example:** *ELSA01B, ELSA01C and ELSA01D*

## *LIAISON\_SOLIDE*

.

**Drank:** *to model an indeformable part of a structure*

**Example:** *ELSA01B, ELSA01C and ELSA01D*

## *LIAISON\_ELEM*

.

**Drank:** *to model the connections of a massive part 3D with a pipe part or of a hull part with a pipe part*

**Example:** *SSLX101B, SSLX102A and SSLX102F*

## *LIAISON\_CHAMNO*

.

**Drank:** *to define a linear relation between all ddls present in a concept CHAM\_NO*

## *TEMP\_CALCULEE*

.

## **Drank**

*: to recover a thermal loading (temperature affected by CREA\_CHAMP)*

**Example:** *HSNS101D, HSNV100C, SSSL101C,...*

## *GRAVITY*

.

**Drank:** *to apply an effect of gravity*

**Example:** *SSSL101, SSSL106*

## *FORCE\_POUTRE*

.

**Drank:** *to apply linear forces, to elements of the type beam*

**Example:** *SSSL106*

## *FORCE\_NODALE*

.

**Drank:** *to apply, with nodes or groups of nodes, nodal forces, definite component by component in*

*TOTAL reference mark or in an oblique reference mark defined by 3 angles  
nautical*

**Example:** *SLL106,...*

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**FORCE\_TUYAU**

.

**Drank:** *to apply, with elements or groups of elements  
of pipe type an internal pressure*

**Example:** *SLL106, SSNL117, SSNL503*

**AFPE\_CHAR\_MECA\_F TUYAU\_3M** *Remarks*

**TUYAU\_6M**

**DDL\_IMPO**

· *Voir*

*above*

**LIAISON\_DDL**

· *Voir*

*above*

**LIAISON\_OBLIQUE**

· *Voir*

*above*

**LIAISON\_GROUP**

· *Voir*

*above*

*LIAISON\_UNIF*

*· Voir*

*above*

*LIAISON\_SOLIDE*

*· Voir*

*above*

*FORCE\_POUTRE*

*· Voir*

*above*

*FORCE\_NODALE*

*· Voir*

*above*

*FORCE\_TUYAU*

*· Voir*

*above*

### ***3.4.2 Application of an internal pressure: key word FORCE\_TUYAU***

*This key word factor is usable to apply an internal pressure to elements pipe, definite by one or more meshes or groups of meshes. The pressure is applied to the level of the ray intern, as in 3D.*

*Syntax to apply this loading is pointed out below:*

*·*  
*AFFE\_CHAR\_MECA:*

*/ FORCE\_TUYAU*

*:*

*(*

*/ALL: "YES"*

*/*

*NET*

*:*

*lma*

*[l\_maille]*

*/*

*GROUP\_MA*

*:*

*lgma*



[l\_gr\_maille]

NEAR

:

P

[R]

)

.

AFFE\_CHAR\_MECA\_F:

/ FORCE\_TUYAU

:

(

/ALL: "YES"

/

NET

:

lma

[l\_maille]

/

GROUP\_MA

:

lgma

[l\_gr\_maille]

*NEAR*

:

*PF*

*[function]*

)

*The operand available is:*

*NEAR:*

*p (PF)*

*Value of the imposed pressure (real or function of time or the geometry).*

*p is positive according to the contrary direction of the normal to the element.*

*This loading applies to the types of meshes and following modelings:*

***Net Modélisation***

*SEG3, SEG4*

*“TUYAU\_3M”*

*SEG3*

*“TUYAU\_6M”*

*Examples of use are available in the base of tests: case-tests ELSA01B, SSLL106A, SSNL117A and SSNL503A.*

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### ***3.4.3 Application of a force distributed: key word FORCE\_POUTRE***

*This key word factor is usable to apply **linear**, constant forces according to X, to elements of the beam type defined on all the grid or one or more meshes or of groups of meshes. The forces are definite component by component, that is to say in the reference mark TOTAL, that is to say in the local reference mark of the element defined by operator AFFE\_CARA\_ELEM [U4.42.01].*

*Syntax is available in the documentation of AFFE\_CHAR\_MECA/AFFE\_CHAR\_MECA\_F [U4.44.01].*

*This loading applies to the types of meshes and following modelings:*

#### ***Net Modélisation***

*SEG3, SEG4*

*TUYAU\_3M*

*SEG3*

*TUYAU\_6M*

*An example of use is available in the base of tests: case-test SSSL106.*

### ***3.4.4 Application of a thermal dilation: key word TEMP\_CALCULEE***

*No thermal calculation is available with modeling PIPE, it is nevertheless possible to apply a dilation (thermal loading of origin), in the shape of a field of temperature with the nodes in the thickness of the tubes.*

*This field will have been beforehand creates using operator CREA\_CHAMP (documentation [U4.72.04]).*

#### ***CREA\_CHAMP***

*TUYAU\_3M*

***Remarks***

## **TUYAU\_6M**

*TYPE\_CHAM “NOEU\_TEMP\_R”*

.

*Field result of the temperature type*

*“NOEU\_TEMP\_F”*

*OPERATION*

*GRID*

*MODEL*

*AFFE*

*ALL: “YES”*

.

*The field is manufactured by*

*GROUP\_MA*

*assignment of values on*

*NET*

*nodes or of the meshes*

*NODE*

*GROUP\_NO*

*NOM\_CMP “TEMP”*

.

*Names of the components that*

*one wants to affect: temperature*

*“TEMP\_INF”*

.

*Lower temperature*

*“TEMP\_SUP”*

.

*Temperature superior*

*The assignment of thermal dilation is carried out using operator AFFE\_CHAR\_MECA  
(documentation [U4.44.01]).*

**AFFE\_CHAR\_MECA**

**TUYAU\_3M**

**Remarks**

## **TUYAU\_6M**

### *MODEL*

.

### *TEMP\_CALCULEE temple*

.

*temple is the field creates by*

*CREA\_CHAMP*

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*The following example is extracted from case-test SSSL101C.*

*TEMP = CREA\_CHAMP (GRID = GRID,*

*TYPE\_CHAM = "NOEU\_TEMP\_R",*

*OPERATION = "AFFE", AFFE= (*

*\_F (ALL = "YES",*

*NOM\_CMP = "TEMP",*

*VALE = 472.22),*

*\_F (ALL = "YES",*

*NOM\_CMP = "TEMP\_INF",*

*VALE = 472.22),*

*\_F (ALL = "YES",*

*NOM\_CMP = "TEMP\_SUP",*

*VALE = 472.22))*

)  
***DILATA=AFFE\_CHAR\_MECA (MODELE=MODELE,  
 TEMP\_CALCULEE=TEMP***  
 )

**Note:**

*If one wants to apply a temperature defined by a function, one can use operator CREA\_RESU (TYPE\_RESU='EVOL\_THER',...) (see the document [U4.44.12]) to create a concept of the type EVOL\_THER usable in AFFE\_CHAR\_MECA. An example is available in the form of case-test HSNS101D.*

*Examples of use are available in the base of tests: case-tests ELSA01B, SSSL106A, SSNL117A and SSNL503A.*

**3.4.5 Application of gravity: key word GRAVITY (AFFE\_CHAR\_MECA only)**

*This key word is used for applied the effect of gravity on piping.*

**AFFE\_CHAR\_MECA**

**TUYAU\_3M**

**Remarks**

**TUYAU\_6M**

**GRAVITY**

*(G, ap, LP, CP)*

·  
*Acceleration and direction of  
 gravity*

*Example of use of the operand GRAVITY:*

***POI\_PROP = AFFE\_CHAR\_MECA (MODELE=MODELE,  
 PESANTEUR= (9.81, 0. , 0. , - 1. , )***  
 )

**3.4.6 Connections hull-pipes, 3D-pipe and pipe-beams: key word LIAISON\_ELEM**

*It is a question of establishing the connection between a node end of a pipe section and a group of mesh of edge of elements of hulls or elements 3D. This makes it possible to net part of piping (by example an elbow) in hulls or elements 3D and the remainder in right pipes. The formulation of the*

## *connection*

*hull-pipes and of the connection 3D-Pipe is presented in the reference document [R3.08.06]. It connection makes it possible to transmit warping and ovalization means of the grid hull or 3D to ddl correspondent of the pipe.*

*The connection:*

***Hull - pipe:** it makes it possible to connect elements of edge (SEG2, SEG3) of the hull part to node of the pipe to be connected. This connection is currently realizable for pipes of which neutral fibre is perpendicular to the normals with the facets of the plates or the hulls. connection is usable by using key word LIAISON\_ELEM: (OPTION: "COQ\_TUYAU") AFFE\_CHAR\_MECA.*

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***Pipe - 3D:** it makes it possible to connect elements of edge (TRIA3, QUAD4, TRIA6,...) part 3D with the node of the pipe to be connected. The connection is usable by using the key word LIAISON\_ELEM: (OPTION: "3D\_TUYAU") of AFFE\_CHAR\_MECA.*

**Appear 3.4.6-a: Example of connection between a grid COQUE\_3D and PIPE**

*The case-tests which test the connections are presented on the following table.*

**NAME**

## **MODELING ELEMENT**

### **Remarks**

*SSLX101B*

*DKT*

*MEDKQU4 Connection COQ\_TUYAU:*

*PIPE*

*METUSEG3 Pipe right modelled in hulls and beams.*

*Doc. V:*

*DIS\_TR*

*POII*

*This test aims to test the connection*

*[V3.05.101]*

*hull pipe "COQ\_TUYAU" in the presence of  
unit loadings: traction, inflection and of  
torsion.*

*SSLX102A*

*DKT*

*MEDKQU4 Connection COQ\_TUYAU:*

*PIPE*

*METUSEG3 Piping bent in inflection.*

*Doc. V:*

*MEDKQU4*

*[V3.05.102]*

*METUSEG3*

*SSLX102F*

*3D*

*HEXA20*

*Connection 3D\_TUYAU:*

*PIPE*

*METUSEG3 Piping bent in inflection: modeling*

*Doc. V:*

*3D-PIPE, relations linear 3D\_TUYAU.*

*[V3.05.102]*

*elbow is modelled with elements 3D.*

*In all these case-tests, the results are satisfactory given that part of the variations  
noted is ascribable with the fusion of the grid 3D or hulls.*

**Note:**



## Connections pipe-beams.

*It is a question of establishing a connection between a node end of a pipe section and a node end of one element of beam. The pipe formulation comprises a kinematics of the beam type identical to kinematics of the elements beams. There is thus no cut between displacements of the type beam (3 displacements and 3 rotations). The average fibre of the beam and the pipe are the same ones.*

*By*

*count, the kinematics of the elements of beam does not include/understand kinematics of hull (the section is indeformable) like in the case of the elements pipes, there is thus a cut on the level of deformation of the transverse section.*

*There does not exist in specific Code\_Aster of connection pipe-beam, the connection between these two elements is automatically assured, without intervention of the user, by the node common to the element pipe and with the element beam. Nevertheless, some care are to be taken, it is necessary that transition between the beam and pipe sections is sufficiently distant from all zones "pipe" or the deformation of the transverse section is significant, i.e. that one should connect only when ovalization is deadened.*

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### **3.4.7 Limiting conditions: key words DDL\_IMPO and LIAISON\_\***

*The key word factor DDL\_IMPO makes it possible to impose, with nodes introduced by one (at least) of the words*

*keys: ALL, NODE, GROUP\_NO, MESH, GROUP\_MA, one or more values of displacement (or of certain associated sizes). According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_MECA) or via a concept function (AFFE\_CHAR\_MECA\_F).*

*The operands available for DDL\_IMPO, are listed below:*

.

*DX DY DZ*

*Blocking on the component of displacement in **translation***

.

*DRX DRY DRZ*

*Blocking on the component of displacement in **rotation***

*If the specified nodes belong to elements “TUYAU\_3M” (these elements 15 DDL have of hull):*

*U: warping*

*V, W: ovalization*

*I: “in plane”*

*O: “out of planes”*

*That is to say:*

.

*UI2 VI2 WI2 UO2 VO2 WO2*

*DDL related to mode 2*

.

*UI3 VI3 WI3 UO3 VO3 WO3*

*DDL related to mode 3*

.

*WO WI1 WO1*

*DDL of swelling and mode 1 on W*

*If the specified nodes belong to elements “TUYAU\_6M” (these elements 33 DDL have of hull), one adds the following DDL:*

.

*UI4 VI4 WI4 UO4 VO4 WO4*

*DDL related to mode 4*

.

*UI5 VI5 WI5 UO5 VO5 WO5*

*DDL related to mode 5*

.

*UI6 VI6 WI6 UO6 VO6 WO6*

*DDL related to mode 6*

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## **4 Resolution**

### **4.1**

***Linear calculations: Linear MECA\_STATIQUE and other operators***

***Linear calculations are carried out in small deformations. Several linear operators of resolution are available:***

.

***MECA\_STATIQUE: resolution of a problem of static mechanics linear ([U4.51.01]),***

.

***MACRO\_ELAS\_MULT: calculate linear static answers for various loading cases or modes of Fourier. ([U4.51.02]),***

.

***MODE\_ITER\_SIMULT: calculation of the values and vectors clean by methods of under spaces. ([U4.52.03]),***

.

***MODE\_ITER\_INV: calculation of the values and vectors clean by the method of iterations opposite ([U4.52.04]),***

**MODE\_ITER\_CYCL**

*: calculation of the clean modes of a structure with cyclic symmetry ([U4.52.05]),*

*DYNA\_LINE\_TRAN: calculation of the transitory dynamic response to a temporal excitation unspecified ([U4/U4.53.02]).*

*Concerning the operator of resolution of static mechanics linear, following information is extracted the documentation of use of operator MECA\_STATIQUE: [U4.51.01].*

**MECA\_STATIQUE**

**TUYAU\_3M**

**TUYAU\_6M**

**ANGLE**

*ndegré*

*This word is used only for the postprocessings required on pipe sections. It is the angle (in degrees) not compared to the generator of the circuit of piping. It is worth 0 per defect*  
**NUME\_COUCHE** *nume*

*This word is used only for the postprocessings required on pipe sections. It is the angle (in degrees) not compared to the generator of the circuit of piping. It is worth 0 per defect*  
**NIVE\_COUCHE** *“INF”*

*This word is used only for the postprocessings required on “SUP” pipe sections. It is the angle (in degrees) “MOY” not compared to the generator of the circuit of piping. It is worth 0 per defect*

*By defect, the only computed field is the fields of displacement DEPL. Other fields are available by the operand OPTION (see the options available in the paragraph [§5.2] bearing on the use of CALC\_ELEM).*

.  
**ANGLE:** /delta (0. per defect)

.  
**NUME\_COUCHE:** /nume (standard entirety, 1 per defect)

.  
**NIVE\_COUCHE:** /"INF", "SUP" or "MOY" ("MOY" by defect)

**with:**

.  
**delta:** angle in degrees counted starting from the position of the generator of the element pipe,

.  
**nume:** number of layer (number 1 corresponds to the internal layer). Must be inferior or equal to the total number of layers given in STAT\_NON\_LINE (key word TUYAU\_NCOU),

.  
**NIVE\_COUCHE** indicates the position of the point of integration in layer (INF corresponds to not more the intern).

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**4.2**

**Nonlinear calculations: STAT\_NON\_LINE and DYNA\_NON\_LINE**

**4.2.1 Behaviors and assumptions of deformations available**

Following information is extracted from the documentation of use of the operator *STAT\_NON\_LINE*: [U4.51.03].

*STAT\_NON\_LINE*

*TUYAU\_3M*

*DYNA\_NON\_LINE*

*TUYAU\_6M*

*COMP\_INCR RELATION*

.  
*all behaviors available  
in C\_PLAN  
DEFORMATION SMALL*

.  
*Incremental relations of behavior (key word factor COMP\_INCR) according to the assumption of small displacements and small deformations (key word DEFORMATION: "SMALL") are only mechanical nonlinear relations of behavior available for modeling PIPE. These relations of behavior connect the rates of deformation to the rates of constraints. Behaviors nonlinear supported are those already existing in plane constraints defined in the operators STAT\_NON\_LINE and DYNA\_NON\_LINE. Moreover, with ALGO\_C\_PLAN: `DEBORST` all them behaviors 2D (D\_PLAN, AXIS) in small deformations are usable.*

*The options specific to modeling PIPE are:*

*The concept RESULT of STAT\_NON\_LINE contains displacement, stress fields and variables intern at the points of integration always calculated at the points of gauss:*

.  
*SIEF\_ELGA: Tensor of the constraints by element at the points of integration in the reference mark room of the element,*

.  
*VARI\_ELGA: Field of variables intern by element at the points of integration in locate local element,*

.  
*DEPL: fields of displacements.*

*Moreover, one call to operator CALC\_ELEM or CALC\_NO, gives access other fields. In particular, one can carry out the passage of the constraints and internal variables of the points of Gauss with the nodes to form fields SIEF\_ELNO\_ELGA and VARI\_ELNO\_ELGA (see the paragraph [§5.2]).*

*A field VARI\_... can have several types of components. For example, components of field VARI\_ELNO\_ELGA are, for the elements PIPE:*

*K time: (V1, V2, ..... Vn)*

*Where:*

*K is the number of points of integration total:  $K = (2 * NCOU + 1) * (2 * NSEC + 1)$ ;*

*NR is the number of variables intern and depends on the behavior.*

#### ***4.2.2 Details on the points of integration***

*For linear and non-linear calculations, numerical integration is carried out with a method of:*

*Gauss along average fibre.*

*The number of points of integration is fixed at 3. For a mesh whose tops are 1 and 2 and numbered from 1 to 2, the 3 points of gauss are such as first is close to 1, it second is at equal distance from 1 and 2 and the third is closer to 2. It is thus necessary to make attention with the orientation of the meshes when one looks at the results at the points of gauss 1 and 3. Indeed if the orientation of the mesh is changed and that one numbers it from 2 to 1, the first not gauss is closer to 2.*

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*Simpson in the thickness and on the circumference:*

-  
*Integration in the thickness is an integration of Simpson at 3 points per layer. a number of points of integration per layer is fixed at 3, in the middle of the layer, in skin higher and in lower skin of the layer, the two points ends being common with the close layers.*

-  
*Integration according to the circumference is an integration of Simpson per sector, each sector being of angle  $2/NSEC$ . is the angle between the generator and the center of the sector. The number of points of integration per sector is fixed at 3, in the middle of the sector, partly higher (+  $/NSEC$ ) and lower (-  $/NSEC$ ) of the sector, two points ends being common with the close sectors.*

*The number of layers and the number of sectors must be defined by the user starting from the key words: TUYAU\_NCOU, TUYAU\_NSEC of operator AFFE\_CARA\_ELEM.*

*For example, with 3 layers and 16 sectors, the number of points of integration per element is  $(2*NCOU+1) * (2*NSEC+1) *NPG$  what gives 693 points of integration. For each point of gauss on the length of the element, one stores information on the layers and for each layer on all sectors. If one wants information at the point of gauss NG, on layer NC level NCN (NCN = 1 so lower, NCN = 0 if medium, NCN = + 1 so higher), on the sector NS, level NSN (NSN = 1 so lower, NSN = 0 if medium, NSN = +1 so higher), then one looks at the values sought with not integration:*

$$NP = (NG-1) * (2NCOU+1) * (2NSEC+1) + (2*NC+NCN-1) * (2NSEC+1) + (2*NS+NSN).$$



*In practice, it is more convenient to observe:*

*that is to say values extracted in a thickness and a sector: \*\_TUYO;*

*maybe of the total values, for example SIEF\_ELNO\_ELGA.*

## **4.3 Calculations**

### **dynamic**

*Concerning dynamic calculations, no specificity due to the finite element PIPE exists.*

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**5**

## **Additional calculations and postprocessings**

**5.1**

### **Elementary calculations of matrices: operator CALC\_MATR\_ELEM**

*Operator CALC\_MATR\_ELEM (documentation [U4.61.01]) allows to calculate matrices elementary gatherable by order ASSE\_MATRICE (documentation [U4.61.22]).*

*The only calculable matrices with the elements pipe are the matrices of rigidity and mass of elements of the model:*

***CALC\_MATR\_ELEM  
TUYAU\_3M  
TUYAU\_6M Remarks***

***“RIGI\_MECA”***

..

***“MASS\_MECA”***

..

*These calculations of elementary matrices for example are used for the determination of the frequencies clean of a thick cylindrical ring, in case-test SDLS109G.*

## **5.2 Calculations by elements: operator CALC\_ELEM**

*Operator CALC\_ELEM (documentation [U4.81.01]) carries out the calculation of the fields to the elements:*

- constraints, deformations, variables intern with the nodes;*
- equivalent values (nonavailable for modeling PIPE).*

*One presents hereafter the options of postprocessing for the pipe sections. For the structures modelled by pipe sections, it is particularly important to know how are presented results of the constraints: the approach adopted in Code\_Aster consists in observing constraints in a particular reference mark related to the element whose reference axis was defined in paragraph [§3.2.2]. This approach seems most physical because, for a cylindrical structure, them the constraints easiest to interpret are not the constraints in Cartesian reference mark but them constraints in cylindrical co-ordinates. Moreover this approach allows a greater flexibility of use.*

***CALC\_ELEM  
TUYAU\_3M TUYAU\_6M Remarks***

***“SIEF\_ELGA\_DEPL”***

..

***“EFGG\_ELNO\_DEPL”***

..  
“EPSI\_ELGA\_DEPL”

..  
“SIGM\_ELNO\_TUYO”

..  
“SIEF\_ELNO\_ELGA”

..  
“VARI\_ELNO\_ELGA”

..  
“VARI\_ELNO\_TUYO”

..

.

*SIEF\_ELGA\_DEPL: calculation of the constraints by element at the points of integration of the element with to leave displacements (Use only in elasticity), in the local reference mark of the element.*

.

*EFGE\_ELNO\_DEPL: calculation of the generalized efforts of traditional beam per element with nodes starting from displacements, in the local reference mark of the element (only in elasticity linear).*

.

*EPSI\_ELGA\_DEPL: calculation of the deformations by element at the points of integration of the element starting from displacements, in the local reference mark with the element (small deformations).*

.

*SIEF\_ELNO\_ELGA: calculation of the torque of the efforts generalized by element with the nodes, in locate local element (calculated by integration starting from SIEF\_ELGA).*

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.

*VARI\_ELNO\_ELGA: calculation of the field of variables intern by element with the nodes to leave points of Gauss, for all the layers (in thickness SUP/MOY/INF) and for all sectors in the local reference mark of the element.*

.

*SIGM\_ELNO\_TUYO: calculation of the local constraints by elements with the nodes from points of integration, in the local reference mark of the element. Calculations provide the constraints at the point defined by options NUME\_COUCHE, NIVE\_COUCHE and ANGLE.*

.

*VARI\_ELNO\_TUYO: calculation of the variables intern **in a layer** and for a sector angular of elements pipe (key words NUME\_COUCHE, NIVE\_COUCHE and ANGLE affected by AFFE\_CARA\_ELEM, to see paragraph [§3.2]).*

*One obtains then by node of each tensor only one element of constraints (or only one whole of variables intern), which allows the graphic examination (evolution of a component,...).*

### 5.3

#### **Calculations with the nodes: operator CALC\_NO**

CALC\_NO  
TUYAU\_3M  
TUYAU\_6M Remarks

“FORC\_NODA”

..

“REAC\_NODA”

..

“EFGE\_NOEU\_DEPL”

..

“SIEF\_NOEU\_ELGA”

..

“VARI\_NOEU\_ELGA”

Operator *CALC\_NO* (documentation [U4.81.02]) carries out the calculation of the fields to the nodes by moyennation and the calculation of the forces and reactions:

fields with the nodes: internal constraints, deformations, variables, equivalent values;

Name of option: to replace *\_ELNO\_* by *\_NOEU\_*

One can calculate the fields with the nodes by *CALC\_NO*  
*SIEF\_NOEU\_ELGA*, *VARI\_NOEU\_ELGA*

forces and reactions:

starting from the constraints, balance: *FORC\_NODA* (calculation of the nodal forces from constraints at the points of integration, element by element),

then by removing the loading applied: *REAC\_NODA* (calculation of the nodal forces of reaction to the nodes, the constraints at the points of integration, element by element):

$REAC\_NODA = FORC\_NODA - \text{loadings applied}$ ,

useful for checking of the loading and calculations of resultants, moments, etc

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## **5.4**

### ***Calculations of the elementary fields: operator CALC\_CHAM\_ELEM***

*Operator CALC\_CHAM\_ELEM (documentation [U4.81.03]) allows to calculate fields elementary starting from already calculated fields of type CHAM\_NO\_\* or CHAM\_ELEM\_\*.*

### ***TUYAU\_3M TUYAU\_6M Remarks***

*“EFGE\_ELNO\_DEPL”*

..

*For modeling PIPE, only the efforts generalized for a field of displacement are available.*

## **5.5 Calculations of quantities on whole or part of the structure: operator POST\_ELEM**

*Operator POST\_ELEM (documentation [U4.81.22]) allows to calculate quantities on all or part of the structure. The calculated quantities correspond to particular options of calculation of affected modeling.*

### ***TUYAU\_3M***

### ***TUYAU\_6M Remarks***

*“MASS\_INER”*

..

*For modeling PIPE, the only currently available option is calculation, on each element, of the mass, inertias and the position of the centre of gravity (option “MASS\_INER”).*

## **5.6 Values of components of fields of sizes: operator POST\_RELEVE\_T**

For modeling PIPE, operator *POST\_RELEVE\_T* (documentation [U4.81.21]) can be used for, on a line, to extract from the values (for example *SIEF\_ELNO\_ELGA* or *SIGM\_ELNO\_TUYO*). The produced concept is of type counts.

**Important remark:**

If one comes from an interface with a maillor (*PRE\_GIBI*, *PRE\_IDEAS*, *PRE\_GMSH*), the nodes of a groupno are arranged by numerical order. It is necessary to reorder the nodes along line of examination. The solution is to use operator *DEFI\_GROUP* with the option *NOEU\_ORDO*. This option makes it possible to create an ordered *GROUP\_NO* containing the nodes of one together of meshes made of segments (*SEG2*, *SEG3* or *SEG4*).

An example of extraction of component is given in case-test *SSNL503* (see description with paragraph [§6.2]):

```
TAB_DRZ=POST_RELEVE_T (ACTION=_F (
GROUP_NO = "Of,
ENTITLE = "TB_DRZ",
RESULT = RESUL,
NOM_CHAM = "DEPL",
NOM_CMP = "DRZ",
TOUT_ORDRE = "YES",
OPERATION = "EXTRACTION"
)
)
```

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*The purpose of this syntax is:*

.

*to extract:*

*OPERATION = "EXTRACTION"*

.

*on the line (the group of nodes) D: GROUP\_NO = "Of*

.

*component DRZ of displacement: NOM\_CHAM = "DEPL", NOM\_CMP = "DRZ",*

.

*for every moment of calculation:*

*TOUT\_ORDRE = "YES"*

## 5.7

### ***Impression of the results: operator IMPR\_RESU***

*Operator IMPR\_RESU allows to write the grid and/or the results of a calculation on listing with the format*

*"RESULT" or on a file in a displayable format by external tools for postprocessing with Aster: format RESULT and ASTER (documentation [U4.91.01]), format CASTEM (documentation [U7.05.11]), format ENSIGHT documentation [U7.05.31]), format IDEAS (documentation [U7.05.01]), format MED (documentation [U7.05.21]) or format GMSH (documentation [Ux.xx.xx]).*

*Currently this procedure makes it possible to write with the choice:*

.

*a grid,*

.

*fields with the nodes (of displacements, temperatures, clean modes, modes statics,...),*

.

*fields by elements with the nodes or the points of GAUSS (of constraints, efforts generalized, of variables intern...).*

*The element PIPE being treated same manner that the other finite elements, we return it reader with the notes use corresponding to the format of exit which it wishes to use.*

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## **6 Examples**

*The tables according to describe some case-tests using the element PIPE.*

### **6.1**

*Analyze static linear*

**SSLL101**

*Titrate: Problem of Hovgaard. Analyze static of a piping*

**E**

*three-dimensional comprising elbows*

**D**

**Z**

*With*

*Documentation V: [V3.01.101]*

**F**

**B**

**y**

*Modelings:*

**SSLL101D TUYAU\_6M SEG3**

**G**

***SSLL101C TUYAU\_3M SEG3***

***SSLL101E TUYAU\_3M SEG4***

***H***

***C***

***X***

***ssl106 Title***

***:***

***Tube right subjected to several loadings.***

***Documentation V: [V3.01.106]***

***Modelings:***

***SSLL106B TUYAU\_3M SEG3***

***SSLL106E TUYAU\_3M SEG4***

***SSLL106D TUYAU\_6M SEG3***

***Loadings: a traction, 2 efforts sharp, 2 moments of inflection, a torsion and a pressure. It makes it possible to test them displacements, efforts with the nodes and constraints and deformations at the points of Gauss, compared to a solution of analytical reference. The grid used is the same one for four modelings. Modelings A and C use MECA\_STATIQUE, while modelings B and D use STAT\_NON\_LINE for the resolution.***

***sslx102 Title***

***:***

***Piping bent in inflection.***

***Documentation V: [V3.05.102]***

**Modelings:**

**SSLX102B TUYAU\_3M SEG3**

**SSLX102C TUYAU\_6M SEG3**

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**6.2**

**Analyze static nonlinear material**

**SSNL503**

**Titrate: Elastoplastic ruin of a thin bent pipe.**

**With**

**0.407m**

**Documentation V: [V2.05.002]**

**1,83**

**p**

**Modelings:**

**y**

**SSNL503A TUYAU\_3M SEG3**

**0.0104m**

**Loading: thin bent pipe subjected to an inflection in sound**

**B**

**X**

***plan and has an internal pressure with basic effect.***

**C**

**D**

**M**

***R= 0.61m***

***0.61m***

***ssNI106 Title***

**:**

***Fixed beam has an end and charged by one traction with linear work hardening or a moment in plasticity perfect.***

***Documentation V: [X]***

***Modelings:***

***SSNLI106E TUYAU\_3M SEG3***

***SSNLI106F TUYAU\_3M SEG4***

***SSNLI106G TUYAU\_6M SEG3***

***Loadings: a traction, 2 efforts sharp, 2 moments of inflection, a torsion and a pressure. Modelings A and C use MECA\_STATIQUE, while modelings B and D use STAT\_NON\_LINE for the resolution.***

***HSNV100 Titrates***

**:**

***Thermoplasticity in simple traction of a pipe.***

***Documentation V: [V7.22.100]***

***Modelings:***

***HSNV100C TUYAU\_3M SEG3***

***HSNV100D TUYAU\_6M SEG3***

**6.3**

***Modal analysis in dynamics***

**SDLX02**

***Titrate:: Problem of Hovgaard. Analyze dynamic of one***

**E**

***three-dimensional piping comprising of the elbows.***

**D**

**Z**

**With**

***Documentation V: [V2.05.002]***

**F**

**B**

**y**

***Modelings:***

***SDLX02D TUYAU\_3M SEG3***

**G**

***SDLX02F TUYAU\_3M SEG4***

***SDLX02E TUYAU\_6M SEG3***

**H**

**C**

**X**

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***Titrate:***

***Note of use of elements TUYAU\_\****

***Date:***

**24/05/02**

***Author (S):***

***A. ASSIRE, P. MASSIN, F. LEBOUVIER Key***

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***sDLL14 Title***

:

***Mode of vibration of a thin elbow of piping.***

***Documentation V: [V2.02.014]***

***Modelings:***

***SDLL14A TUYAU\_3M SEG3***

***SDLL14C TUYAU\_3M SEG4***

***SDLL14B TUYAU\_6M SEG3***

**6.4**

***Analyze dynamic nonlinear***

***ELSA***

***Titrate: Nonlinear seismic analysis of a line of piping.***

***Documentation V: [V1.10.119]***

***Modelings:***

***ELSA01B TUYAU\_3M SEG3***

***ELSA01C TUYAU\_3M SEG4***

***Loadings: a seismic excitation is imposed on the line.***

***This one involves a partial plasticization (1%) elbows only.***

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***Date:***

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**A. ASSIRE, P. MASSIN, F. LEBOUVIER Key**

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*Titrate:*

*Pre and post-processor “composite thin hulls”*

*Date:*

22/01/02

*Author (S):*

**A.M. DONORE, Mr. BONNAMY**

*Key: U2.02.03-B Page*

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*Organization (S): EDF/AMA, AUSY France*

***Instruction manual***

***U2.02 booklet: Elements of structure***

***Document: U2.02.03***

***Note of use of Pre and Post-processor  
“composite thin hulls”***

***Summary***

***The modeling of the thermomechanical behavior of a structure made up of a composite material***

***multi-layer breaks up into three stages:***

***determination of the mechanical magnitudes and thermal on the average surface of the hull, i.e., the study of the relation stress-strains of the multi-layer composite from characteristics of each layer and a simple space description of multi-layer, as described in [R4.01.01].***

***This stage wants to be independent of the type of element used in the phase of calculation and constitutes it preprocessor “composite thin hulls” of Aster,***

***calculation by finite elements, on the average surface of the hull,***

***the determination sleeps by layer, of the tensor of deformations, the tensor of constraints, and of criterion of rupture says criterion of the maximum constraint. This is carried out by the post-processor.***

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***1 Preprocessor***

***The preprocessor must determine the coefficients of the matrix of rigidity, characterizing the relation stress-strains, which in the case of brings back the hulls to a relation between the efforts generalized (NR, M) and tensors of deformation (E) and variation of curve (K); It is added if necessary to this relation generalized efforts of thermal origin NR, M***

***HT***

***HT.***

**HT**  
**NR**  
**WITH B**  
**NR**  
**=**  
**E +**  
**M**  
**B D**  
**K**  
**HT**  
**M**

*This determination requires the following data:*

.  
*characteristics of various constituent materials the multi-layer one (each layer can be an isotropic material or an orthotropic material defined by a suitable number of constants rubber bands).*

*Note:*

*Several layers can be of the same material.*

.  
*direction of reference, definite on the average surface of the hull, and allowing to introduce easily, orientation of the layers ones compared to the others; this direction of reference is that defined by the key word ORIENTATION of HULL by the operator AFFE\_CARA\_ELEM (see [U4.24.01]).*

.  
*of a space description of the multi-layer one which includes/understands, layer by layer, (while beginning by the sub-base relative than the normal with the element), the data of material, of the thickness and of the orientation of the axes of orthotropism of material compared to the axis of reference.*

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***1.1***  
***Definition of a material***

***The definition of material is done using operator DEFI\_MATERIAU [U4.23.01].***

***materi [to subdue] = DEFI\_MATERIAU***

***(//ELAS:***

***(***

***For a material***

***E:***

***yg***  
***[R]***

***isotropic,***

**NAKED**

:

**naked**

**[R]**

**RHO**

:

**rho**

**[R]**

**ALPHA:**

**dil**

**[R]**

)

/

**ELAS\_FO**

:

(

**E:**

**yg**

**[function "TEMP"]**

**NAKED**

**:**  
**naked**  
**[function "TEMP"]**

**RHO**

**:**  
**rho**  
**[R]**

**ALPHA**

**: dil**

**[function "TEMP"]**

)

**for a material**

**/**  
**ELAS\_ORTHO**

:  
(

*orthotropic (L, T)*

*E\_L:*

*ygl*

*[R]*

*axes of orthotropism,*

*E\_T*

*: Ygt*

*[R]*

*NU\_LT*

*: nult [R]*

*G\_LT*

*:*

*gl*

*[R]*

***RHO:***  
***rho***  
***[R]***

***according to L in traction***

***ALPHA\_L: dil [R]***

***according to L in compression***

***ALPHA\_T: known as [R]***

***according to T in traction***

***XT***  
***: trl***  
***[R]***  
***constraints according to***  
***T in compression***

***XC***  
***: collar***



**[R]**  
***with in***  
***shearing***

***YT***  
***: trt***  
**[R]**

***YC***  
***: cot***  
**[R]**  
***rupture***

***S\_LT***  
**:**  
***cis***  
**[R]**

***for a material***

)

*isotropic,*

*//THER:*

(

*CP:*

*CP*  
*[R]*

*LAMBDA*

:

*[R]*

)

/

*THER\_FO*

:

(

*for a material*

**CP:**  
**CP**

**[function "INST"] orthotropic (L, T) axes**

**LAMBDA**

**:**  
**[function "INST"] of orthotropism NR centers**

)

**normal on surface**

**/**  
**THER\_ORTHO**

**:**  
**(**

**average.**

**CP:**

**CP**

**[function "INST"]**

**LAMBDA\_L: lal [function "INST"]**

**LAMBDA\_T: lat [function "INST"]**

**LAMBDA\_N: [function "INST"]**

)  
);

**Note:**

.  
*the application of a criterion of rupture, whatever it is, requires the knowledge of the constraints with the rupture in traction, compression and shearing. They are characteristics of material that one can introduce on the level of operator **DEFI\_MATERIAU**, by the key words **XT, XC, YT, YC** and **S\_LT**, and which are exploited by postprocessing.*

.  
*it is possible to define a material of which elastic constraints **E\_L, E\_T, NU\_LT** and **G\_LT** are identically null.*

*That is particularly useful in the case of a material "sandwich" of which the central layer does not intervene by its rigidity but only by the spacing which it imposes on the layers located on both sides.*

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**1.2**

**Definition of a direction of reference**

**The direction of reference is defined by X1 projection of a vector V chosen by the user by data of 2 angles, on the tangent level with the hull [R4.01.01]**

**Angle 1 =  $X, V_{proj}(X, Y)$**

**Angle 2 =  $V$**

**,  $V$**

**$proj(X, Y)$**

**with X, Y, Z locate total.**

**The data of these two angles, is done using operator AFFE\_CARA\_ELEM [U4.24.01].**

**[will cara] = AFFE\_CARA\_ELEM**

**(MODEL: MOD**

**[model]**

**HULL:**

**(**

**/ALL: “YES”**

**/MESH:**  
*lma*  
*[l\_maille]*

/

**GROUP\_MA: l $\gamma$ ma**  
*[l\_gr\_maille]*

**THICK:**  
*thick*  
*[R]*

**ANGL\_REP:**  
*angle1, angle2*

*[l\_R]*

**COURB**  
*: curve*

**[R]**

)  
);

**Note:**

**Currently, only one finite element of thin hull makes it possible to treat orthotropic materials: the cylindrical element of hull (MODELING: "COQU\_CYL" specified by AFFE\_MODELE), for which the radius of curvature 1/R is given by key word COURB. The orthotropic behavior for modelings DKT and DST is under development.**

**1.3**

**Definition of the space description of the multi-layer one**

**The definition of multi-layer is done using operator DEFI\_COQU\_MULT:**

**multi-layer = DEFI\_COQU\_MULT**

**(LAYER**

**:(**

**THICK: thick**

**thickness of layer I**

**MATER**

**:**

**[checkmate] associated layer I**

**ORIENTATION**

**:**

**orien**

**orientation of the layer**

*compared to the reference axis*

*(angle in degrees)*

***IMPR: /  
0***

***/ 1***

***/ 2***



)  
);

*The key word factor **LAYER** appears time as many as there are layers in composite material. The layers are given sub-base than the roadbase while referring than the normal with the element.*

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## *2 Post-processor*

*The role of the post-processor, is to provide, layer by layer, the state of the strains, the stresses and an evaluation of the criterion of rupture, known as of the maximum constraint.*

*Its use is done using operator **CALC\_CHAM\_ELEM**:*

*result = **CALC\_CHAM\_ELEM***

*(*

***MODEL***

*:*

***Mo***

*[model]*

***CHAM\_MATER***

:  
***chmater [cham\_mater]***

***CARA\_ELEM***

:  
***carac***  
***[cara\_elem]***

***NUME\_COUCHE***

:  
***[I]***

***NIVE\_COUCHE***

:  
***/"SUP"***  
***[K3]***

***/"INF"***  
***[K3]***

**/“MOY”**  
**[K3]**

**INST**  
**:**  
**/**  
**tps**  
**[R]**  
**/**  
**0.**  
**{DEFECT}**

**/**  
**OPTION**  
**:**  
**/“SIEF\_ELGA\_DEPL”**  
**[K16]**

**/“SIGM\_ELNO\_DEPL”**

**/“EFGE\_ELNO\_DEPL”**

***/"DPGE\_ELNO\_DEPL"***

***/"EPSI\_ELNO\_DEPL"***

***/"CRIT\_ELNO\_RUPT"***

***DEPL***  
***: depl [cham\_no\_DEPL\_R]***

***CHARGE***  
***:***  
***charge***  
***[load]***

***CHAM\_ELEM***  
***:***  
***carac***  
***/***  
***[cham\_elem\_SIEF\_R]***  
***[cham\_elem\_EPSI\_R]***

/  
**OPTION**  
:  
/  
**“FLUX\_ELGA\_TEMP”**  
**[K16]**

/  
**“FLUX\_ELNO\_TEMP”**  
**[K16]**

**TEMP**  
:  
*temp*  
**[cham\_no\_TEMP\_R]**

);

*The result is according to the option chosen by the user, a tensor of deformations, a tensor of constraints, a criterion of rupture...*

*In the case of a criterion of rupture the calculated sizes are:*

**CR**  
**LL**  
**=**  
**if**  
**0 X**  
**LL**  
**:**  
**X**  
**LL**  
**T**  
*breaking stress in traction along the axis L*  
**T**

*(1st direction of orthotropism),*

**LL**

= -

*if*

**< 0 X:**

**X**

**LL**

**C**

*breaking stress in compression along the axis*

**C**

**L.**

**CR**

**TT**

=

*if*

**0 Y**

**TT**

:

*breaking stress in traction along the axis T*

**Y**

**LL**

**T**

**T**

*(2ème direction of orthotropism),*

**TT**

= -

*if*

**< 0 Y:**

*breaking stress in compression along the axis*

**Y**

**LL**

**C**

**C**

**T.**

**CR**

**LT**

=  
***S\_LT***  
***breaking stress in shearing in the plan***  
***LT***  
:  
***S\_LT***  
***L, T.***

***The breaking stresses are introduced using operator DEFI\_MATERIAU as indicated in [§ 1.1].***

***The result is calculated, with the choice of the user, on the upper surface, lower or average (word key NIVE\_COUCHE), of a layer specified by key word NUME\_COUCHE.***

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***Instruction manual***  
***U2.03 booklet: Thermomechanical***  
***Document: U2.03.03***

***Note of use of the mean model of hull thermics***

***Summary***

***Determination of the field of temperature in a mean structure subjected to various conditions thermics can be done advantageously using the model of thin hull thermal describes in [R3.11.01]. The temperature is described by three scalar fields, noted TEMP, TEMP\_INF, TEMP\_SUP defined on***

***surface average (X) hull, which will have to be with a grid, and by a distribution in the thickness x3 given by***

***:***  
***T (X, x3) = TEMP (X) P (X***

***(X***

***(X***

***1***

***3) + TEMP\_INF (X) P2***

***3) + TEMP\_SUP (X) P3 3)***

***the functions P***

***and being given. In this model, the curve of the hull does not intervene.***

***1, P2***

***P3***

***One can treat the stationary situations, as well as the problems of evolution. The latter must however to respect a limitation: it is necessary that the moments Tc characteristics of the evolution of the loadings***

***are such as:***

***T > C H2***

***C***

***33***

***with:***

*C: voluminal heat of material constitutive of the hull,*

*H: half thickness of the hull,*

*33: coefficient of transverse conductivity.*

*One gives here the description of the Aster orders useful for calculation, classified by chronological functionalities.*

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*1*

*Management of work: grid*

*The process of grid more general of an unspecified surface in IR3 being the triangularisation, one must thus constitute a grid by triangles of the average surface of the hull, plunged in IR3. That can be done with IDEAS and procedure PRE\_IDEAS for the conversion of the universal file*

*IDEAS [U4.13.01].*

*In the case of a plate or of a cylinder, one can use Ali-Baba and procedure PRE\_ALIBABA for the conversion [U4.13.02], which generates a grid plunged in IR3.*

*Example:*

*PRE\_ALIBABA (*

*PLATE*

: /"YES"

/  
"NOT"  
[DEFECT]

**ROLL:**  
(R: ray)

);

*In the case of the cylinder the plane grid (X, Y) of Ali-Baba is transformed into a grid:*

*(X = R cos X, y = R sin X, Z = Y)  
in IR3, where R is the ray.*

R  
R

y  
Y  
X/R  
B  
D  
F  
With

X  
C  
E  
B  
D  
Z  
F  
0  
X  
With  
C  
E

**Z**  
**2R**

*The cylinder created by rolling up of the plate 2D is of axis  $z>0$ ; the wall external with the cylinder corresponds to the face 2D higher  $Z>0$ .*

*The equations of the thermics of hull being of order 2, one will be able to use to net:*

.  
*triangles with 3 nodes (which will give P1 elements),*

.  
*triangles with 6 nodes (for of P2).*

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**2**

*Modeling, characteristics, material, loadings*

.  
*To describe for example the materials, the loadings..., one can use constants, functions or of the tablecloths with operators `DEFI_CONSTANTE`, `DEFI_FONCTION` or `DEFI_NAPPE` [U4.21.01, -.02, -.03].*

.  
*To affect the finite elements on the grid, one uses operator `AFFE_MODELE` in the way following:*

***MOD = AFFE\_MODELE (***

***GRID:***

***my***

***[grid]***

***AFFE:***

***(***

***ALL***

***:***

***“YES”***

***PHENOMENON: “THERMAL”***

***MODELING: “HULL”***

***);***

.

*To assign the geometrical characteristics to the elements, in fact the thickness, one must to use operator **AFFE\_CARA\_ELEM** [U4.24.01]:*

*= **AFFE\_CARA\_ELEM** will cara  
(MODEL: MOD  
[model]*

***HULL:**  
(ALL  
:  
"YES"*

***THICK: thick***

*);*

.

*The definition of materials and their assignment with the grid are made in a usual way [U4.23.01 and -.02].*

.

*The assignment of the thermal loadings is done using operators **AFFE\_CHAR\_THER** or*

***AFFE\_CHAR\_THER\_F [U4.25.02]. The various key words usable are:***

***I TEMP\_IMPO***

***: (/NODE***

***: lno***

***/***

***GROUP\_NO***

***: lgn0***

***I TEMP***

***:***

***T1***

***[R]***

***or***

***[function]***

***I TEMP\_INF***

***: t2***

***[R]***

***or***

***[function]***

***I TEMP\_SUP***

***: T3***

***[R]***

***or***

***[function]***

);

*One can thus choose the ddl which will have specified values.*

***I EXCHANGE***

:  
(  
/  
***ALL***  
:  
***“YES”***  
/  
***NET***  
:  
***lma***  
/  
***GROUP\_MA***  
:  
***lgma***

***I COEF\_H\_INF***

:  
***hinf***  
***[R]***  
***or***  
***[function]***  
***TEMP\_EXT\_INF***  
:  
***tinf***  
***[R]***  
***or***  
***[function]***

***I COEF\_H\_SUP***

:



*hsup*  
**[R]**  
*or*  
**[function]**  
*TEMP\_EXT\_SUP*  
:  
*tsup*  
**[R]**  
*or*  
**[function]**

);

*One thus gives the coefficients of exchange and the outside temperatures on the walls higher and lower. It should be noted that the coefficients of exchange also intervene in the expression of “rigidity” in the equations, and not only (as for the temperatures external) in the second members.*

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*Note:*

*The model considered here neglects the curve of the hull. However [R1.03.01.] if the thickness hull is not weak enough compared to the average radius of curvature, it is preferable to correct the values of the coefficients of exchange, or else one makes an error on*

***temperature about:***

***hinf - hsup***

***thick***

***\****

***hinf + hsup***

***ray***

***The correction is as follows:***

***COEF\_H\_INF: the value hinf multiplied by (1 - thick X courbure\_moyenne).***

***COEF\_H\_SUP: the value hsup multiplied by (1 + thick X courbure\_moyenne),***

***.***

***For the plates, that does not take place to be.***

***.***

***For the cylinders, the correction will be respectively:***

***(1 + thick/ray), (1 - thick/ray).***

***I FLUX\_REP***

***:(***

***/***

***ALL***

***:***

***“YES”***

***/***

***NET***

***:***

***lma***

***/***

***GROUP\_MA***

***: lgma***

***I FLUX\_INF***

***: finf [R]***

***or***

***[function]***

***I FLUX\_SUP***

***: fsup [R]***

***or***

***[function]***

)

***One thus provides the values of the flows imposed on the 2 faces of the hull.***

***Note:***

***As for the coefficients of exchange (see above), one can be brought to correct them  
flow in higher or lower wall by:  
(thick  $l \pm$ . courbure\_moyenne).***

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**3**

***TOTAL order: elementary calculation, assembly, resolution***

*One can be useful oneself of total order THER\_LINEAIRE for a stationary calculation [U4.33.02].*

*temp =*

*THER\_LINEAIRE*

*(MODEL: MOD*

*CHAM\_MATER*

:

*chechmate*

*TEMP\_INIT*  
: (*STATIONARY*: “yes”)

*EXCIT*:  
(*LOAD*: *cht*

*FONC\_MULT*: *coef*  
[*function*]

)

*CARA\_ELEM: will cara*

);

*Or one can use the core operators:*

```
mel =  
CALC_MATR_ELEM  
(  
OPTION  
:  
"RIGI_THER"  
[U4.41.01]
```

```
MODEL  
:  
MOD  
,
```

```
CHAM_MATER  
:  
chechmate  
,
```

*CARA\_ELEM*  
: *will cara,*

*CHARGE*  
: *cht*

);

*vel =*  
*CALC\_VECT\_ELEM*  
(  
*OPTION*  
:  
"CHAR\_THER"  
[U4.41.02]

*MODEL*  
: *MOD*

*CHAM\_MATER*

:  
*chechmate*

*CARA\_ELEM*

: *will cara,*

*CHARGE*

: *cht*

);

*naked*

=

*NUME\_DDL*



*(MATR\_RIGI*

*: mel*

*); [U4.42.01]*

*my =*

*ASSE\_MATRICE*

*(MATR\_ELEM*

*: mel*

*[U4.42.02]*

*NUME\_DDL*

*: naked*

*);*

*vecas =*

*ASSE\_VECTEUR*

*(VECT\_ELEM*

*: vel*

*[U4.42.03]*

*NUME\_DDL*  
*: naked*

) ;

*&ma*

=

*FACT\_LDLT*  
*(MATR\_ASSE*  
*: my*  
*); [U4.51.01]*

*temper = RESO\_LDLT*

*(MATR\_FACT*  
*: my,*

*[U4.51.02]*

*CHAM\_NO*

:

*vecas*

);

*If one wishes to solve a problem of evolution, one will be able to use a decomposition on space clean modes [R1.03.01].*

*One must initially build the matrix of “mass”, then to solve the problem with the eigenvalues associated. For that one uses the succession of the operators (with the concepts created previously described: mel, naked, my).*

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*melma =*

*CALC\_MATR\_ELEM*

*(*

*OPTION*

*:*

*“MASS\_THER”*

*[U4.41.01]*

*MODEL*

: *MOD*

,

*CHAM\_MATER*

:

*chechmate*

,

*CARA\_ELEM*

: *will cara,*

*CHARGE*

: *cht*

);

*mama* =  
*ASSE\_MATRICE*  
(  
*MATR\_ELEM*  
:  
*melma*  
[U4.42.02]

*NUME\_DDL*  
:  
*naked*  
,

);

*modeth* = *MODE\_ITER\_INV*

(  
*MATR\_A*  
:  
*my*  
,  
[U4.52.01]

*MATR\_B*

*: mama,*

*CALC\_FREQ: (LIST\_FREQ: l\_f)*

*);*

**4**

### ***Post treatment of calculation***

*The calculation of the heat flows in the structure can be done using the following operator:*

*flu = CALC\_CHAM\_ELEM*

*(*

*MODEL*

*:*

*MOD*

*CHARGE*

*:*

*cht*

*TEMPLE*  
*: temper*

*CARA\_ELEM*  
*: will cara*

*CHAM\_MATER*  
*:*  
*chekmate*

*OPTION*  
*:/“FLUX\_ELNO\_TEMP”*

*/“FLUX\_ELGA\_TEMP”*

*);*

*Option 'FLUX\_ELNO\_TEMP' makes it possible to calculate flows with the nodes of each element by interpolation (the concept result is well a field with the elements).*

*Option “FLUX\_ELGA\_TEMP” makes it possible to calculate flows at the points of GAUSS of each element.*

**5**

### ***Impressions of results***

*Procedure IMPR\_RESU will be used:*

*IMPR\_RESU  
(MODEL  
: MOD*

*RESU  
:  
(  
CHAM\_GD: nom\_cham)*



);

*nom\_cham, indicating a concept of the type: temperature, flow... (field with the nodes or field with elements).*

*Example:*

*IMPR\_RESU  
(MODEL  
: MOD*

*RESU:  
(CHAM\_GD: temper),  
RESU  
:  
(CHAM\_GD  
:  
flu)*

);  
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*Organization (S): EDF-R & D /AMA*

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***Note of use for calculations  
thermometallomecanic on steels***

### ***Summary***

***The objective of this note is to give information necessary so that a user can realize easily a calculation thermo-metal-worker-mechanics in Code\_Aster. This type of calculation relates to steels which undergo during a heating or of a cooling of structure transformations.***

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## **1**

### ***The broad outline of calculation thermo-metal-worker-mechanics***

***In Code\_Aster, calculations thermics, metallurgical and mechanical are uncoupled. Stages successive of a complete calculation are as follows:***

***1) One carries out a thermal calculation which makes it possible to obtain the field of temperature in each node.***

***2) One realizes in post treatment of thermal calculation, the metallurgical calculation which makes it possible to obtain proportion of the various metallurgical phases in each node and possibly hardness associated.***

***In Code\_Aster, one can treat two different types of material, which undergo metallurgical transformations: steels or the ZIRCALOY. One is interested here only in materials of the steel type.***

***For a steel, one can take into account five different metallurgical phases: ferrite, pearlite, the bainite, martensite, known as phase, and austenite, known as phase.***

***3) From the field of temperature and metallurgical phases, one carries out mechanical calculation by choosing a model of behavior which takes into account the various possible effects metallurgical transformations. One obtains the stress fields thus, of deformations and of variables intern in each point of Gauss.***

## **2**

### ***That to make to carry out a calculation thermo-metal-worker-mechanics***

#### **2.1**

##### ***Stage 1: which documents lira summarized***

##### ***2.1.1 For the thermal part***

***The document [R5.02.02] contains information necessary to the comprehension of a calculation nonlinear thermics.***

***In Code\_Aster, for a nonlinear calculation, one treats the diffusion of heat with one enthalpic formulation. One can provide is conductivity and the enthalpy according to temperature, is conductivity and the specific heat  $C$   $P$  according to the temperature.***

##### ***2.1.2 For the part models metallurgical behavior***

*The document [R4.04.01] of Code\_Aster describes the various metallurgical models.*

*Brief summary:*

*When a material is heated, the phases are transformed into phase. When it is cooled material, austenite is transformed, according to the speed of cooling, into ferrite and/or pearlite and/or bainite and/or martensite. It is thus necessary to define for the heating the kinetics of transformation and for cooling the nature and the kinetics of the possible transformations.*

*Kinetics of transformation to the heating:*

*The law of evolution of austenite is given by the equation:*

*Z*  
*Z*  
*Z*  
*eq -*  
*& =*

*0*  
*if T*  
*1*  
*Ac*

*if T*  
*1*  
*1*  
*Ac*

*1*  
*TAC*

*1*  
*TAC*  
*with Z*  
*=*  
*eq*

*if*  
*1*

*Ac T Ac*  
*3 and = +*  
*(-) if*  
*1*  
*Ac T Ac*  
*3*  
*1*  
*3*  
*1*

*Ac3*  
*1*  
*- Ac*

*Ac3*  
*1*  
*- Ac*  
*1*  
*if T Ac3*

*if*

*T Ac3*  
*3*

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*where Z is the proportion of phase,*

1

*Ac the quasi-static temperature of beginning of transformation phases, Ac3 the quasi-static temperature of end of transformation of the phases and 1, 3 two coefficients of material. Z eq corresponds to the evolution of the austenite rate transformed at the time*

*quasi-static evolutions. Initial temperatures*

1

*Ac and of end Ac3 of transformation austenitic and parameters 1 and 3 can be identified starting from experimental data providing for different heating rates, the proportion of austenite formed according to the temperature. One will find in [bib1] precise details on the method of identification of the coefficients.*

*Example:*

*For a steel 16MND5, the coefficients are worth*

1

*Ac = 716°C, Ac3 = 802°C,*

12s

1 =

and

5

.

0 S

3 =

.

*Kinetics of transformation to cooling:*

*For the ferritic, perlitic and bainitic transformations, the kinetics is given by the relation following:*

+

C

T

(- Ms)

$$Z \& = F T$$

(, T&, Z, ms; D)

with  $Z = \{Z F, ZP, ZB\}$

T

(- Ms)

*where M S represents the martensitic initial temperature of transformation, C*

***D size of grain  
austenitic and***

***+***

***(X) the positive part of X. For the functions of evolution F, one does not impose particular forms and the identification of F is summarized with the definition of diagrams of the type TRC***

***(transformation into Continuous Cooling). This diagram makes it possible to define the evolutions of ferrite, pearlite and bainite associated with a thermal history with cooling and conditions of austenitization given (for a size of grain C D given).***

***For the martensitic transformation, one uses the kinetics of Koistinen-Marburger given by the equation:***

***Z  
= 1  
(- Z - Z - Z)  
M  
F  
P  
B [1 - exp ((M  
T) +  
-  
)  
S  
J  
M***

***if Z  
+ Z + Z threshold***

***M =***

***0***

***S***

***S***

***F***

***P***

***B***

***M + Akm (Z + Z + Z) + Bkm***

***if Z***

***+ Z + Z > threshold***

***s0***

***F***



**P**  
**B**  
**F**  
**P**  
**B**

*where  $M_{s0}$  represents the martensitic initial temperature of transformation when that  $C_i$  is total and,  $A_{km}$ ,  $B_{km}$  and threshold are parameters materials.*

*In the simplest case, one can take the temperature  $M_S$  constant and thus equalizes with  $M_{s0}$ . For a steel 16MND6,  $M_{s0}$  is worth 365°C.*

*Note:*

*Diagrams TRC relate to conditions of austenitization given to which correspond a value of size of grain  $D$ . This size of grain results from the history thermics undergone with the heating and does not evolve/move any more with cooling. In Code\_Aster, it is possible to calculate starting from the thermal history with the heating, the evolution of cut grain and to take account of its effect on the metallurgical behavior with cooling (see case test of reference [hsnv126a.com m](#), [hsnv126b.com m](#) and [mtlp102a.com m](#) for the use).*

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*Note:*

*It is possible in Code\_Aster to calculate  $H_v$  hardness of the multiphase mixture*

*5*

*given by the Hv relation =  $Z_k H_{vk}$  where  $H_{vk}$  is hardness associated with the phase  $K$  and  $K = 1$*

*informed under operator DEF1\_MATERIAU under key word "DURT\_META". Hardness multiphase mixture is obtained by operator CALC\_ELEM with the option "DURT\_ELNO\_META" (hardness with the nodes by element).*

### *2.1.3 For the part mechanical behavior with effects models of metallurgical transformations*

*The reference document of Code\_Aster is the note [R4.04.02].*

*Several models of behavior are available in the code. They make it possible to model them various following phenomena: plastic behavior or viscous behavior, work hardening isotropic linear or not linear or linear kinematic work hardening, plasticity of transformation, restoration of metallurgical work hardening of origin, restoration of work hardening of viscous origin. One*

*can carry out a calculation in small deformations but also in great deformations (attention them great deformations for a model with kinematic work hardening are not activated). For one comprehension on the aspect great deformations, lire reference documents [R5.03.31] (great deformations without metallurgical effect) and [R4.04.03] (great deformations with effects metallurgical).*

*Brief summary:*

*The effects of structure transformations on the mechanical behavior are of 4 types:*

*.  
the mechanical characteristics of the material which undergoes transformations are modified. In private individual, plastic characteristics (elastic limits in particular) and the coefficient of thermal dilation are strongly affected. For the elastic limit of the multiphase point, one use a non-linear law of the mixtures given by:*

*4*

*Z*

*4*

*4*

*I there I*

*= I*

*[- G (*

*y*

*Z)] + G (*

*I*

*y*

*i=*

**Z)**  
**,**  
**= 1**  
**I**  
**y**  
**ya**

**4**  
**i=1**  
**i=1**  
**Zi**  
**i=1**

*where Zi is the proportion of each phase and G a function of Zi.*

*the expansion or the voluminal contraction which accompanies structure transformations translated by a spherical deformation “of transformation” which is superimposed on thermal deformation. In general, one gathers this effect with that due to the modification of thermal dilation coefficient. The thermal deformation is given by:*

**4**  
**HT**  
**= Z [**  
**R**  
**Tref**  
**T**  
**(- T**

**ref.) - 1**  
**(- Z)**

**+ Z T**  
**(- T**  
**) + Z**

**F**  
**]**  
**I [**  
**R**  
**Tref**  
**F**  
**ref.**

***F***  
***J***  
***i=1***

***where and F are the dilation coefficients of the austenitic and ferritic phases, respectively.***

***Tref***

***F translates the difference in compactness between the two phases with temperature of reference. There are R***

***Z = 1***

***when the phase of reference is the phase austenitic and R***

***Z = 0***

***when the phase of reference is the ferritic phase.***

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***.***

***a transformation proceeding under constraints can give rise to a deformation irreversible and this, even for levels of constraints much lower than the elastic limit material. One calls this phenomenon the plasticity of transformation. Into small deformations, this additional term appears in the expression of the total deflection. The law of evolution of the deformation which accompanies this phenomenon writes:***

***4***

**$P_t$**   
 **$\& = 3 \sim K F ($**   
 **$I I Z). Z\&$**

**2**  
**I**  
 **$i=1$**

*where  $\sim$  is the diverter of the tensor of the constraints,  $X$  the positive part of  $X$ ,  $K_i$  and  $I$   $F$ , coefficients of the 4 ferritic phases. It is considered that this phenomenon does not exist at the time austenitic transformations.*

*finally, one can have at the time of the transformation a phenomenon of restoration of work hardening:*

*the work hardening of the mother phase (or not completely) is not transmitted to the phases lately created. The phases lately created can be born with a state of virgin work hardening, either to inherit only part of work hardening of the mother phase or to inherit the totality of the work hardening of the mother phase.*

*In the case of an isotropic work hardening, the plastic deformation  $p$  is not characteristic any more state of work hardening and it is necessary to define other variables for each phase, noted  $K$   $r$ .*

*Isotropic work hardening is written then:*

**4**  
 **$F Z$**   
**4**  
 **$R = 1$**   
 **$(- F (Z))R + ()$**

**$Z. R$**   
**I**  
 **$I, Z = Z$**   
**Z**  
**I**  
 **$i=1$**   
 **$i=1$**

*where  $R_k$  is the variable of work hardening of the phase  $K$  which can be linear or not linear by report/ratio with  $K$*

*$R$  and  $F (Z)$  a function depending on  $Z$  such as  $F (Z) []$*

**I**  
**,**  
**0.**

*The laws of evolution of the ir variables are given by:*

*4*  
*- Z& (R - R)*  
*I*  
*I I*

*I I*  
*r& = p& + =*  
*- (Cr*  
*) m*

*if*

*Z > 0*

*moy*

*Z*

*4*

*1*

*4*

*2 3*

*only*

*viscosity*

*in*

*Z& (R - R)*  
*r& = p& + I*  
*I*  
*I*  
*- (Cr*  
*) m*

*if*

*Z > 0*

*I*

*moy*

*I*

*Zi*

*4*

**1**  
**4**  
**2 3**  
**only**  
**viscosity**

**in**

**5**  
**R**  
**=**  
**moy**  
**Zk Kr**  
**k=1**  
**5**  
**C = ZkCk**  
**k=1**  
**5**  
**m = Zkmk**  
**k=1**

*Ck and mk are the coefficients of viscous restoration associated the phase K, I and I characterize the proportion of work hardening transmitted at the time of the transformation and of transformation, respectively. The memory is non-existent if = 0, supplement if = 1.*

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**In an equivalent way, a kinematic work hardening in the case of is written:**  
**4**

4  
X =  
F Z  
1  
(- F (Z))X + ()

Z .iXi, Z = Z  
Z  
I  
i=1  
i=1

where X K is the kinematic variable of work hardening of the phase K which is linear compared to variable K:

2  
X K = Hkk  
3

The laws of evolution of the variables kinematics K are given by:

4  
Z& (-)  
I  
I I

p  
3  
I I

& = & + =  
+ (C) m

if  
Z > 0

Z  
2  
eq

eq  
1 4  
4 2 4  
4 3  
only



*viscosity*

*in*

*Z& (-)*

*p*

*I*

*I*

*I*

*3*

*& = & +*

*+ (C) m*

*if*

*> 0*

*I*

*Z*

*Z*

*2*

*eq*

*I*

*I*

*eq*

*1 4*

*4 2 4*

*4 3*

*only*

*viscosity*

*in*

*~*

*p*

*3*

*( - )*

*& =*

*X*

*p&*

*2 (- X) eq*

*where  $H_K$  are the slopes of work hardening associated with each phase  $K$ .*

*For a model of plasticity, the plastic multiplier is obtained by writing the condition of coherence  $\dot{\phi} = 0$  and one  $a$ :*

*$p$  and,*

*$0 < F < 0$*

*and  $\dot{\phi}$*

*$p = 0$*

*In the viscous case,  $p$  is written:*

*$N$*

*$F$*

*$p =$*

*where  $F$  is the threshold of plasticity given by:*

*$F = \sigma - R - \gamma$  in the case of an isotropic work hardening*

*$F =$*

*$(-X) \sigma - \gamma$  in the case of a kinematic work hardening*

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*2.2*

*Stage 2: construction of the command file*

*2.2.1 Parts thermics and metallurgical*

*1) Definition of diagram TRC: to see order DEFI\_TRC in the document [U4.43.04].*

*This order is made up of three parts: a part where the ferrite evolutions are defined, pearlite and bainite associated with a unit with thermal history to cooling and conditions of austenitization given (size of grain), one second part which defines them parameters related to the change of temperature ms and a third part which defines the influence of size of grain on the metallurgical transformations with cooling by diagram TRC. This last part is not obligatory.*

*2) Definition of the initial metallurgical phases: to see order CREA\_CHAMP in document [U4.72.04]. This order makes it possible to define the initial metallurgical phases present in material.*

*3) Definition of material: to see order DEFI\_MATERIAU (document [U4.43.01]). For thermal part, it is necessary to inform the key word THER\_NL which contains the values of conductivity thermics and those of the enthalpy, functions possibly of the temperature. For the part metallurgical, it is necessary to inform the key word META\_ACIER of which the structure is as follows:*

*META\_ACIER: (*

*TRC: name of diagram TRC defines into 1)*

*AR3: quasi-static temperature of beginning of decomposition of austenite to cooling.*

*ALPHA: coefficient has law of Koistinen-Marburger*

*MS0: martensitic initial temperature of transformation when this one is total.*

*AC1: quasi-static temperature of beginning of transformation into austenite with the heating.*

*AC3: quasi-static temperature of end of transformation into austenite.*

*TAUX\_1: parameter intervening in the kinetics with the heating.*

*TAUX\_3: parameter intervening in the kinetics with the heating.*

*LAMBDA: parameter material intervening in the model of evolution of size of grain.*

*QSR\_K: parameter energy of activation intervening in the model of evolution of size of grain.*

*DI0: parameter material intervening in the model of evolution of size of grain.*

*WSR\_K: parameter energy of activation intervening in the model of evolution of size of grain.*

*4) Realization of thermal calculation: to see documentation of Use and Reference of thermal operators: THER\_LINEAIRE and THER\_NON\_LINE.*

*5) Realization of metallurgical calculation: to see order CALC\_META (document [U4.85.01]). This order makes it possible to obtain starting from preceding thermal calculation, the proportions of various metallurgical phases. It is on this level that the initial metallurgical state is informed (order CREA\_CHAMP).*

## **2.2.2 Part mechanics**

### **1) Definition**

***material: to see order DEF1\_MATERIAU (document [U4.43.01]). According to phenomena which one wishes to model, several key words must be indicated. In all the cases, the user must supplement the key words:***

•  
***ELAS\_META (\_FO) which contains information on the elastic characteristics, of thermal dilations and of elastic limits,***

•  
***META\_ECRO\_LINE to define an isotropic or kinematic work hardening linear and META\_TRACTION to define a nonlinear isotropic work hardening.***

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*The other possible phenomena (nonobligatory) are as follows:*

.  
*viscoplasticity + restoration of viscous origin: key word factor META\_VISC (\_FO)*

.  
*plasticity of transformation: key word factor META\_PT*

.  
*metallurgical restoration of origin: key word factor META\_RE*

**Note:**

*\_FO means that the coefficients can possibly depend on the temperature.*

**2) Realization of mechanical calculation:** order STAT\_NON\_LINE (document [U4.51.03]). Under key word COMP\_INCR, one must specify under RELATION, the name of the model chosen among the 24 models below and under RELATION\_KIT, material "STEEL".

*The various models are:*

*/“META\_P\_IL”*

*/“META\_P\_INL”*

*/“META\_P\_IL\_PT”*

*/“META\_P\_INL\_PT”*

*/“META\_P\_IL\_RE”*

*/“META\_P\_INL\_RE”*

*/“META\_P\_IL\_PT\_RE”*

*/“META\_P\_INL\_PT\_RE”*

*/“META\_P\_CL”*

*/“META\_P\_CL\_PT”*

/"META\_P\_CL\_RE"  
 /"META\_P\_CL\_PT\_RE"  
 /"META\_V\_IL"  
 /"META\_V\_INL"  
 /"META\_V\_IL\_PT"  
 /"META\_V\_INL\_PT"  
 /"META\_V\_IL\_RE"  
 /"META\_V\_INL\_RE"  
 /"META\_V\_IL\_PT\_RE"  
 /"META\_V\_INL\_PT\_RE"  
 /"META\_V\_CL"  
 /"META\_V\_CL\_PT"  
 /"META\_V\_CL\_RE"  
 /"META\_V\_CL\_PT\_RE"

### ***Significance of the letters:***

*P = plasticity, V = viscoplasticity, IT = linear isotropic work hardening, INL = work hardening isotropic nonlinear, linear CL = kinematic work hardening, Pt = plasticity of transformation, RE = restoration of metallurgical work hardening of origin.*

### ***2.2.3 Example of command file***

*The example that we present now is that of a thin steel 16MND5 disc which is heated on its face higher by a laser beam then cooled than the ambient air. Modeling is axisymmetric. The imposed loading is a flow on part of the higher face, the remainder of faces undergoing of the conditions of natural convection and radiation. Initially the disc is composed of 61% of ferrite and bainite 39%. With the heating, ferrite and the bainite change into austenite. With cooling, austenite is transformed into bainite and martensite (it thus does not have there pearlite). This study is presented in detail in document HI-74/99/002.*

*One presents Ci below the command file of this simulation. One gives only them principal orders which refer to a metallurgical calculation.*

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**Command file**

**# CALCULATION ON a STEEL 16MND5 DISC  
# I - THERMAL AND METALLURGICAL PART  
# I.1 - DEFINITION OF the GRID  
# I.2 - DEFINITION OF the MODEL**

**moth=AFFE\_MODELE (  
MAILLAGE=mail,  
AFFE=\_F (  
TOUT=' OUI',  
PHENOMENE=' THERMIQUE',  
MODELISATION=' AXIS',,));**

**# I.3 - DEFINITION OF MATERIAL  
# I.3.1 - DEFINITION OF DIAGRAM TRC**

**TRC = DEFI\_TRC (  
HIST\_EXP= (  
\_F (VALE = (  
-1.000D+00 1.000D+01 0.000D+00 0.0000D+00  
0.000D+00 0.000D+00 0.000D+00 0.0000D+00  
0.000D+00 0.000D+00 0.000D+00 8.3000D+02  
0.000D+00 0.000D+00 0.000D+00 5.6520D+02  
0.000D+00 0.000D+00 1.000D-02 5.6000D+02  
0.000D+00 0.000D+00 2.400D-02 5.5062D+02  
0.000D+00 0.000D+00 7.600D-02 5.3670D+02  
0.000D+00 0.000D+00 12.00D-02 5.2960D+02  
0.000D+00 0.000D+00 22.70D-02 5.1380D+02  
0.000D+00 0.000D+00 32.50D-02 5.0155D+02  
0.000D+00 0.000D+00 41.80D-02 4.8748D+02  
0.000D+00 0.000D+00 52.80D-02 4.6595D+02  
0.000D+00 0.000D+00 57.60D-02 4.5422D+02  
0.000D+00 0.000D+00 60.00D-02 4.4531D+02  
0.000D+00 0.000D+00 69.00D-02 4.0712D+02  
0.000D+00 0.000D+00 72.20D-02 3.9157D+02**

**0.000D+00 0.000D+00 7.500D-01 3.6600D+02  
0.000D+00 0.000D+00 7.600D-01 3.6080D+02)),  
\_F (VALE = (  
-3.400D+00 1.000D+01 0.000D+00 0.0000D+00  
0.000D+00 0.000D+00 0.000D+00 0.0000D+00  
0.000D+00 0.000D+00 0.000D+00 8.3000D+02  
0.000D+00 0.000D+00 0.000D+00 5.6530D+02  
0.000D+00 0.000D+00 1.000D-02 5.6000D+02  
0.000D+00 0.000D+00 5.980D-02 5.4326D+02  
0.000D+00 0.000D+00 35.00D-02 5.0750D+02  
0.000D+00 0.000D+00 44.00D-02 4.9711D+02  
0.000D+00 0.000D+00 52.50D-02 4.7641D+02  
0.000D+00 0.000D+00 65.00D-02 4.2853D+02  
0.000D+00 0.000D+00 6.840D-01 3.8393D+02  
0.000D+00 0.000D+00 6.800D-01 3.8200D+02  
0.000D+00 0.000D+00 6.900D-01 3.7670D+02)),  
\_F (VALE = (  
-8.000D+00 1.000D+01 0.000D+00 0.000D+00  
0.000D+00 0.000D+00 0.000D+00 0.000D+00  
0.000D+00 0.000D+00 0.000D+00 8.300D+02  
0.000D+00 0.000D+00 0.000D+00 5.570D+02  
0.000D+00 0.000D+00 1.000D-02 5.500D+02  
0.000D+00 0.000D+00 1.800D-02 5.4746D+02  
0.000D+00 0.000D+00 10.80D-02 5.2087D+02  
0.000D+00 0.000D+00 27.00D-02 4.8780D+02  
0.000D+00 0.000D+00 37.30D-02 4.5920D+02  
0.000D+00 0.000D+00 44.40D-02 4.2560D+02  
0.000D+00 0.000D+00 49.70D-02 3.7440D+02  
0.000D+00 0.000D+00 5.115D-01 3.6400D+02  
0.000D+00 0.000D+00 5.215D-01 3.5660D+02))),  
TEMP\_MS = \_F (  
THRESHOLD = 1.000D+00  
AKM = 0.000D+00  
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**BKM = 0.000D+00**

**TPLM = -5.000D-01));**

### **# I.3.3 DEFINITION OF MATERIAL**

**ACIER=DEFI\_MATERIAU (**

**THER\_NL=\_F (**

**LAMBDA= conductivity,**

**BETA=enthalpie,)**

**META\_ACIER=\_F (**

**TRC=TRC,**

**AR3=830.0,**

**ALPHA=-0.0247,**

**MS0=365.0,**

**AC1=716.29,**

**AC3=802.58,**

**TAUX\_1=12.0,**

**TAUX\_3=0.5,));**

### **# I.3.4 - ASSIGNMENT OF MATERIAL**

### **# I.4 - BOUNDARY CONDITIONS AND LOADING**

### **# I.5 - CALCULATION THERMAL**

#### **# I.5.1 - LIST D URGENT**

#### **# I.5.2 - RESOLUTION WITH the HEATING AND COOLING**

**TEMPE=THER\_NON\_LINE (**

**MODELE=moth,**

**CHAM\_MATER=matc,**

**EXCIT=\_F (CHARGE=char\_c,)**

**INCREMENT=\_F (**

**LIST\_INST=list,**

**NUME\_FIN=70,)**

**TEMP\_INIT=\_F (VALE=28.0,)**

**CONVERGENCE=\_F (**

**RESI\_GLOB\_RELA=5.E-05,**

**ITER\_GLOB\_MAXI=40,));**

**TEMPE=THER\_NON\_LINE (**  
**reuse =tempe,**  
**MODELE=moth,**  
**CHAM\_MATER=matr,**  
**EXCIT=\_F (CHARGE=char\_r),**  
**INCREMENT=\_F (**  
**LIST\_INST=list,**  
**NUME\_INIT=70,)**  
**TEMP\_INIT=\_F (**  
**EVOL\_THER=tempe,**  
**NUME\_INIT=70,)**  
**NEWTON=\_F (REAC\_ITER=1,)**  
**CONVERGENCE=\_F (**  
**RESI\_GLOB\_RELA=5. E-05,**  
**ITER\_GLOB\_MAXI=40,),);**

**# I.6 - CALCULATION METALLURGICAL**  
**# I.6.1 - STATE METALLURGICAL STARTING**  
**# “v1” = Proportion of ferrite**  
**# “v2” = Proportion of pearlite**  
**# “v3” = Proportion of bainite**  
**# “v4” = Proportion of martensite**  
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**PHASINIT=CREA\_CHAMP (**  
**OPERATION='AFFE',**

**TYPE\_CHAM=' CART\_VAR2\_R',  
MAILLAGE=MAIL,  
AFFE=\_F (  
ALL = "YES",  
NOM\_CMP = ("V1", "V2", "V3", "V4"),  
VALE = (0.61, 0.0, 0.39, 0.0,))**

**# I.6.2 - RESOLUTION METALLURGICAL**

**TEMPE=CALC\_META (  
reuse =TEMPE,  
MODELE=moth,  
CHAM\_MATER=matr,  
RESULTAT=tempe,  
ETAT\_INIT=\_F (META\_INIT\_ELNO=phasinit),  
COMP\_INCR=\_F (RELATION=' ACIER',),);**

**# II - MECHANICAL CALCULATION WITH AN ELASTOPLASTIC MODEL INTO LARGE DEFORMATIONS WHICH TAKES INTO ACCOUNT THE PLASTICITY OF TRANSFORMATION AND RESTORATION D WORK HARDENING**

**# II.1 DEFINITION OF THE MODEL**

**MOMECA=AFFE\_MODELE (  
MAILLAGE=MAIL,  
AFFE=\_F (  
TOUT=' OUI',  
PHENOMENE=' MECANIQUE',  
MODELISATION=' AXIS',),);**

**# II.2 - DEFINITION OF MATERIAL**

**# II.2.1 DEFINITION OF THE COEFFICIENTS ACCORDING TO THE TEMPERATURE**

**# Modulus Young E**

**# Coefficient Naked fish**

**# Limit D elasticity of Sy\_a austenite, Sy\_f ferrite, the Sy\_b bainite and Sy\_m martensite**

**# function of multiphase plasticity for the elastic limit mixes**

**# Slopes D work hardening for H\_a austenite and ferrite, bainite and H\_f martensite**

**# Dilation coefficients for AlphaA austenite**

**# and for ferrite, bainite and AlphaF martensite**

**# Functions of plasticity of transformation for bainite and FzBM martensite, FzF ferrite**

**# II.2.2 - DEFINITION OF MATERIAL**

**ACIERM=DEFI\_MATERIAU (  
ELAS\_META\_FO=\_F (**

**E=E,**  
**NU=NU,**  
**F\_ALPHA=ALPHAF,**  
**C\_ALPHA=ALPHAA,**  
**PHASE\_REFE=' FROID',**  
**EPSF\_EPSC\_TREF=1.E-2,**  
**F1\_SY=SY\_F,**  
**F2\_SY=SY\_F,**  
**F3\_SY=SY\_B,**  
**F4\_SY=SY\_M,**  
**C\_SY=SY\_A,**  
**SY\_MELANGE=MELANGE,),**  
**META\_ECRO\_LINE=\_F (**  
**F1\_D\_SIGM\_EPSI=H\_F,**  
**F2\_D\_SIGM\_EPSI=H\_F,**  
**F3\_D\_SIGM\_EPSI=H\_F,**  
**F4\_D\_SIGM\_EPSI=H\_F,**  
**C\_D\_SIGM\_EPSI=H\_A,),**  
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**META\_PT=\_F (**

**F1\_K=7.E-11,**

**F2\_K=7.E-11,**

**F3\_K=7.**

**E-11,**

**F4\_K=7.**

**E-11,**

```
F1_D_F_META=FZF,  
F2_D_F_META=FZF,  
F3_D_F_META=FZBM,  
F4_D_F_META=FZBM,),  
META_RE=_F (  
C_F1_THETA=0.0,  
C_F2_THETA=0.0,  
C_F3_THETA=0.0,  
C_F4_THETA=1.0,  
F1_C_THETA=0.0,  
F2_C_THETA=0.0,  
F3_C_THETA=0.0,  
F4_C_THETA=0.0,));
```

### **# II.2.3 - ASSIGNMENT OF MATERIAL**

```
CHMATM=AFFE_MATERIAU (  
MAILLAGE=MAIL,  
AFFE=_F (  
TOUT=' OUI',  
MATER=ACIERM,  
TEMP_REF=28.0,));
```

### **# II.3 - LIMITING CONDITION AND LOADING**

**# ONE IMPOSES THE FIELD OF TEMPERATURE AND THE METALLURGICAL CHART  
OBTAINED OUT OF I**

### **# II.4 - MECHANICAL CALCULATION**

#### **# II.4.1 - LIST D URGENT**

#### **# II.4.2 - MECHANICAL RESOLUTION**

```
U=STAT_NON_LINE (  
MODELE=MOMECA,  
CHAM_MATER=CHMATM,  
EXCIT=_F (CHARGE=CHMECA,),  
COMP_INCR=_F (  
RELATION=' META_P_IL_PT_RE',  
RELATION_KIT=' ACIER',  
DEFORMATION=' SIMO_MIEHE',  
TOUT=' OUI',),  
INCREMENT=_F (LIST_INST=LISTM,),  
NEWTON=_F (  
REAC_INCR=1,  
MATRICE=' TANGENTE',  
REAC_ITER=5,),
```

```
RECH_LINEAIRE=_F (ITER_LINE_MAXI=3),  
CONVERGENCE=_F (  
RESI_GLOB_RELA=5.E-06,  
ITER_GLOB_MAXI=34,)),);  
END ();
```

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### **3 Bibliography**

**[1]**

**WAECKEL F.: Modeling of the austenitic transformation in Code\_Aster.**

**Note EDF/DER/IMA, note HI-74/95/017/0**

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***Note of use for calculations of welding***

***Summary***

***The objective of this note is to give information necessary so that a user can realize multirun calculations of welding with Code\_Aster. It is based on an example of welding of piping on the 13 ways. The first 2 master keys of this example constitute a case-test Aster [V7.42.100].***

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***Thermal modeling of welding***

### ***1.1 General***

***The modeling of an operation of welding requires the good knowledge of the process with to simulate, in particular that of the parameters of welding. Moreover, phenomena to be taken in account are many and complex: contribution of the molten metal, flow generated by the arc unit + electrode, effect of gas protecting the bath melted, etc...***

***The principal difficulty of the thermal modeling of welding is the way in which one takes into account the contribution of heat. In front of the great number of operational data accessible (energy from welding, speed of the source, tape speed of the wire of contribution, output of the process...), it is necessary***

***in general to adopt a simplified method. These methods will be described in the § according to. simulations carried out within the framework of a collaboratif work EDF-ECA-Framatome [bib1] showed***

***that other phenomena concerned (heat exchange, change of state, convection of the bath melted...) are suitably taken into account by the computer codes by finite elements.***

***In the case which we present in the continuation, one has at the same time a good knowledge of parameters of welding and elements of retiming like macrographies and the cycles***

*thermics. A correct thermal simulation is thus possible. The problem is then to choose a method which will make it possible to represent accurately the contribution of heat due to the Arc unit -*

*Electrode - Filler.*

*If one does not have elements of retiming, the digital simulation of an operation of welding can be carried out in a predictive way using calculations simplified of Rosenthal type. For more details, one will consult [bib1]*

## **1.2**

### **Modeling of the contribution of heat**

*Two methods are possible:*

*.  
the first consists in imposing cycles of temperature on the matter which one deposits. These imposed temperatures can be applied either to the only cord deposited, or on the cord unit deposited more molten zone. This method applies easily only to two-dimensional problems. If one imposes a temperature in the filler, it calculation proceeds in 3 phases:*

- 1) Temperature imposed in the cord deposited until a temperature of molten bath higher than the melting point.*
- 2) Maintenance of the constant temperature during a time characteristic and increase of thermal conductivity for temperatures higher than the melting point so to find the molten zone.*
- 3) Cooling with exchange by convection and radiation*

*The thermal cycle applied to the filler can result either from a calculation 3D or in using calculations of the Rosenthal type to determine the maintenance and boarding times.*

*.  
the second method, which is that recommended now, consists in imposing a heat flow on weld bead modelled. It can this time apply in 2D and 3D and present the advantage of modelling only the filler (it is not necessary to know the zone melted). On the other hand, it is difficult to fix but the choices are to be carried out on the space distribution*

*flow (surface, voluminal) and the temporal distribution of flow.*

*The chock of flow can be controlled on the basis of calculations 2D of the Rosenthal type or by using them*

*experimental thermal cycles. In order to find the molten zone and to take account of the homogenisation of the temperature due to the movements of the bath melted, one increases beyond*

*melting point of a factor 100 thermal conductivity in the added metal.*

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**1.3**

**Case of a piping welded by pulsated process TIG (card 3488)**

***Here one knows a priori the form of the cords and the zones melted thanks to macrographies. It is nevertheless difficult to use the method No 1 (approach in imposed temperature) insofar as the chamfer contains 13 welding layers. To model the molten zones associated with the 13 cords would have asked too much work in term of grid. This method is applicable only if the number cords remains limited or if macro deposits are considered.***

***The other methods were tested but require all of the chocks with the results experimental and give unequal results. Thus, approach in imposed temperature considering the contribution of heat that in the filler over-estimates the molten zones and the cycles thermics. This method is too calorific.***

***It is thus the approach in imposed heat flux which is retained. The application of the quantity of heat  $Q_r$  presents two alternatives: the application of surface or voluminal  $Q_r$ . If one is considered axisymmetric model of piping, the quantity of  $Q_r$  heat is applied in all the meshes modelled cord and one represent a flow 3D thus. In the case of a model 3D, it is difficult of to consider voluminal  $Q_r$  because one precisely does not know the form of the heat source. It is thus surface  $Q_r$  on the free edge of the cord that it is to better retain. However,  $Q_r$  surface is representative only if the cords deposited are not too thick, which is the case here.***

**1.3.1 Methodology: choice of an approach 2D or 3D**

***In any rigour, the process of welding is strictly 3D, the contribution of heat and possibly of***

*matter being mobile and constant speed. Numerical calculations should thus hold account of it. However, complex and expensive calculations 3D being, they are seldom implemented and one limits oneself*

*with the 2D. Modeling 2D implies an important simplification: one neglects the effect speed of welding and one suppose that the cord is deposited simultaneously over the entire length of the chamfer.*

*However, in order to carry out the chock of the yield coefficient of the process, calculations 3D in locate mobile were also led for 2 master keys of the chamfer: the master key of root and one pass current (master key 13).*

*The chock of master key 13 was then applied to all the other current passes.*

*The methodology retained for the thermal simulation of pulsated process TIG is thus the following one:*

*• chock of the yield coefficient of the process for master keys 1 to 13 thanks to calculations 3D in pointer on master keys 1 and 13,*

*• transposition with the model 2D by preserving the yield coefficient and by applying one quantity of heat to the meshes of the modelled cord. The temporal distribution this flow is fixed on the results of calculations 3D,*

*• validation of this approach to the thermal simulation of master keys 2 to 13.*

### *1.3.2 Approach thermal 3D in pointer on the plate 3D developed of the tube*

*The chock of the method is done on the transverse form of the zone melted by adjusting the coefficient*

*of output of the process. Several iterative calculations make it possible to have an acceptable molten zone.*

*For the master key of root, the yield coefficient is worth 0.65 then.*

*UI*

*The quantity of heat applied is worth  $Q_r =$   
with:*

*S*

*• U, the voltage welding taken equalizes with 11V,*

*• I, the intensity of welding taken equalizes with 200A,*

*• S, the surface of the source which is worth R2 with R=5mm.*

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= 0 6

. 5

thus  $Q$

W mm

$R = 18\ 21$

2

.

/

*For master key 13, one considers a circular heat source of  $R=3.5\text{mm}$  ray, therefore lower than that of the master key of root. Following the chock, the yield coefficient is worth 0.55 and.*

$Q$

W mm

$R = 32\ 87$

2

.

/

### **1.3.3 Approach thermal 2D on the tube**

*The axisymmetric approach 2D is easy to implement but presents the disadvantage of not to take into account the effect speed and to consider that each cord is deposited “of only one blow”. Comparisons between approaches 2D and 3D [bib3] nevertheless showed the maid representativeness of the approach 2D.*

#### **1.3.3.1 Temperatures**

***imposed***

*This method is the first method described in [§2.2]. The contribution of heat is modelled by one cycle thermal resulting from calculation in pointer. This cycle is applied to the nodes of the added metal. It is noted that calculations 2D over-estimate the molten zone and maximum thermal cycles. The approach in imposed temperatures is thus too energy.*

***1.3.3.2 Heat flow***

*This method is the second method described in [§2.2] and is that recommended now. The application of the heat flow  $Q_r$  is carried out on the meshes of the cord deposited. This heat flow is voluminal, c.a.d. per circumferential unit of length ( $J/mm^3$ ). Flow is given by:*

*UI*  
 $Q_r =$   
*with v: speed of the source.*  
 $Sv$

*Calculation 2D disregarding speed of the source, it is necessary to distribute this heat flow in function of time: a descent and maintenance, boarding time.*

$Q^*$  ( $W/mm^3$   
 $R$   
 $)$   
 $0$   
 $T$   
*time (S)*  
 $1$   
 $t_2$   
 $T_3$

$Q = Q^*$   
 $1$   
 $\times (T + T - T$   
 $R$   
 $R$   
 $)$   
 $2\ 3$   
 $2$   
 $1$

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*It is necessary to determine moments  $T1$ ,  $t2$  and  $T3$  to find the molten zones and the thermal cycles. Several distributions corresponding to more or less long rise and fall times have summer compared. In fact finally the following distributions were retained [bib3]:*

$Q^*$  (W/mm<sup>3</sup>

$R$

)

***pass from root***

*time (S)*

7.

12.8

13.8

$Q^*$  (W/mm<sup>3</sup>

$R$

)

***pass 13***

*time (S)*

7.

10.4

11.4



### **1.3.4 Conclusion**

*Within the framework of the thermal simulation of welding by pulsed process TIG of a piping in stainless steel 316L, the thermal history of the process can be represented by a model 2D axisymmetric, even if retiming is better by considering an approach 3D in pointer which account of the effect speed of the heat source takes. The methodology retained in 2D is one approach in heat flow which requires to fix the yield coefficient of the process as well as temporal distribution this flow. It is also necessary to know either the forms of the melted zones, or thermal cycles of the process studied in order to allow this chock. It makes it possible not to model melted zones, which is an important advantage in the case of a great number of master keys.*

*The principal characteristics of simulation are as follows:*

- .  
heat flow applied in the metal added according to time (gone up in 7s, times of maintenance of 5.8s for the master key of root and 3.4s for a current master key and descent in 1s),*
- .  
the yield coefficient of the process is fixed at = 0 6  
. 5 for the master key of root and with  
= 05  
. 5 for the current master keys,*
- .  
the conductivity of the added metal is increased between 1500°C and 1700°C of a factor 100 so to take into account a homogenisation of the temperatures in the bath melted,*
- .  
one takes into account the heat of fusion-solidification,*
- .  
the thermal characteristics vary with the temperature.*

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## **2** **Modeling of welding in Aster**

### **2.1** **Grid of the weld beads**

*The weld beads can be with a grid in a more or less complex way.*

*There are 3 possible choices, while going from most complicated towards simplest:*

.

*one can choose to respect at the same time the volume and the form of the master key. The shape of the cords*

*being curved, one will have to net surfaces on curved board, therefore to use finite elements at least of degree 2,*

.

*one respects only the volume of the master key, the cords being of triangular form or quadrangular. In this case, one can use linear elements,*

.

*the weld beads are quadrangular, while trying to respect volume as well as possible of each master key.*

*Comparisons were made in the case of the tubular model. It proves that the results of mechanical calculations differ very little from one grid to another. Nevertheless, the comparison with coarser grid is delicate, thermal being different to it.*

*One can however note that, to thermics equivalent, the curved grid does not bring anything significant on the level of the results compared to the polygonal grid.*

### **2.2 Calculation** **thermics**

#### **2.2.1 Modelings associated with the master keys**

*To simulate welding multirun, one carries out a transitory nonlinear thermal calculation, passes by master key, by adding to each master key in the thermal model corresponding the finite elements modelling the weld bead deposited during the master key. Thus, each master key I has one thermal model including/understanding the weld beads of numbers 1 to I. There are thus models thermics encased with the following direction:*

*if mothi indicates the thermal model of master key I  
and mothj indicates the thermal model of the master key J  
then mothi mothj if  $I < J$ .*

*This poses a problem at the time of the sequence of thermal calculations, the fields of temperature of model mothi not being defined in all the nodes of the model corresponding to the following master key  $i + 1$ .*

*It is thus necessary to carry out a prolongation of the computed fields from one model to another. (see [§3.2.3]).*

**Note:**

*Another solution consists in considering one model containing all the passes and “artificially to decontaminate” the cords not yet deposited in their imposing one null thermal conductivity. This artifice can cause light numerical oscillations temperature due to the discontinuity of conductivity to the interfaces between the cords. It is nevertheless this method which is used in the cast-test [V7.42.100]. It allows to save the stage of prolongation of the fields [§2.2.3].*

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## **2.2.2 Boundary conditions (convection and radiation)**

*For the modeling of the convectif and radiative exchange, one chose to make appear:*

.

during the rise and the maintenance of  $Q_r$ : convective and radiative exchange on all the borders except that of the cord of the current master key,

during cooling: same boundary conditions with in more the border of the cord current master key (to take into account the weld bead have been just deposited).

The figures of boundary conditions (meshes of edge support of the boundary conditions) are with to reactualize with each master key on the level of the chamfer, cords piling up the ones on the others. It is necessary to have envisaged this operation upon the departure, at the moment it grid, i.e. to have created as many figures as there are master keys.

### 2.2.3 Prolongation of the fields

The prolongation of the fields of temperature (and possibly of metallurgy) is necessary to end of each master key so that those are defined on the model of the following master key. One proceeds in

4 stages:

one starts by creating a field of temperature to ambient ( $T_{20}$ ) on all the grid by order CREA\_CHAMP (operation "AFFE"),

one extends the first field of temperature calculated to master key I (sequence number 1) in supplementing by  $T_{20}$  on new meshes (CREA\_CHAMP operations "EXTR" then "ADZE"),

one stores this field in a new structure of data of the evol\_ther type by order CREA\_RESU,

one makes a loop on the remaining sequence numbers and one repeats operations 2 and 3 for each sequence number by enriching the structure of data created in 3 (key words reuse of CREA\_RESU).

Example:

```
#EVOTH1: EVOL_THER ON MODEL MOTH1 KNOWN EAST
#ON WANTS TO CALCULATE EVOTH2 ON "A LARGER" MODEL MOTH2 THAN MOTH1.
#LES 2 MODELS ARE BASED ON the SAME GRID EMAIL
# EXTENSION OF THE FIELDS OF TEMPERATURE BY 20 DEGREES C:
T20=CREA_CHAMP (OPERATION=' AFFE', TYPE_CHAM=' NOEU_TEMP_R',
MAILLAGE=MAIL, AFFE=_F (TOUT=' OUI', NOM_CMP = ("TEMP",),
```

```
VALE = (20. ,) )
```

```
# EXTENSION OF FIELD TCH1 IN TCH2 ON the FIRST SEQUENCE NUMBER:
```

```
TCH1=CREA_CHAMP (OPERATION=' EXTR', TYPE_CHAM=' NOEU_TEMP_R',
RESULTAT=EVOTH1, NOM_CHAM=' TEMP', NUME_ORDRE=0,)
TCH2=CREA_CHAMP (OPERATION=' ASSE', TYPE_CHAM=' NOEU_TEMP_R',

MAILLAGE=MAIL, ASSE= (_F (ALL = "YES", CHAM_GD = T20),
_F (ALL = "YES", CHAM_GD = TCH1,))
EVOTH12 = CREA_RESU (TYPE_RESU=' EVOL_THER', NOM_CHAM=' TEMP',
AFFE= (_F (CHAM_GD=TCH2, LIST_INST= LPAS,
NUME_INIT=0, NUME_FIN=0,)))
TO DESTROY (CONCEPT=_F (NOM= ("TCH1", "TCH2"),,));
# EXTENSION OF FIELDS TCH1 IN TCH2 ON the OTHER SEQUENCE NUMBERS:
for I in arranges (325):
iordr=i+1;
TCH1=CREA_CHAMP (OPERATION=' EXTR', TYPE_CHAM=' NOEU_TEMP_R',
RESULTAT=EVOTH1,
NOM_CHAM=' TEMP',
NUME_ORDRE=iordr,)
TCH2=CREA_CHAMP (OPERATION=' ASSE', TYPE_CHAM=' NOEU_TEMP_R',

MAILLAGE=MAIL, ASSE= (_F (ALL = "YES", CHAM_GD = T20),
```

```
_F (ALL = "YES", CHAM_GD = TCH1,))
EVOTH12=CREA_RESU (reuse=EVOTH12, TYPE_RESU=' EVOL_THER
, NOM_CHAM=' TEMP',
AFFE= (_F (CHAM_GD=TCH2, LIST_INST=LPAS, NUME_INIT=iordr,
NUME_FIN=iordr,)))
```

```
TO DESTROY (CONCEPT=_F (NOM= ("TCH1", "TCH2"),,));
```

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***For the metallurgy fields, the sequence of the orders is the same one but the types of field are different.***

***# SAME TREATMENT FOR THE METALLURGY FIELDS***

***MOTH13 = AFFE\_MODELE (GRID = EMAIL, AFFE= \_F (GROUP\_MA = ("PASSE13"),***

***PHENOMENON = "THERMAL", MODELING = "AXIS",))***

***MINIT=CREA\_CHAMP (OPERATION=' AFFE', TYPE\_CHAM=' CART\_NEUT\_R',***

***MODELE=MOTH13, AFFE=\_F (TOUT=' OUI',***

***NOM\_CMP = ("X1", "X2", "X3", "X4", "X5"), VALE = (1. , 0. , 0. , 0. , 10. ,)) )***

***# EXTENSION OF FIELDS MCH1 IN MCH2 ON the OTHER SEQUENCE NUMBERS:***

***for iordr in arranges (325):***

***MCH1=CREA\_CHAMP (OPERATION=' EXTR', TYPE\_CHAM=' ELGA\_VARI\_R',***

***RESULTAT=EVOTH1, NOM\_CHAM=' META\_ELGA\_TEMP', NUME\_ORDRE=iordr,) )***

***MCH2=CREA\_CHAMP (OPERATION=' ASSE', TYPE\_CHAM=' ELGA\_VARI\_R',***

***MODELE=MOTH13, PROL\_ZERO=' OUI',***

***ASSE= (\_F (TOUT=' OUI', NOM\_CMP= ("X1", "X2", "X3", "X4", "X5"),***

***NOM\_CMP\_RESU= ("V1", "V2", "V3", "V4", "V5"), CHAM\_GD=MINIT,) )***

***\_F (TOUT=' OUI',***

***CHAM\_GD=MCH1,))***

***EVOTH12=CREA\_RESU (reuse=EVOTH12, TYPE\_RESU=' EVOL\_THER',***

***NOM\_CHAM=' META\_ELGA\_TEMP',***

***AFFE= (\_F (CHAM\_GD=MCH2, LIST\_INST= LPAS,***

***NUME\_INIT=iordr,***

***NUME\_FIN=iordr,))***

**TO DESTROY (CONCEPT=\_F (NOM= (“MCH1”, “MCH2”),),),);**

## 2.3

### **Mechanical calculation**

#### **2.3.1 Modelings associated with the master keys**

**Contrary to thermal calculations, it is advised to use the same mechanical model for all passes. This model will include/understand all the cords, the cords not deposited being decontaminated artificially in their affecting a very weak Young modulus ( $E =$**

**-**  
**10 the 11th reality in**

**practical). The interest of such a technique is that the soft cords become deformed with the chamfer, allowing to take again the following master key on the geometry deformed without having mending of meshes to make.**

**It should nevertheless be taken care that the not activated cords preserve a realistic form during calculations. If it is not the case, they should be re-meshed.**

**For the cord deposited, the real mechanical characteristics are imposed to him when this one has reached the melting point. Thus, in the phase of heating, the cord is still fictitious.**

**This technique is preferable with that consisting in duplicating all the nodes of the interfaces of cords and to impose connections in increment of displacement between ddl. Indeed, the latter technique, even if it reproduces reality rather accurately, has as a disadvantage of involving whimsical deformations, cords not being attached to the structure at the beginning of each master key. Of**

**more, the setting in data of the connections is heavy and their expensive taking into account in time CPU.**

#### **2.3.2 Fastening of the welded zone**

**The axisymmetric modeling of welding on a tube supposes implicitly wrongly that welding has place simultaneously on all the circumference of the tube, therefore that the temperature rises everywhere in**

**chamfer. In reality, the heat source progresses towards part of structure remained cold, who attaches obligatorily the welded zone. The part, on the level of the heat source, thus cannot to dilate freely. This effect of autobridage must grow blurred when diffuse heat and disappear with run of the phase of cooling.**

**To cure this problem, one can force an axial fastening on the tube, only in the phase of heating. One thus prevents the tube from freely dilating with the heating, on the other hand it is free to deform with cooling.**

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**The implementation in Aster is done in the following way:**

•  
**one models the supports by elements of edge (segments) which one blocks them displacements. These elements have nodes confused geometrically with the nodes in with respect to the border of the tube,**

•  
**one puts in contact the supports and the elements of edge of the border (key word CONTACT of AFFE\_CHAR\_MECA),**

•  
**at the end of each master key, when the geometry is reactualized, i.e. one replaces initial geometry by the deformed geometry, these fictitious supports also should be reactualized by repositioning them on the deformed border, as the 3 diagrams show it below:**

**initial supports  
chamfer**

**deformed after master key 1**

**reactualized supports**

**2.3.3 Mechanical calculation of a master key**



*The mechanical model used is that which can take into account the effects of the transformations metallurgical. The law of behavior used is élasto-visco-plastic. The model is isotropic with a function threshold of the Von Mises type and a nonlinear isotropic work hardening with restoration viscous of work hardening. One does not take account of the phenomena of plasticity of transformation and of metallurgical restoration of work hardening (law of behavior META\_VNL in Aster). The effect kinematic work hardening was not looked at but it can be taken into account. The increments of deformations used for the incremental relation of behavior are them linearized deformations of the increment of displacement in the reactualized geometry (large displacements, small deformations). It is option PETIT\_REAC of STAT\_NON\_LINE (the large ones deformations are possible but are generally not necessary)*

*The convergence of the method of Newton is difficult at the beginning of cooling and it is necessary to use the linear algorithm of research to improve convergence. (key word RECH\_LINEAIRE STAT\_NON\_LINE by using the default values).*

*At the end of each master key, one reactualizes the grid, i.e. one replaces the initial grid by deformed geometry. (operator MODI\_MAILLAGE key word factor DEFORMS) and they are reactualized supports.*

*The treatment of the plastic incompressibility poses problem by generating oscillations of important constraints, in particular of the trace. The use of under-integrated elements QUAD8 does not have not made it possible to solve the problem because the grids comprise many elements TRIA6 in the plasticized zones for which one did not have a version under not integrated. One recommends to use them new incompressible elements (modelings PLAN\_INCO, AXIS\_INCO and 3D\_INCO), which have given promising results from this point of view. These elements will be available in version 6.3 of Aster.*

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### **3 Conclusion**

***The digital simulation of a test of welding on tube on the 13 ways made it possible to release one method for calculation whose principal points can be summarized as follows:***

***grid: each cord must be with a grid by a group of meshes. It is not necessary to have a very precise representation of the shape of the cords. On the other hand, the respect of volume and of the position of the cord in the chamfer is important.***

***thermics: the modeling of the contribution of heat is the essential point. Method recommended consists in imposing a heat flow on the meshes of the cords deposited. This flow is constant spaces some and function of time. To determine the temporal dependence, it is necessary to proceed to a thermal retiming starting from experimental data (evolutions of temperature, zones molten) or in the absence of data on the process of welding and of simplified calculations.***

***thermal retiming has an important effect on the final mechanical results, them deformations and residual stresses being sensitive as much to the value that with distribution of the heat source.***

***mechanics: in the case of a high number of master keys, the displacements cumulated in chamfer are important and it is preferable to make a calculation in great displacements with reactualization of the grid at the end of each master key. The assumption of the great deformations is on the other hand not necessary.***

***in the case of a tube, the axisymmetric modeling of welding requires the catch in account of boundary conditions particular, more precisely axial fastening zone welded to take into account the fact that the torch progresses towards one part of structure remained cold. This fastening is essential to obtain correct values of the contracting of the chamfer.***

***modeling Aster: one recommends to build encased thermal models container that cords actually deposited and to prolong the computed fields of one***

*model with the other. On the other hand, it is preferable to have only one mechanical model comprising the totality of the cords upon the departure, cords being decontaminated artificially in their affecting a Young modulus quasi-no one. In this way, one avoids having to re-mesh them weld beads as the chamfer becomes deformed.*

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**Document: U2.03.06**

## ***Realization of a study civil engineering with cables of prestressing***

### ***Summary:***

***The purpose of this document is to give councils to make concrete studies reinforced with cables of prestressed. It gives information on the precautions of grid, on the methods of application of prestressed and on the possibilities of phasage.***

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### ***1 Introduction***

***The studies of Civil Engineering are often rather complex to carry out insofar as they make to intervene of modelings 3D, hulls, bars and several materials. This document tests mutualiser the experience gained on the subject by giving councils of methodology for the grid and the phase of modeling, concerning the prestressed structures.***

***Implementation the numerical of the tension requires some precautions of use, in particular in case of non-linear calculations, since the chronology of the loadings can impact the results. In this document we see how to set up the orders ASTER to reproduce some examples of possible situations in reality.***

### ***2 Remark preliminary***

*In Code\_Aster, the cables of prestressing are modelled by elements 1D (bars with 2 nodes). Their setting in tension is possible and consists in applying a nonnull tension in these cables. Two alternatives exist to carry out this setting in tension. First method (available in Code\_Aster since the v5) consists in setting up the conditions kinematics between the cable and it concrete, to calculate the tension along the cable and then to apply these loadings to the model (instantaneous loading) to seek the balance of the structure. Its disadvantage is that the tension who results from balance is generally weaker than that requested by the user.*

*The second method, developed in v7, is an improvement of the first: it guarantees that tension with balance is exactly that required, but also allows the setting in tension successive of the cables to recreate the phasage setting in prestressed structure. The last interest of this method it is the possibility of applying the tension of the cable in a gradual way, which can be necessary for behaviors of the nonlinéaire type, in particular in the event of cracking of concrete during the phase of setting in prestressing.*

*In both cases, the basic ingredients are the same ones (operator `DEFI_CABLE_BP` and `AFFE_CHAR_MECA`). The difference comes owing to the fact that in the first case, the setting in balance is made simply by a `STAT_NON_LINE` whereas in the second case, one uses the macro-order `CALC_PRECONT` which includes a certain number of handling of the model to ensure the setting in tension (cf [R7.01.02]).*

3

*First stage: grid*

*To carry out a calculation on a structure of civil engineering, it is necessary to net the concrete, and possibly reinforcements as well as the cables of prestressing.*

- The grid of the concrete can be carried out with any voluminal element in 3D or in 2D. The elements can be linear or quadratic. If cables of prestressing are also envisaged with the grid then there are some restrictions on the choice of the elements of concrete according to the type of resolution (see paragraph [§4.2] and Notices paragraph [§5]).*
- The reinforcements are obligatorily with a grid with `SEG2` whose nodes must be confused with those of the concrete. It thus should be thought of it when the concrete is netted. In addition, it is necessary to be vigilant if the concrete is with a grid with cubic elements in order to make well to correspond all the nodes concrete located along the reinforcement with a node steel: in other words if the concrete is with a grid with quadratic elements, at the place where must pass a reinforcement, it is necessary to define 2 `SEG2` steel for a mesh concrete.*

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· *The cables of prestressed must be with a grid with SEG2. On the other hand, it is not necessary to make coincide nodes of the cable and the nodes concrete: the order DEFI\_CABLE\_BP indeed makes it possible to also create connections kinematics which will bind nodes of the cable with the nodes of the concrete of the surrounding mesh. On the other hand, that generate a great number of multipliers of Lagrange which will weigh down calculation. There is thus a compromise to find between facility to carry out the grid and cost of calculation.*

· *In order to be able to define the cables, it is necessary to have named the nodes of anchoring with each end of the cable.*

**4**

## ***Second stage: the setting in fact of the case***

*One details here the various stages of the setting in data of a standard prestressed concrete problem in Code\_Aster. For each phase, one specifies the possible questions to be posed and them information which should be provided. An example of application is proposed in appendix where one gives various alternatives for the phase of resolution.*

**4.1**

### ***Reading and possible enrichments of the grid***

*To check that the nodes of anchoring are quite accessible (individually) by a GROUP\_NO.*

*To create the possible groups of nodes or meshes for postprocessing.*

*To direct the groups of meshes correctly where one imposes loadings of the pressure type or flow (order ORIE\_PEAU\_3D (2D)).*

### ***4.2 Assignment***

***of one***

***model***



*At present, the reinforcements and the cables of prestressed can be modelled only by elements BARS (resting on SEG2). For the concrete, the choice is much freer, in revenge it is necessary to note the following limitations:*

*In the presence of cable of prestressing, the use of DEFI\_CABLE\_BP authorizes only the elements voluminal or modeling DKT. In addition, the operator CALC\_PRECONT who allows in particular not to put all the cables in tension simultaneously is compatible only with the elements voluminal.*

### **4.3** **Characteristics of the elements of structure**

*To define the section of the passive reinforcements and the cables of prestressing.*

### **4.4** **Definition of materials**

*Laws of behavior available for the concrete:*

- *ELAS,*
- *MAZARS local or not-local version [R7.01.08]*
- *ENDO\_ISOT\_BETON or not local local version [R7.01.04]*
- *BETON\_DOUBLE\_DP [R7.01.03]*
- *KIT\_DDI to combine a mechanical model with the models of creep: GRANGER\_FP, GRANGER\_FP\_V, [R7.01.01], BAZANT\_FD [R7.01.05]*

#### **Note:**

*Model LABORD\_ID [R7.01.07] is available only for the multifibre elements beams POU\_D\_EM thus incompatible for a use with cables of prestressing.*

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*Laws of behavior available for steels: about all the laws are usable with elements bars, most usually used are:*

- *ELAS*
- *VMIS\_CINE\_LINE* (plasticity with linear kinematic work hardening)
- *PINTO\_MENEGOTTO*
- *VMIS\_ISOT\_LINE* (plasticity with linear isotropic work hardening)
- *VMIS\_ISOT\_TRAC* (plasticity with isotropic work hardening given by a traction diagram)

*The choice of the law determines the key words to inform under `DEFI_MATERIAU`.*

*In the presence of cables and to be able to use `DEFI_CABLE_BP`, it is also necessary to have informed:*

- *key words `BETON_BPEL` (`PERT_FLUA`, `PERT_RETR`) for the meshes concrete,*
- *key words `ELAS` and `ACIER_BPEL` (`SY`, `FROT_LINE`, `FROT_COURB`, `MU0_RELAX`, `RELAX_1000`) for the steel of the cables of prestressing.*

*All these parameters are not obligatory.*

#### **Note:**

- *Parameter `SY` requires a detailed attention since as opposed to what one could wait, it does not intervene in a possible nonlinear calculation with plasticity cables. The `SY` indicated under `ACIER_BPEL` corresponds to the `Fprg` parameter indicated in the payment `BPEL` and which makes it possible to calculate the loss by relieving. To allow a calculation with plasticization, it is necessary to declare the elastic limit with the law of behavior selected.*
- *Order `DEFI_CABLE_BP` cannot consider the case where characteristics rubber bands of the concrete crossed by the cable can vary with the temperature.*
- *Order `DEFI_CABLE_BP` cannot support the case where several materials concrete are traversed by the same cable.*

## **4.5**

### **Definition of the cables**

*The phase of definition of the cables places by order `DEFI_CABLE_BP`. That makes it possible to define which must be the tension in the cables according to rules' of the `BPEL`, according to the initial tension, retreat of anchoring (which applies only for active anchorings), of the relieving of steel and deformations differed from the concrete (creep and withdrawal).*

*Let us announce that only one `DEFI_CABLE_BP` can gather several cables provided that they have them same parameters of entry for the calculation of the tension, and which one wishes to tighten all these*

*cables  
at the same time.*

*The punching created by anchorings can some times give place to numerical difficulties of modeling. The origin of this problem is related to the incompatibility of the load pattern (a force specific created by anchoring) compared to the grid of the concrete (2D or 3D). To avoid this problem, it*

*key word CONE under DEFI\_CABLE\_BP (available starting from the v7 of Code\_Aster) makes it possible to define one*

*volume representing the cone of fainding placed at the end of the cables, and thus to distribute force punching on a volume of the concrete, and either on one or, some nodes at the maximum. geometry of this volume corresponds to a cylinder whose dimensions (length and ray) would have to correspond to the cone of fainding really employed. However it should be noted that if it grid of the concrete in this area is not sufficiently fine, the volume of the cone will not be able to integrate concrete nodes moreover. But under this condition the problem of concentration of constraint will be probably unimportant.*

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**Note:**

- Each end of cable can be declared as being “active” or “passive”. If one cable comprises any active end, no tension is not then applied.*
- The use of the option **CONE** requires a detailed attention as for the way of imposing boundary conditions under penalty of seeing appearing conditions kinematics superabundant which prevents the resolution of the problem.*

**4.6**

**Definition of the loadings**

*It is necessary to define separately (either as many calls to AFFE\_CHAR\_MECA (\_F)) loadings following:*

- Boundary conditions as well as the possible valid instantaneous loadings as of beginning of calculation*
- The relations kinematics making it possible to connect the nodes cables with the nodes concrete: RELA\_CINE\_BP=\_F (RELA\_CINE=' OUI'). This loading is necessary for any calculation with STAT\_NON\_LINE on the model containing the cables of prestressed (if not fatal error for cause of matrix not factorisable).  
During the call to CALC\_PRECONT, the connections kinematics are inutiles\* except when one carry out the setting in tension in several stages. The connections should indeed be included kinematics for the cables which were already put in tension by a first CALC\_PRECONT: that thus relates to the cables which enter neither key word CABLE\_BP nor in the key word CABLE\_BP\_INACTIF (cf example in appendix and more particularly scenario 1). In it case, it is necessary to think of defining as much loading than of phases of setting in tension different.*
- Posterior loadings with the setting in tension of the cables.*

**\* Caution:**

*When the nodes of cable and concrete are not confused (presence of relations kinematics, RELA\_CINE=' OUI') this generates an error. It thus should be avoided in this case.*

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## 5

***The resolution of the mechanical problem***

*It is a question here of specifying the loading to be included (key word EXCIT) at the time of the call to CALC\_PRECONT.*

*Several cases arise.*

*1) The user wishes to thus put in tension simultaneously all the cables of prestressed that an instantaneous loading, without other loadings as a preliminary. In this case, it is enough to call upon macro-order CALC\_PRECONT only once. The loading is made up boundary conditions and possible instantaneous loadings. Under key word CABLE\_BP, all concepts DEFI\_CABLE\_BP will be included (see scenario 3 in appendix).*

*2) The user wishes to make calculations before the setting in tension of the cables. In this case, it is appropriate:*

- is not to include the cables in the model used to make calculations before the setting in tension of the cables*

- is to use under key word COMP\_INCR of STAT\_NON\_LINE, the law of behavior RELATION=' SANS' for the meshes of the cable. In this case, it is essential to add in the loadings, the relations kinematics binding cable and concrete (obtained while writing AFFE\_CHAR\_MECA (RELA\_CINE\_BP=\_F (RELA\_CINE=' OUI')) (see scenario 1 and 3 in appendix).*

*3) The user wishes successively to put in tension the cables. In this case, it is necessary to appeal with CALC\_PRECONT as many time as necessary. CABLE\_BP will contain the concepts DEFI\_CABLE\_BP associated with the cables which one is tending during this call to CALC\_PRECONT, CABLE\_BP\_INACTIF will contain those which one wishes to tighten later on: in this way, it is the macro-order which is given the responsibility to affect a law of behavior WITHOUT with these cables and to include the connections kinematics associated with these same cables. For the loading, it is a question systematically of including the boundary conditions as well as possible instantaneous loadings. From the second call to CALC\_PRECONT, it is appropriate to include moreover, the connections kinematics related to the cables already put in tension at the stages the preceding ones (see scenario 1 in Appendix).*

*In all the cases of figure, for the STAT\_NON\_LINE which follow the setting in tension of the cables, it is important not to forget the whole of the connections kinematics related to the cables*

***Note:***

*For the moment, the use of macro-order CALC\_PRECONT is not compatible with the use of hulls to represent the concrete surrounding the cables. It is thus necessary to have recourse to the old method of setting in tension of the cables in spite of its disadvantages [R7.01.02]. The setting in tension is carried out simply while including in loads concept AFFE\_CHAR\_MECA defined by RELA\_CINE\_BP = F (RELA\_CINE = "YES",*

**SIGM\_BPEL=' OUI')**. With the exit of this calculation, the tension in the cables is not equal any more to those prescribed by the BPEL, it is thus necessary to determine the coefficients of correction to apply with the initial tensions applied to the cables (on the level of the declaration of the operator **DEFI\_CABLE\_BP**) allowing to compensate for the loss by instantaneous strain of structure. Once the command file modified by these coefficients of correction, modeling of the cables of prestressing is accomplished.

Attention, in the case of sequence of **STAT\_NON\_LINE**, it is appropriate starting from the second call, to include in the loading only the relations kinematics and not the tension in cables, under penalty of adding this tension, with each calculation (see scenario 2 in appendix). That thus requires to create a second **AFFE\_CHAR\_MECA** with the operand **RELA\_CINE\_BP = F (RELA\_CINE = "YES", SIGM\_BPEL=' NON')** (cf scenario 2 in Appendix).

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## **6 Appendix**

**Here an example of application inspired of the case test [V6.04.164] (SSNV164). It is about a crossed post by 5 cables, and the loading is composed of:**

- 1) gravity**
- 2) prestressing in the cables**
- 3) a pressure on the higher face**

**The setting in data is common, then one shows 3 scenarios to solve the problem:**

***The first scenario is most physical:***

- 1) taken into account of gravity***
- 2) put in tension of cables 1 and 2***
- 3) put in tension of cables 3 and 4***
- 4) put in tension of cable 5***
- 5) pressurization***

***The second scenario is that which one applied before the development of the operator CALC\_PRECONT (to version 6 of Code\_Aster) and which is the method which remains recommended in case where one uses a model DKT for the concrete***

- 1) taken into account of gravity and setting in tension of the 5 cables***
- 2) pressurization***

***The third scenario is identical to the second with regard to the order of application of loadings but it uses operator CALC\_PRECONT and thus makes it possible to have directly the tension lawful in the cables of prestressing***

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***The setting in fact of the case***

***PRE\_GIBI ();***

***MA=LIRE\_MAILLAGE (VERI\_MAIL=\_F (VERIF='NON'),);***

**MA=DEFI\_GROUP (reuse =MA,  
MAILLAGE=MA,**

**CREA\_GROUP\_NO= (\_F (GROUP\_MA=' SU3'),  
Reading and enrichment of the grid. The creation of  
\_F (GROUP\_MA=' PP'),  
GROUP\_NO related to the cables are essential only for  
\_F (GROUP\_MA=' CAB1'),  
\_F (GROUP\_MA=' CAB2'),  
a possible postprocessing along those.  
\_F (GROUP\_MA=' CAB3'),  
  
\_F (GROUP\_MA=' CAB4'),  
  
\_F (GROUP\_MA=' CAB5'),  
),);**

**MO=AFFE\_MODELE (MAILLAGE=MA,**

**AFFE= (  
\_F (GROUP\_MA=' VOLTOT',**

**PHENOMENE=' MECANIQUE',**

**MODELISATION=' 3D'),  
Definition of the models (3D for the concrete, BARS for  
\_F (GROUP\_MA= ("CAB1", "CAB2", "CAB3", "CAB4", "CAB5"),  
cables)**

**PHENOMENE=' MECANIQUE',**

**MODELISATION=' BARRE'),),);**

**CE=AFFE\_CARA\_ELEM (MODELE=MO,**

**BARRE=\_F (**

**GROUP\_MA= ("CAB1", "CAB2", "CAB3", "CAB4", "CAB5"),  
Geometrical characteristics (transverse) of  
SECTION=' CERCLE',  
elements bars**

**CARA=' R',  
VALE=2.8209E-2),),);**



**MBETON=DEFI\_MATERIAU (ELAS=\_F (E=4.E10,  
NU=0.20,**

**RHO=2500,)**,

**BPEL\_BETON=\_F (,);**

**MCABLE=DEFI\_MATERIAU (ELAS=\_F (E=1.93E11,  
Creation and assignment of the characteristics materials  
NU=0.3,**

**for the cable and the concrete:**

**RHO=7850,)**,

**Concrete: rubber band + given lawful BPEL by**

**BPEL\_ACIER=\_F (SY=1.94E11,**

**FROT\_COURB=0.0,**

**defect**

**FROT\_LINE=1.5E-3,)**,

**Steel: rubber band +données lawful BPEL +**

**ECRO\_LINE = \_F (SY = 1.94E11,**

**data for plastic model with isotropic work hardening**

**D\_SIGM\_EPSI=1000.,))**

**CMAT=AFFE\_MATERIAU (MAILLAGE=MA,**

**AFFE= (**

**\_F (GROUP\_MA=' VOLTOT',**

**MATER=MBETON,)**,

**\_F (GROUP\_MA= ("CAB1", "CAB2", "CAB3", "CAB4", "CAB5"),**

**MATER=MCABLE,)),);**

**CAB\_BP1=DEFI\_CABLE\_BP (MODELE=MO,**

**CHAM\_MATER=CMAT,**

**CARA\_ELEM=CE,**

**GROUP\_MA\_BETON=' VOLTOT',**

**DEFI\_CABLE=\_F (GROUP\_MA=' CAB1',**

**GROUP\_NO\_ANCRAGE= (“PC1D”, “PC1F”),),**  
**TYPE\_ANCRAGE= (“ACTIVE”, “PASSIVE”),)**  
**TENSION\_INIT=3.75E6,**  
**RECU\_L\_ANCRAGE=0.001,);**

**CAB\_BP2=DEFI\_CABLE\_BP (MODELE=MO,**

**CHAM\_MATER=CMAT,**

**CARA\_ELEM=CE,**

*Definition of the 5 cables of prestressing*

**GROUP\_MA\_BETON=' VOLTOT',**

**DEFI\_CABLE=\_F (GROUP\_MA=' CAB2',**

*Note:*

**GROUP\_NO\_ANCRAGE= (“PC2D”, “PC2F”),),**

**TYPE\_ANCRAGE= (“ACTIVE”, “PASSIVE”),)**

*It is possible to gather:*

**TENSION\_INIT=3.75E6,**

**RECU\_L\_ANCRAGE=0.001,);**

**CAB\_BP1 and CAB\_BP2 but also CAB\_BP3 and**

**CAB\_BP4 since they have the same characteristics**

**CAB\_BP3=DEFI\_CABLE\_BP (MODELE=MO,**

**and are put in tension simultaneously.**

**CHAM\_MATER=CMAT,**

**CARA\_ELEM=CE,**

**GROUP\_MA\_BETON=' VOLTOT',**

*If all the cables are tended*

**DEFI\_CABLE=\_F (GROUP\_MA=' CAB3',**

**at the same time (scenario 2 and 3) one can gather**

**GROUP\_NO\_ANCRAGE= (“PC3D”, “PC3F”),),**

**all the cables except the 5 whose anchorings are**

**TYPE\_ANCRAGE= (“ACTIVE”, “PASSIVE”),)**

**TENSION\_INIT=3.75E6,**

**different (ACTIF/PASSIF counters ACTIF/PASSIF).**

**RECU\_L\_ANCRAGE=0.001,);**

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***CAB\_BP4=DEFI\_CABLE\_BP (MODELE=MO,  
CHAM\_MATER=CMAT,***

***CARA\_ELEM=CE,***

***GROUP\_MA\_BETON=' VOLTOT',  
DEFI\_CABLE=\_F (GROUP\_MA=' CAB4',***

***GROUP\_NO\_ANCRAGE= ("PC4D", "PC4F"),),***

***TYPE\_ANCRAGE= ("ACTIVE", "PASSIVE"),***

***TENSION\_INIT=3.75E6,  
RECU\_L\_ANCRAGE=0.001,);***

***CAB\_BP5=DEFI\_CABLE\_BP (MODELE=MO,  
... continuation.***

***CHAM\_MATER=CMAT,***

***CARA\_ELEM=CE,***

***GROUP\_MA\_BETON=' VOLTOT',***

```
DEFI_CABLE=_F (GROUP_MA=' CAB5',  
GROUP_NO_ANCRAGE= ("PC5D", "PC5F"),),  
TYPE_ANCRAGE= ("ACTIVE", "ACTIVE"),  
# CONE=_F (RAYON=0.21,  
# LONGUEUR=2.1,  
# PRESENT= ("YES", "YES"),),  
TENSION_INIT=3.75E6,  
RECU_L_ANCRAGE=0.001,  
INFO=2,  
);  
CLIM =AFFE_CHAR_MECA (MODELE=MO,  
DDL_IMPO= (  
Creation of the loadings  
_F (GROUP_NO=' PP',  
DX=0.0, DY=0.0),  
_F (GROUP_NO=' PX',  
Boundary conditions and gravity  
DY=0.0),  
_F (GROUP_NO=' PY',  
DX=0.0),  
_F (GROUP_NO=' SU3',  
DZ=0.0),),  
PESANTEUR= (9.81, 0.0, 0.0, - 1.0),)  
CMCAB1=AFFE_CHAR_MECA (MODELE=MO,  
RELA_CINE_BP=_F (CABLE_BP=CAB_BP1,  
SIGM_BPEL=' NON',  
RELA_CINE=' OUI'),)  
CMCAB2=AFFE_CHAR_MECA (MODELE=MO,
```

**RELA\_CINE\_BP=\_F (CABLE\_BP=CAB\_BP2,**  
*The connections kinematics connecting the cable to the concrete*  
**SIGM\_BPEL='NON',**  
*(here SIGM\_BPEL='NON', because one does not want to include*  
**RELA\_CINE='OUI',),)**  
**CMCAB3=AFFE\_CHAR\_MECA (MODELE=MO,**  
*in this loading the tension in the cables)*  
**RELA\_CINE\_BP=\_F (CABLE\_BP=CAB\_BP3,**  
**SIGM\_BPEL='NON',**  
**RELA\_CINE='OUI',),)**  
**CMCAB4=AFFE\_CHAR\_MECA (MODELE=MO,**  
**RELA\_CINE\_BP=\_F (CABLE\_BP=CAB\_BP4,**  
**SIGM\_BPEL='NON',**  
**RELA\_CINE='OUI',),)**  
**CMCAB5=AFFE\_CHAR\_MECA (MODELE=MO,**  
**RELA\_CINE\_BP=\_F (CABLE\_BP=CAB\_BP5,**  
**SIGM\_BPEL='NON',**  
**RELA\_CINE='OUI',),);**

*Posterior loadings with the setting in tension*  
**CLOSE =AFFE\_CHAR\_MECA (MODELE=MO,**  
**PRES\_REP =\_F (GROUP\_MA = “HIGH”,**  
*cables (here a pressure)*  
**CLOSE = 500,);)**

**FCT = DEFI\_FONCTION (NOM\_PARA = “INST”,**  
**VALE = (0. , 0. , 600. , 0. , 1000. , 1.),)**

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***Scenario 1***

***LINST=DEFI\_LIST\_REEL (VALE= (0.0, 150. , 300. , 450. , 600. , 1000.),);***

***# STAGE 1: EFFECT OF GRAVITY***

***RES1 = STAT\_NON\_LINE (MODELE=MO,***

***CHAM\_MATER=CMAT,***

***The cables do not intervene: from where***

***CARA\_ELEM=CE,***

***COMP\_INCR= (\_F (RELATION = "ELAS"),***

***RELATION=' SANS', but as they are present***

***\_F (RELATION = "WITHOUT",***

***in the model, one includes the connections kinematics them***

***GROUP\_MA= ("CABLE"),),),***

***concerning (if not the cables "fall").***

***EXCIT = (\_F (LOAD = CLIM),***

***\_F (LOAD = CMCAB1),***

***\_F (LOAD = CMCAB2),***

***\_F (LOAD = CMCAB3),***

***\_F (LOAD = CMCAB4),***

***\_F (LOAD = CMCAB5),),***

***INCREMENT=\_F (LIST\_INST = LINST, INST\_FIN = 150.),)***

**# loading 2: cables 1 and 2**

#-----

**RES1 = CALC\_PRECONT (reuse=RES1,  
 ETAT\_INIT=\_F (EVOL\_NOLI=RES1),**

**MODELE=MO,**

*Whereas boundary conditions and gravity*

**CHAM\_MATER=CMAT,**

*are maintained, CALC\_PRECONT, will put in*

**CARA\_ELEM=CE,**

**COMP\_INCR= (\_F (RELATION = "ELAS",**

*tension cables 1 and 2, while maintaining inactive*

**GROUP\_MA=' VOLTOT'),**

*cables 3,4 and 5.*

**\_F (RELATION = "VMIS\_ISOT\_LINE",**

*To assign the real law of behavior to the cables.*

**GROUP\_MA = "CABLE"),),**

**EXCIT= (\_F (LOAD = CLIM,)),**

*Not to include the connections kinematics binding them*

**CABLE\_BP= (CAB\_BP1, CAB\_BP2),**

*cables with the concrete, CALC\_PRECONT takes care some*

**CABLE\_BP\_INACTIF = (CAB\_BP3, CAB\_BP4, CAB\_BP5),**

**INCREMENT=\_F (LIST\_INST = LINST, INST\_FIN = 300. ,**

**SUBD\_PAS = 4,**

**SUBD\_PAS\_MINI = 0.01,))**

**# loading 3: cables 3 and 4**

#-----

**RES1 = CALC\_PRECONT (reuse=RES1,**

**ETAT\_INIT=\_F (EVOL\_NOLI=RES1),**

**MODELE=MO,**

**CHAM\_MATER=CMAT,**

*This time cables 1 and 2 are already tended and are not*

**CARA\_ELEM=CE,**

**COMP\_INCR= (\_F (RELATION = "ELAS",**

*thus more managed by CALC\_PRECONT, this is why it*  
**GROUP\_MA=' VOLTOT',),**  
*is necessary to include in the loading in addition to the conditions*  
**\_F (RELATION = "VMIS\_ISOT\_LINE",**  
*with the limits, the connections kinematics for these 2*  
**GROUP\_MA = "CABLE"),),**  
**EXCIT = (\_F (LOAD = CLIM,)**  
*cables. On the other hand nothing to put for cable 5,*  
**\_F (LOAD = CMCAB1,)**  
*always inactive, and for cables 3 and 4 that*  
**\_F (LOAD = CMCAB2,)),**  
**CALC\_PRECONT will put in tension at this stage**  
**CABLE\_BP = (CAB\_BP3, CAB\_BP4),**  
**CABLE\_BP\_INACTIF = (CAB\_BP5,)**

**INCREMENT=\_F (LIST\_INST = LINST, INST\_FIN = 450. ,**

**SUBD\_PAS = 4,**

**SUBD\_PAS\_MINI = 0.01,))**

*# loading 4: cable 5*

**#-----**

**RES1 = CALC\_PRECONT (reuse=RES1,**

**ETAT\_INIT=\_F (EVOL\_NOLI=RES1),**

**MODELE=MO,**

**CHAM\_MATER=CMAT,**

**CARA\_ELEM=CE,**

**COMP\_INCR= (\_F (RELATION = "ELAS",**  
*Only cable 5 is managed by*  
**GROUP\_MA=' VOLTOT',),**  
**CALC\_PRECONT, it is necessary**  
**\_F (RELATION = "VMIS\_ISOT\_LINE",**  
*thus to include the connections kinematics for the others*  
**GROUP\_MA = "CABLE"),),**  
*already tended cables (1,2,3 and 4).*  
**EXCIT = (\_F (LOAD = CLIM,)**  
**\_F (LOAD = CMCAB1,)**



***\_F (LOAD = CMCAB2,)***,

***\_F (LOAD = CMCAB3,)***,

***\_F (LOAD = CMCAB4,)),***  
***CABLE\_BP = (CAB\_BP5,)***,

***INCREMENT=\_F (LIST\_INST = LINST, INST\_FIN = 600. ,***

***SUBD\_PAS = 4,***  
***SUBD\_PAS\_MINI = 0.01,))***

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***# loading 5: pressure***

***#-----***  
***RES1 = STAT\_NON\_LINE (reuse=RES1,***

***ETAT\_INIT=\_F (EVOL\_NOLI=RES1),***

***MODELE=MO,***  
***CHAM\_MATER=CMAT,***

**CARA\_ELEM=CE,**  
**COMP\_INCR= (\_F (RELATION = “ELAS”,**  
**GROUP\_MA=' VOLTOT',),**  
**\_F (RELATION = “VMIS\_ISOT\_LINE”,**  
**GROUP\_MA = “CABLE”),),**  
*All the cables are now active. The loading*  
**EXCIT = (\_F (LOAD = CLIM,),**  
*must include/understand the boundary conditions, them*  
**\_F (LOAD = CMCAB1,),**  
**\_F (LOAD = CMCAB2,),**  
*instantaneous loadings, the connections kinematics*  
**\_F (LOAD = CMCAB3,),**  
*for all the cables and the new loadings with*  
**\_F (LOAD = CMCAB4,),**  
*to apply (here*  
**\_F (LOAD = CMCAB5,),**  
**NEAR).**  
**\_F (LOAD = NEAR, FONC\_MULT = FCT,)),**  
**INCREMENT=\_F (LIST\_INST = LINST, INST\_FIN = 1000. ,**  
**SUBD\_PAS = 4,**  
**SUBD\_PAS\_MINI = 0.01,))**

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**Scenario 2**

**LINST=DEFI\_LIST\_REEL (VALE= (0.0, 600. , 1000.),);**

**CMCAB1B=AFFE\_CHAR\_MECA (MODELE=MO,  
RELA\_CINE\_BP=\_F (CABLE\_BP=CAB\_BP1,**

**SIGM\_BPEL=' OUI',**

**RELA\_CINE=' OUI',),)**

**CMCAB2B=AFFE\_CHAR\_MECA (MODELE=MO,  
RELA\_CINE\_BP=\_F (CABLE\_BP=CAB\_BP2,**

**SIGM\_BPEL=' OUI',**

**RELA\_CINE=' OUI',),)**

**CMCAB3B=AFFE\_CHAR\_MECA (MODELE=MO,**

**To directly apply the tension in the cables,**

**RELA\_CINE\_BP=\_F (CABLE\_BP=CAB\_BP3,**

**one needs to define new loadings**

**SIGM\_BPEL=' OUI',**

**containing at the same time the connections kinematics binding cable**

**RELA\_CINE=' OUI',),)**

**and concrete, and the value of the tension to be included in**

**CMCAB4B=AFFE\_CHAR\_MECA (MODELE=MO,**

**RELA\_CINE\_BP=\_F (CABLE\_BP=CAB\_BP4,**

**cables (from where SIGM\_BPEL=' OUI', contrary to**

**SIGM\_BPEL=' OUI',**

**CMCABi loadings defined initially).**

**RELA\_CINE=' OUI',),)**

**CMCAB5B=AFFE\_CHAR\_MECA (MODELE=MO,**

**RELA\_CINE\_BP=\_F (CABLE\_BP=CAB\_BP5,**

**SIGM\_BPEL=' OUI',**

***RELA\_CINE=' OUI',,);***

***# STAGE 1: EFFECT OF GRAVITY + TENSION OF THE CABLES***

***RES1 = STAT\_NON\_LINE (MODELE=MO,***

***CHAM\_MATER=CMAT,***

***CARA\_ELEM=CE,***

***COMP\_INCR= (\_F (RELATION = "ELAS",***

***GROUP\_MA=' VOLTOT',),***

***The loading is composed of CLIM and of***

***\_F (RELATION = "VMIS\_ISOT\_LINE",***

***GROUP\_MA = "CABLE"),,***

***CMCABiB containing the connections kinematics and***

***EXCIT = (\_F (LOAD = CLIM,),***

***tension in the cables***

***\_F (LOAD = CMCAB1B),***

***\_F (LOAD = CMCAB2B),***

***\_F (LOAD = CMCAB3B),***

***\_F (LOAD = CMCAB4B),***

***\_F (LOAD = CMCAB5B),,***

***INCREMENT=\_F (LIST\_INST = LINST, INST\_FIN = 600.),)***

***# loading 2: pressure***

***#-----***

***RES1 = STAT\_NON\_LINE (reuse=RES1,***

***ETAT\_INIT=\_F (EVOL\_NOLI=RES1),***

***MODELE=MO,***

***CHAM\_MATER=CMAT,***

***CARA\_ELEM=CE,***

***COMP\_INCR= (\_F (RELATION = “ELAS”,  
GROUP\_MA=' VOLTOT'),  
One always maintains the boundary conditions and  
\_F (RELATION = “VMIS\_ISOT\_LINE”,  
gravity, one includes the pressure. For the cables, it is  
GROUP\_MA = “CABLE”),),  
EXCIT = (\_F (LOAD = CLIM),  
well CMCABi because one just wishes to maintain them  
\_F (LOAD = CMCAB1),  
connections kinematics (if not, a news is added  
\_F (LOAD = CMCAB2),  
time the tension in the cables)  
\_F (LOAD = CMCAB3),  
\_F (LOAD = CMCAB4),  
  
\_F (LOAD = CMCAB5),  
  
\_F (LOAD = NEAR, FONC\_MULT = FCT)),  
  
INCREMENT=\_F (LIST\_INST = LINST, INST\_FIN = 1000. ,  
SUBD\_PAS = 4,  
  
SUBD\_PAS\_MINI = 0.01),)***

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**Scenario 3**

***LINST=DEFI\_LIST\_REEL (VALE= (0.0, 600. , 1000.),);***

***# STAGE 1: EFFECT OF GRAVITY + TENSION OF THE CABLES***

***RES1 = CABLE\_PRECONT (MODELE=MO,***

***CHAM\_MATER=CMAT,***

***CARA\_ELEM=CE,***

***COMP\_INCR= (\_F (RELATION = “ELAS”,***

***The loading is composed of CLIM and the 5 cables***

***GROUP\_MA=' VOLTOT'),***

***are put in tension simultaneously***

***\_F (RELATION = “VMIS\_ISOT\_LINE”,***

***GROUP\_MA = “CABLE”),)***

***CABLE\_BP = (CAB\_BP1, CAB\_BP2, CAB\_BP3, CAB\_BP4, CAB\_BP5),***

***EXCIT =\_F (LOAD = CLIM,)***

***INCREMENT=\_F (LIST\_INST = LINST, INST\_FIN = 600.),)***

**# loading 2: pressure**

**#-----**

**RES1 = STAT\_NON\_LINE (reuse=RES1,**

**ETAT\_INIT=\_F (EVOL\_NOLI=RES1),**

**MODELE=MO,**

**CHAM\_MATER=CMAT,**

**CARA\_ELEM=CE,**

**COMP\_INCR= (\_F (RELATION = "ELAS",**

**GROUP\_MA=' VOLTOT'),**

**\_F (RELATION = "VMIS\_ISOT\_LINE",**

**GROUP\_MA = "CABLE"),),**

**One always maintains the boundary conditions and**

**EXCIT = (\_F (LOAD = CLIM),**

**gravity, one includes the pressure. For the cables, one has**

**\_F (LOAD = CMCAB1),**

**always need for the connections kinematics them**

**\_F (LOAD = CMCAB2),**

**concerning.**

**\_F (LOAD = CMCAB3),**

**\_F (LOAD = CMCAB4),**

**\_F (LOAD = CMCAB5),**

**\_F (LOAD = NEAR, FONC\_MULT = FCT,)),**

**INCREMENT=\_F (LIST\_INST = LINST, INST\_FIN = 1000. ,**

**SUBD\_PAS = 4,**

**SUBD\_PAS\_MINI = 0.01,))**

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***Document: U2.04.04***

## ***Modeling of the contact***

***Summary:***

***One describes in this document the methods available in Code\_Aster to deal with the problems of contact***

***with or without friction, into small or great displacements.***

***One will treat in details the loads of contact, used by operators STAT\_NON\_LINE and DYNA\_NON\_LINE. And one will approach the modeling of the specific contact on DYNA\_TRAN\_MODAL or with***

*elements DIS\_CONTACT.*

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## **1 Introduction**

*One speaks about study of contact as soon as there can be interaction of contact during calculation. It is possible to model the problems of contact-impact and contact-friction with Code\_Aster, into small or great displacements.*

*This document reviews the various methods available, underlines the encountered difficulties and gives councils of use. One will privilege the treatment of the contact by the loads of contact. It exist other methods, they relate to only the specific contact and they are presented in chapter 6.*

### **General step**

*The contact is declared in AFFE\_CHAR\_MECA, like a load. All conditions of contact must be declared in the same AFFE\_CHAR\_MECA (each one in an occurrence of the key word CONTACT).*

*Initially, one indicates surfaces between which one wants to treat the contact.*

*One then chooses to treat the contact with or without friction. In the case of the contact with friction, it is necessary to give the coefficient of friction.*

*One also indicates the methods of calculation to be used and the method of pairing.*

*It is through these stages that one defines all the parameters of the contact.*

*They take place in operator AFFE\_CHAR\_MECA.*

*The conditions of contact are thus declared like a load. They are used like such*

*(key word EXCIT) in the operators mechanics STAT\_NON\_LINE or DYNA\_NON\_LINE.*

*Once completed calculation, one can make a postprocessing of the efforts of contact.*

### **Useful readings**

*Documentation here presents has the role to guide the user at the time of a modeling in contact friction. It takes again the essential indications and gives councils of use.*

*It does not replace the reading of U4 documentations of each operator. The user will find*

*in these documentations the syntax of the operator, as well as the significance of each parameter.*

*In addition, the user who wishes to have more detailed approach and comments on*

*algorithms or the equations of the contact, will refer to the reference materials R5: [R5.03.50]*

*and [R5.03.51].*

*Examples are provided here to illustrate certain points. One will be able in addition to refer to the cases test (V6 documentation) and to be inspired some.*

## ***Plan***

*In a second part, we will give some elementary definitions specific to modeling of the contact.*

*Partly 3, one finds a short description of the Code\_Aster operators concerned.*

*In parts 4 and 5, one will approach the difficulties of modeling and calculation. One will find in these parts councils to use the contact in Code\_Aster.*

*Part 6 is devoted to other modelings of the contact in Code\_Aster. It is reserved for specific contact.*

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## ***2 Definitions***

### ***Contact***

*The taking into account of the contact by Code\_Aster does not go from oneself. Without specific declaration, two elements can occupy the same place of space.*

*If it is provided that two surfaces can come into contact during calculation, one should be done declaration of contact. Surfaces in questions are called surfaces of contact.*

*The surface of contact is 2D for a structure 3D, 1D for a structure 2D.*

### *Master/Slave*

*When it is declared that two surfaces S1 and S2 are likely to come into contact, Code\_Aster writes them suitable relations. These relations are not symmetrical. This is why one is brought to distinguish two surfaces, to the first one gives the name of Master, at the second the name of slave. The treatment of the contact consists in preventing the nodes slaves from penetrating surface Master.*

### *Note:*

*For the methods LAGRANGE and CONSTRAINT, Code\_Aster treats the contact while applying multipliers of Lagrange carried by the nodes slaves.*

*One understands in this case that the main choice of surface and surface slave can have one influence on the result of calculation. One will find thereafter councils to make this choice.*

### *Pairing*

*Pairing is the phase of calculation where Code\_Aster calculates between which point slave and which point*

*Master (or which mesh Master) will be written the relations of contact.*

*One calls “NODAL” pairing pairing between a node slave and a main node.*

*One calls pairing “MAITRE-ESCLAVE” pairing between a node slave and his projection on surface Master.*

*Appear 2-a: Pairing “MAITRE-ESCLAVE” and “NODAL” pairing*

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**Normal**

*The normals on the surfaces have a very important role at the time of pairing and writing of relation of the contact.*

*Their direction allows the projection of the points slaves on surfaces Master, but they are too used for the writing of the equations of contact. Their direction makes it possible to distinguish the interior of*

*the outside of the structure. The normals must always be outgoing.*

*This is why it is essential always to define and correctly direct the normals of surfaces in contact.*

**N**

*Appear 2-b: The normal must be outgoing*

**Conditions of Signorini**

*The conditions of Signorini are the conditions of noninterpenetration.*

**Force**

**normal**

**dn**

**Appear 1-c: Condition of Signorini**



*They say that the normal force of contact is null when there is not contact ( $dn > 0$ ), and that the interpenetration (i.e.  $dn < 0$ ) is impossible. If there is contact, normal reaction can take any positive value (effort of repulsion) which answers the mechanical problem and which prevents the interpenetration.*

### *Force contact*

*During the contact, two surfaces in contact generate forces one on the other. These forces allow two surfaces not to interpenetrate. They respect the principle of action and reaction. One has access to these forces during postprocessing.*

*These forces are always forces of repulsion (to move away surfaces in contact). They do not act remotely, i.e. they are null when two surfaces do not touch.*

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*Coefficient of friction  $\mu$*

*Friction is taken into account by the law of Coulomb.*

*Appear 2D: Law of Coulomb*

*This law utilizes a coefficient  $\mu$ , called coefficient of Coulomb. During the phase of adherence,*

*the point does not move (null speed). During the phase of slip, the point has a speed not null, it is subjected to a tangent reaction equalizes with  $\mu$  time the normal reaction. The coefficient of Coulomb depends on surfaces in contact. If the coefficient of friction is null (i.e., if there is no friction), there is no reaction tangential.*

### ***Penalization***

*One can treat the contact in a penalized way.*

*For the normal direction, in other words, once in contact, the structure are pushed back by a stiffness. This stiffness exerts a repulsive effort between the structures. During this phase, there is interpenetration of the structures.*

*One fixes this stiffness with the normal coefficient of penalization  $E_N$ .*

***F***

***NR***

***Appear 2nd: Coefficient of normal penalization***

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***This penalization corresponds to a regularization of the curve of Signorini:***

***Force normal***

$$F = - E_N \cdot dn$$

***dn***

***Appear 2-f: Condition of Signorini penalized***

***For friction, the penalization appears on the curve of Coulomb.***

***In this case, there is no phase of adherence, the infinite slope is replaced by a slope finished of value the tangent coefficient of penalization  $E_T$ .***

***RT***

$$\mu \cdot |RN|$$

$$E_T$$

$$- vT$$

$$- \mu \cdot |RN|$$

***Appear 2-g: Law of Coulomb penalized***

***One should not confuse the tangent coefficient of penalization  $E_T$  with the coefficient of friction  $\mu$ . On the preceding curve, the first fixes the slope at the origin, the second fixes the value of the stage.***

## ***Loads of contact***

***In Code\_Aster, one speaks about loads of contact. All the declarations of the contact are done like a declaration of load. One defines the parameters in AFFE\_CHAR\_MECA and one uses them in key word EXCIT of the operator of calculation.***

## ***Interpenetration***

***One speaks about interpenetration when a structure penetrates inside the other and reciprocally. The interpenetration is not a physical phenomenon. A physical object can come to be crushed on one other but does not penetrate in the matter of the other.***

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### ***Exact solution***

*One will use the expression “solution exact” to indicate a solution which follows the laws exactly of contact (conditions of Signorini and law of Coulomb).*

*In particular, an exact solution does not allow the interpenetration.*

*The exact solution is obtained without the recourse to coefficients of penalization chosen by the user, and on which strongly the solution depends.*

*Obviously, an “exact” solution is not inevitably physically acceptable, and it depends always other parameters of calculation and modeling.*

### ***Specific contact***

*One speaks about specific contact when two “surfaces” potentially in contact are reduced to points. For example, on telegraphic models, one can be brought to use the specific contact.*

*One can use the specific contact in 2D or 3D.*

*It should not be confused with nodal pairing where the relations are written between two nodes but where the contact can be done between two surfaces (or segments), and pairings can evolve/move with run of calculation.*

*One can treat the specific contact with the methods presented here. Other methods are too available. They are presented at chapter 6.*

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**3**

### ***Operators of the contact***

*At the time of the modeling of the contact, one will be brought to use two Code\_Aster operators: AFFE\_CHAR\_MECA which makes it possible to regulate all the parameters of the contact and to declare surfaces of contact.*

*STAT\_NON\_LINE or DYNA\_NON\_LINE which carry out static or dynamic calculation with contact. For each operator, one will refer to U4 documentations. They contain syntax operators, as well as the significance of each keyword.*

**3.1**

#### ***AFFE\_CHAR\_MECA***

*[U4.44.01]*

*AFFE\_CHAR\_MECA, key word CONTACT*

*It is in AFFE\_CHAR\_MECA that one defines the parameters of the loads of contact, under the key word CONTACT.*

*It is here that one chooses surfaces of contact.*

*· The contact will be done between the GROUP\_MA\_1 (or MAILLE\_1) and the GROUP\_MA\_2 (or MAILLE\_2).*

*the declaration of these two elements is essential.*

**Appear 3.1-a: Declaration of surfaces of contact**

*Only the couples of surfaces declared here will be taken into account. If ever the contact were to be done elsewhere, Code\_Aster will not hold account of it.*

*· All the loads of contact must be declared in the same AFFE\_CHAR\_MECA, and in the same key word contact. One will add as many occurrences of this key word there is zones to be declared.*

**Example:**

*CHA = AFFE\_CHAR\_MECA (MODELE=MO,  
DDL\_IMPO=\_F (GROUP\_MA='SOCLE',  
DX=0.0,  
DY=0.0,)*

*CONTACT= (\_F (GROUP\_MA\_1 = "COTE\_AB",  
GROUP\_MA\_2  
=  
"COTE\_EF",  
METHOD  
=  
"LAGRANGIAN",  
PAIRING  
=  
"MAIT\_ESCL",),*

*\_F (  
GROUP\_MA\_1  
=  
"COTE\_MP",  
GROUP\_MA\_2  
=  
"COTE\_RS",  
METHOD  
=  
"LAGRANGIAN",  
PAIRING  
=  
"MAIT\_ESCL",  
FRICTION*

=  
"COULOMB",  
COULOMB  
=  
2.0,)),);  
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**3.2**

***STAT\_NON\_LINE and DYNA\_NON\_LINE***

*[U4.51.03] and [U4.53.01]*

*STAT\_NON\_LINE and DYNA\_NON\_LINE, key word EXCIT*

*The declaration of the load is very simple, since it is enough to give the name of the load built by AFFE\_CHAR\_MECA.*

*It is necessary of course, to regulate the parameters of specific steps of time... to any mechanical study, without to forget that the problem of contact is nonlinear.*

***Important remark:***

*One cannot use piloting in a problem of contact, nor linear research.*



**Example:**

```
RESU = STAT_NON_LINE (MODELE=MO,  
CHAM_MATER=CHMAT,  
EXCIT=  
(_F (CHARGE=CHA1,  
FONC_MULT=F,)  
  
_F (CHARGE=CONTACT,)),  
  
COMP_INCR=_F (RELATION=' ELAS',  
  
TOUT=' OUI',),  
INCREMENT=_F (  
LIST_INST=L_INST,  
INST_FIN=1.5,  
SUBD_PAS=2,  
SUBD_PAS_MINI=1.E-3,)  
NEWTON=_F (MATRICE=' TANGENTE',  
REAC_ITER=1,)  
CONVERGENCE=_F (RESI_GLOB_MAXI=1.E-8,  
ITER_GLOB_MAXI=20,  
ARRET=' OUI',),  
ARCHIVAGE=_F (LIST_INST=L_INST,));
```

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## **4 Modeling**

*The taking into account of the contact intervenes as of the creation of the grid.  
One will tackle in this part the questions useful to arise at the time of the stages of modeling.  
This reflexion relates to the grid, but also the boundary conditions, the definition of surfaces of contact and the taking into account of friction.*

### **4.1 Grid**

#### **4.1.1 Smoothness of the grid**

*In the majority of the cases, it is preferable to refine the grid in the zones of contact.  
In particular in the curves, a fine grid allows a better definition of the normal.  
If the structure presents angles, a refined grid will make it possible to round them slightly.*

*Appear 4.1.1-a: Grid of an angular structure*

*On the other hand, on rigid levels, the treatment of the contact is satisfied with a coarse grid.*

*Appear 4.1.1-b: Grid of a rigid plan*

#### **4.1.2 Choice of the finite elements**

*All the finite elements are compatible with calculations of contact.  
The meshes of surfaces of contact are surface in dimension 3, linear in dimension 2. They must be defined in the grid, they are not automatically extracted from the meshes voluminal by Code\_Aster.*

*Case of quadratic meshes HEXA20 in 3D, and QUAD9 in hulls:*

*Appear 4.1.2-a: Quadratic mesh with its nodes top (X) and its nodes medium (O)*

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***In the case of the quadratic elements, Code\_Aster imposes relations kinematics between nodes mediums and the nodes tops. Multipliers of Lagrange are applied to the nodes mediums.***

***The first consequence is that the structure is more rigid.***

***Moreover, if boundary conditions (or of symmetry) are imposed on these elements, one needs them to impose on the nodes tops, but not on the nodes mediums not to create redundancies (two multipliers of Lagrange on the same node).***

***In addition, the multiplier of Lagrange imply the use of larger matrices, and can thus to harm the performances, and to pose problems of memory in the case of very large models.***

### ***4.1.3 Case of the beams***

***There is a problem specific to the beam, it does not have a single normal vector. The user must to fix the direction of the normal with key word VECT\_Y.***

***The conditions of contact will be correctly taken into account only if the contact is done according to this normal.***

***If these restrictions are incompatible with the restrictions of the problem, one can always net beam in 3D.***

### ***4.1.4 Thickness material***

***Key words DIST\_1 and DIST\_2 make it possible to simulate defects of surface which are not represented in the grid. One adds on GROUP\_MA\_1 (or MAILLE\_1) for DIST\_1 and on GROUP\_MA\_2 (or MAILLE\_2) for DIST\_2 a thickness in the direction of the normal. Thus, DIST\_1 > 0 corresponds to a larger thickness, DIST\_1 < 0 with a smaller thickness.***

## ***Appear 4.1.4-a: Use of dist\_1***

### ***Note:***

***This option replaces the grid of defects of surface, but does not simulate the addition of matter (inertia, arm of lever...).***

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***One can make use of it for the contact between hulls whose only average surface was with a grid. One can***

***also to make use of it to represent a broken surface.***

***During visualization, one does not see DIST\_1 and DIST\_2. One can then see interpenetration then that there is not ( $DIST_1 + DIST_2 < 0$ ) or not to see a contact whereas there is ( $DIST_1 + DIST_2 > 0$ ).***

***dist\_2***

***surfaces***

***of contact***

***interpenetration***

***dist\_1***

***Appear 4.1.4-b: Visualization of an interpenetration***

## **4.1.5 VECT\_Y**

*VECT\_Y, key word of AFFE\_CHAR\_MECA/CONTACT makes it possible to define a local reference mark on a surface*

*of contact. In this case, the local reference mark is built in the following way: the first V1 vector is obtained by orthogonal projection of VECT\_Y on the surface of the element considered, second V2 is obtained by vector product of V1 with the normal vector NR.*

*Is also used it to give a normal to the beams.*

*In this case, VECT\_Y is the vector, which, by vector product with the tangent vector with the beam, give the normal to be used.*

**NR**

**T**

**VECT\_Y**

*Appear 4.1.5-a: Use of VECT\_Y to define the normal in a beam*

*For other uses of VECT\_Y, one can refer to U4 documentation of AFFE\_CHAR\_MECA.*

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## **4.2**

### **normals**

*It is imperative that the meshes of contact are defined so that the normals are*

*outgoing.*

*To have outgoing normals, one uses operator MODI\_MAILLAGE, with the mots\_clef ORIE\_PEAU\_2D, ORIE\_PEAU\_3D or ORIE\_NORM\_COQUE, according to modeling [U4.23.04].*

*N*

*Appear 4.2-a: The normal must be outgoing*

*Example:*

```
MA = MODI_MAILLAGE (reuse=MA,  
MAILLAGE=MA,  
ORIE_PEAU_3D= (_F (GROUP_MA=' SURF_1'),
```

```
_F (GROUP_MA=' SURF_2'),),  
MODELE=MO,);
```

### *4.3 Pairing*

*Two methods of pairing are available: “NODAL” or “MAITRE-ESCLAVE”.*

#### *4.3.1 Method*

*“nodal”*

*Pairing is done between a node of surface slave and a main node of surface.*

*With each node slave, one pairs the main node nearest.*

*The relation of noninterpenetration uses by defect the normal with the mesh slave. Direction of approach is either the normal with the mesh Master, or a fixed arbitrary direction (VECT\_NORM\_2).*

*Normal*

*Master*

*Vect\_norm\_2*

*Master*

*Slave*

*Appear 4.3.1-a: Example of use of VECT\_NORM\_2*

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***Surface Master is that which comprises the most nodes (or if equality MAILLE\_2 or GROUP\_MA\_2).  
Indeed, it is preferable that each main node is paired only with one node slave.***

***The Councils of use:***

***It is advised to have the compatible grids and which remain compatible during calculation.***

***The method "NODAL" does not make it possible to correctly take into account great displacements.***

***One advises to use method "MAITRE-ESCLAVE".***

### 4.3.2 Method

***"maitre-slave"***

***It is the advised method of pairing.***

***It is a pairing node-facet. It is done between a node slave and a facet Master.***

***The condition of contact is that the nodes slaves should not enter the meshes Masters.***

***It is noticed that the reverse is possible.***

***The relation of noninterpenetration uses by defect the normal with the mesh Master. One can also use  
the average enters the normal to the mesh Master and the normal to the mesh slave.***

***Normal***

***Normal***

***slave***

***Master***

***Average of***

***two directions***

***Master***

***Slave***

***Appear 4.3.2-a: Example of use of the average enters the direction  
normal Master and that of the normal slave***

*Surface Master is that defined by GROUP\_MA\_1 (or MAILLE\_1), the mesh slave is that definite by GROUP\_MA\_2 (or MAILLE\_2).*

*This method of pairing can be used in great displacements.*

*Main choice of surfaces and slaves:*

*If a surface is with a grid much more finely than the other, it is better that it is the slave for to limit the interpenetration.*

*If one of surfaces is rigid, it is better that it is surface Master.*

*A surface Master can be paired on several surfaces slaves but a surface slave cannot to correspond that to only one surface Master.*

### **4.3.3 difficulties**

*For the methods FORCED and LAGRANGE, the conditions of contact are imposed by means of multipliers of Lagrange on the nodes slaves (for the methods FORCED and LAGRANGE).*

*However one can put only one multiplier of Lagrange by node and direction.*

*The immediate consequences of this remark are:*

- a point should not belong to several surfaces slaves,*
- the points of surfaces slaves should not carry conditions of Dirichlet (DDL\_IMPO, FACE\_IMPO, LIAISON\_...).*

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#### **4.3.4 Possible solutions**

*One can gather various surfaces of contact in only one. Surfaces of contact can be angular. They can also be made up of disjointed surfaces of grid.*

*surface slave*

*surface main*

*Appear 4.3.4-a: Example of angular surfaces of contact*

*One can exclude certain points from surfaces slaves. One uses for that key words SANS\_NO and SANS\_GROUP\_NO. This method is used for example to exclude from a surface slave them nodes of an edge on which one imposed a boundary condition.*

#### **4.3.5 A particular case**

*It is possible that surface slave comes into contact with a main prolongation of surface.*

*surface slave*

*surface main*

*Appear 4.3.5-a: Example of contact with the main prolongation of surface*

*There are two solutions with this problem.*

*The first consists in choosing for the widest surface Master.*

*The second consists to widen surface Master and to take into account the other sides. (see [Figure 4.3.4-a]).*

*This behavior can also disturb problems of more complicated geometry.*

### **4.4**

#### **Boundary conditions**

*It is pointed out that a node slave should not carry boundary condition (see paragraph precedent).*

*Calculation must be able to be done even when the contact is removed. In dynamics, that does not impose*

*of particular constraint. In statics, it is necessary that the structure does not hold only by the contact.*

*One will make*

*thus attention to block all the modes of rigid bodies.*

*To block a rigid mode of body, it is enough to apply to the structure a displacement imposed (no one or not) in the direction to be blocked. Another method is to block the mode of rigid body with one comes out from low stiffness which too much will not disturb the result of calculation. This solution is not*

*alleviating and it is advised to check the results of calculation by making a parametric study on stiffness of the spring.*

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## **4.5 Surfaces**

### **rigid**

*It may be that one of surfaces of the model is infinitely rigid.*

*One will even advise, in a preoccupation with a simplification of the problem, to regard as infinitely rigid any surface much more rigid than the others.*

*The modeling of a rigid surface is done by blocking its degrees of freedom with conditions kinematics.*

*One can also increase his Young modulus to place it at at least an order of magnitude at above Young moduli of other surfaces. But this last method is largely disadvised because it can introduce numerical difficulties.*

*In the case of a problem of contact, rigid surface will be preferably surface Master.*

*The plane parts of rigid surface can be modelled very coarsely. On the other hand, for a better definition of the normals, it is advised to net the curved zones finely.*

*If rigid surface is surface slave, one will not be able to deal with the problem while posing conditions kinematics....*

#### 4.5.1 Extracts of a command file comprising a rigid surface

```
...  
MODE=AFFE_MODELE (MAILLAGE=MA,  
VERIF=' MAILLE',  
AFFE= (_F (TOUT=' OUI',  
PHENOMENON = "MECHANICAL",  
MODELING = "D_PLAN"),),);  
  
MA=MODI_MAILLAGE (REUSE=MA,  
MAILLAGE=MA,  
MODELE=MODE,  
ORIE_PEAU_2D=_F (GROUP_MA= ("CONTACT", "SURFACE")),  
INFO=2);  
  
...  
CH=AFFE_CHAR_MECA (MODELE=MODE,  
DDL_IMPO= (_F (GROUP_MA = "SURFACE", DX = 0. , DY = 0. ),),  
CONTACT=_F (REAC_GEOM=' CONTROLE',  
NB_REAC_GEOM=2,  
GROUP_MA_1=' SURFACE',  
GROUP_MA_2=' CONTACT',  
METHODE=' LAGRANGIEN',  
FRICTION = "COULOMB",  
PESANTEUR= (9.8, 0. , - 1. , 0.),);
```

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```
RESU=DYNA_NON_LINE (  
MODELE=MODE,  
CHAM_MATER=CHMAT,  
EXCIT=_F (CHARGE=CH,),  
ETAT_INIT=_F (QUICKLY = VIT_0),  
COMP_INCR=_F (RELATION=' ELAS',  
DEFORMATION=' SIMO_MIEHE',  
TOUT=' OUI',),  
INCREMENT=_F (LIST_INST=L_INST,  
SUBD_PAS=4,  
SUBD_PAS_MINI=1.E-17,  
COEF_SUBD_PAS_1=1.0,),  
HHT=_F (ALPHA=-0.05),  
NEWTON=_F (REAC_ITER=1,  
MATRICE=' TANGENTE',),  
CONVERGENCE=_F (RESI_GLOB_RELA=1.E-06,  
ITER_GLOB_MAXI=25,  
ARRET=' OUI',),  
ARCHIVAGE=_F (ARCH_ETAT_INIT=' OUI',  
PAS_ARCH=100,));
```

## **4.6**

### ***friction***

*The modeling of friction in 3D is a rather delicate thing. Also, if in a study 3D it coefficient of friction is very low, it is advised to neglect frictions.*

*For a study with friction, it is advised to initially treat it without friction so to give an order of magnitude of the answer and with the aim of introduce the difficulties ones after the others.*

## **5 Calculations**

*It is strongly advised to read U4 documentations of AFFE\_CHAR\_MECA and STAT\_NON\_LINE or DYNA\_NON\_LINE.*

*The contact is treated like a load in the equation of dynamics.*

*The difficulties encountered during calculation are not obligatorily due to the contact.*

*The treatment of the contact is one of nonthe linearities of the problem. The problem can comprise others not linearities.*

### **5.1**

*Taking into account of the contact friction*

*In operator AFFE\_CHAR\_MECA, one is brought to choose the method of calculation of the contact.*

*Three methods are possible: “FORCED”, “LAGRANGE” and “PENALIZATION”.*

#### **5.1.1 “CONSTRAINT”**

*It is based on the algorithm of the active constraints (see documentations R of reference for more details).*

*It is an exact method. It uses the multipliers of lagrange. There is not interpenetration enters structures.*

*One cannot use it with friction.*

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### **5.1.2 “LAGRANGE”**

*It is an exact method.*

*It uses the multipliers of Lagrange and an algorithm equivalent to that of the method CONSTRAINT.*

*This method allows the use of friction.*

### **5.1.3 “PENALIZATION”**

*This method treats penalized friction (coefficient AND), but the contact is is penalized (coefficient IN) is treated by multiplier of lagrange. It is the user who decides (if it provides IN contact is penalized, if it does not provide it the contact is treated by multiplier of Lagrange).*

#### **5.1.3.1 Choice of the coefficients of penalization**

*The choice of the coefficients of penalization is a delicate choice. More especially as the result obtained is very dependent on this coefficient.*

*The higher the coefficient of penalization will be, the more the result will be close to the exact result. But one too high coefficient of penalization (compared to the other stiffnesses of the problem) can induce numerical problems.*

*In practice, one can start with a coefficient of the same smallest order of magnitude as Young modulus of the problem. Then, one gradually increases it (of a factor 10 for example) until the stabilization of the results.*

**Note:**

*For the coefficient IN, one can validate the result of calculation by checking that the interpenetration is not too large. One can sometimes increase it up to 107 to 108 times the smallest Young modulus.*

#### **5.1.3.2 Advantages and disadvantages**

*The penalization does not induce discontinuity of the fields speed. What can be an advantage in a calculation in dynamics.*

However it is not exact because it authorizes the interpenetration, and the results are very dependent on the coefficients of penalization.

#### **5.1.4 Remarks**

*Here a list of remarks to contribute to the choice of the method.*

*For an elastic design, active method “LAGRANGE” (or constraints if there is not friction) is faster.*

*The penalization gives results very dependent on the coefficients of penalization.*

*In the case of a calculation with penalized friction, one can check his results while testing with one another method.*

*In the case of a penalized normal contact, a checking can be the depth of interpenetration.*

*It should not be too large.*

*It is pointed out that one can use only one method for the conditions of contact of same calculation.*

*In 2D, one will rather use “LAGRANGE” or “CONSTRAINT”.*

#### **5.2 Friction**

*When friction is activated, it is necessary to provide a coefficient of Coulomb friction in all the cases.*

*In*

*3D in surface contact (meshes 2D), it is also necessary to fix the COEFFICIENT\_MATR\_FROT (see U4 documentation). And in the case of a calculation with penalization, it is necessary to give AND (see § penalization).*

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## **5.3 Interpenetration**

*At the end of calculation, one can observe an interpenetration of the structures. It can be due to several reasons.*

### **5.3.1 Calculation penalized**

*In the case of a penalized calculation, there is always interpenetration at the time of the contact, since the forces of contact become active when the play is negative. This interpenetration is weaker if the normal coefficients of penalization (IN) are higher.*

### **5.3.2 Dissymmetry Master/slave**

*One can have an interpenetration of the main nodes in surfaces slaves. For some geometries, this phenomenon can become awkward (too major interpenetration, or penetration supplements of a main relief of the mesh in a surface slave). It is enough to net them more finely surfaces slaves in the areas concerned.*

*surface slave  
surface  
Master*

*Appear 5.3.2-a: Example of interpenetration due to dissymmetry Master/slave*

### **5.3.3 Visualization**

*One will of course pay attention to the artifacts of visualization. Like one saw in the § Epaisseur material, if one uses key words DIST\_1 and DIST\_2, one can then to see interpenetration whereas there is not ( $DIST_1 + DIST_2 < 0$ ) or not to see a contact whereas there is ( $DIST_1 + DIST_2 > 0$ ).*

*During a visualization, one is brought to choose a scale factor. This factor multiplies them displacements and makes it possible the user to better observe them. In the case of a study with contact, it is necessary to put this scale factor at 1. If this factor is higher than 1, one can observe much interpenetration where there is not all.*

## **5.4**



## **calculation**

**Calculation is done with STAT\_NON\_LINE or DYNA\_NON\_LINE. It is advised to read documentations**

**U4 associated with its operators. One will be able to also refer to the documents of the Aster formation.**

**At the time to make the choices of the various options, one will not forget that the problem of contact is**

**nonlinear.**

**One will put the question to know if one works into small or in great displacements.**

**It is pointed out that the options of linear research and that of piloting are not possible with contact.**

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**5.5 Large**

**displacements**

**One considers in this paragraph, the problems in great displacements.**

**The detection of the contact is done according to the geometry of the structure and the relations of not interpenetration are based on the directions of the normals. In the event of great displacements, one thus has**

**need to work on a reactualized geometry.**

**One does not speak here about great deformations. The possibility or not of treating the great deformations**

*does not depend on the contact.*

*In addition, one will choose parameters of calculation in operator STAT\_NON\_LINE or DYNA\_NON\_LINE compatible with a calculation in great displacements.*

### **5.5.1 Seek**

*The research of pairing is done either in the direct vicinity of the node of preceding contact, or on all the structure. In the event of great displacements, one uses research on all the structure.*

### **5.5.2 Reactualization geometry**

*According to if one works into large or small displacements, one will choose a reactualization of different geometry.*

*REAC\_GEOM=' SANS'. In this case, one works on the initial geometry. One uses this choice only for studies in small displacements.*

*For great displacements, one uses one of the two other choices.*

*The choice by defect is:*

*REAC\_GEOM=' AUTO'. The reactualization of the geometry is automatic. It is done until satisfying a geometrical criterion of convergence.*

*One can also impose the iteration count with: REAC\_GEOM=' CONTROLE'. This number is specified*

*with NB\_REAC\_GEOM=n.*

*· Value 1 indicates that with convergence, one reactualizes the geometry and one passes to the step of charge according to.*

*· Value 2 indicates that to convergence, one does not pass to the step of load according to.*

*One reactualizes the geometry and one reiterates until convergence.*

*· The value  $n > 2$  indicates that one makes N cycles reactualization geometrical-iterations until convergence.*

## **5.6**

### **The dynamic case**

*The preceding remarks are valid in statics (STAT\_NON\_LINE) and dynamics (DYNA\_NON\_LINE).*

*One will draw the attention to some points particular to dynamic calculations.*

*In a problem dealt with with multipliers of Lagrange, at the time of the impact speed is discontinuous. Acceleration is thus not defined in this moment.*

*This remark can be in the beginning strong oscillations of the answer, or a strong sensitivity to diagram of calculation used and with the step of time. One strongly advises to start with the step of time which observes the condition of current (time put by the wave to cross an element) then to test several steps of smaller or larger times.*

*One can attenuate the oscillations by using a diagram which generates numerical damping.*

*In the case of a penalized calculation, it is not there a jump speed. This method east can be more correct on a mathematical level, but it generates it also oscillations of the answer to moment of the contact.*

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*6 Others*

*methods*

*In this part, one presents two other methods available in Code\_Aster to treat it contact. Their applicability is more restricted (penalized calculation and specific contact) but they have some characteristics which can be useful and which are exposed Ci below.*

*6.1*

*DYNA\_TRAN\_MODAL*

*For the use of this operator, one advises the reading of U4 documentation.*

*For postprocessing, one will read in particular U4 documentation of POST\_DYNA\_MODAL\_T.*

*6.1.1 Presentation*

*DYNA\_TRAN\_MODAL calculates a transitory dynamic response on truncated modal basis. It allows taking into account of contact-friction.*

*The use of this operator supposes that modal calculation is already made.*

*DYNA\_TRAN\_MODAL proposes several methods of calculation. The explicit methods will be used*

*(“EULER”, “DEVOGE”, “ADAPT”) to treat the contact.  
One enters the data relating to contact-friction under the key word “SHOCK”.*

### **6.1.2 Treatment of the contact**

*It is about a specific contact, penalized, in small displacements.  
One can take into account the damping of shock. (It is pointed out that the effect of this damping depends on the step of time.).  
The user potentially provides the couples of nodes in contact, as well as the coefficients of penalization (IN and AND) and of damping.*

### **6.1.3 Modeling**

#### **6.1.3.1 Thickness material**

*It corresponds to the thickness material of the loads of contact.  
It is noticed that a negative initial play is equivalent to a prestressing.*

#### **6.1.3.2 Obstacles nonwith a grid**

*It is possible to take account of not modelled rigid surfaces. They are defined by **DEFI\_OBSTACLE**. They block the displacement of a point inside a defined pre curve, or between two plans.*

*obstacle  
Structure  
defined by  
studied  
**DEFI\_OBSTACLE***

*Appear 6.1.3.2 - has: Example of use of **DEFI\_OBSTACLE***

*These surfaces are infinitely rigid, but one can affect a flexibility to them by the means of coefficients of penalization.*

*Note:*

*One can make evolve/move these obstacles during calculation according to profiles' determined with operators **POST\_USURE** and **MODI\_OBSTACLE**. On this point, it is advised to consult them U4 documentations of **POST\_USURE** and **MODI\_OBSTACLE**, to see on which types of study these calculations are applicable.*

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#### **6.1.4 The Councils of use**

*The choice of the coefficients of penalizations is in the same way made that for the penalized method of loads of contact.*

*The modal base is worked out and one keeps it in an Aster base. Much time then is gained on transitory calculations.*

*If the problem includes/understands rigid surfaces, or surfaces of contact which do not move, one can model them with **DEFI\_OBSTACLE**.*

#### **6.1.5 Postprocessing**

*The components of the results are directly accessible by **RECU\_FONCTION**.*

***DYNA\_TRAN\_MODAL** have postprocessing specific. They make it possible to make studies of impact or studies of wear. They are accessible starting from **POST\_DYNA\_MODAL\_T** and its options*

*“**IMPACT**” or “**WEAR**”. One will refer to U4 documentation of **POST\_DYNA\_MODAL\_T** for the list postprocessing included/understood in these two options.*

#### **6.1.6 Assessment**

*This method of the treatment of the contact is limited to the specific studies of contact, penalized, into small displacements.*

*Put aside nonlocal linearities envisaged by the operator (like the specific shocks), the problem must be linear, since calculation is made starting from the modal base.*

*In its field of application, it has the advantage of taking into account damping and of laying out of a rich postprocessing.*

*The truncation of the modal base makes it possible to make fast transitory calculations. One will make however*

*attention to choose the size of the base used well. In the case of a study with shock, one can be brought to go up rather high in frequency.*

*The creation of obstacles except grid can represent an important profit of size for the model.*

### **6.1.7 One example**

**TRANGENE = DYNA\_TRAN\_MODAL (**

**METHOD = "euler",**

**MASS\_GENE**

**=**

**MASSEGEN,**

**RIGI\_GENE**

**=**

**RIGIGEN,**

**EXCIT**

**=**

**(\_F (VECT\_GENE**

**=**

**FORC1,**

**FONC\_MULT**

**=**

**FONC1,)**,

**\_F (VECT\_GENE = FORC2,**

**FONC\_MULT**

**=**

**FONC2,)),**

**INCREMENT**

**=**

**\_F (INST\_INIT**

**=0.,**

**INST\_FIN**

**=**

**2.5,**

**NOT**

**=**

*4.E-5*),  
*SHOCK*  
=  
\_F (  
*GROUP\_NO\_1*  
=  
“A”,  
*GROUP\_NO\_2*  
=  
“AA”,  
*OBSTACLE*  
=  
*OBST1*,  
*NORM\_OBST*  
=  
(0.,1.,0.),

*PLAY = 0.1*,  
*RIGI\_NOR*  
=  
*1.E11*,  
*RIGI\_TAN*  
=  
*1.5E8*,  
*COULOMB*  
=  
0.6),

\_F (  
*GROUP\_NO\_1*  
=  
“B”,  
*OBSTACLE*  
=  
*OBST2*,  
*NORM\_OBST*  
=  
(0.,1.,0.),

*PLAY*  
=  
*0.05,*  
*RIGI\_NOR*  
=  
*2.E9,*  
*RIGI\_TAN*  
=  
*2.E7,*  
*COULOMB*  
=  
*0.5,)),);*  
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## ***6.2***

### ***DIS\_CONTACT***

*Elements DIS\_CONTACT make it possible to model a specific contact, penalized, into small displacements. They are discrete elements.*

*Contrary to the preceding chapter, calculation is then direct (operators STAT\_NON\_LINE or DYNA\_NON\_LINE).*

*Elements DIS\_CONTACT are generally elements with two nodes, present in grid. They connect the two points which will be potentially in contact during calculation. There is too elements with a node, for which it is necessary to affect a play in the normal direction of shock*



*(confused  
with the local axis X).*

*These elements have many characteristics which one declares in `DEFI_MATERIAU`.  
One advises the reading of Doc. U4 of `DEFI_MATERIAU` to obtain the exhaustive list of these  
parameters and their definition.*

*The interest of these elements is their great richness of behavior. One can give them laws of  
behavior particular (elastoplastic, dependent on time...).*

*Of course, for multiplying the use of these parameters, it will be necessary to raise the question of  
to know which have a relevant direction for the study.*

*In the command file according to, one uses them to calculate the contact between two beams  
modelled in 3D.*

### **6.2.1 Example of command file**

**POU1**

**POU2**

**Elements of contact**

**ACHOC 1 to 4**

**Appear 6.2.1-a: Grid of the study**

**# Construction of the grid**

```
MAIL=LIRE_MAILLAGE ();
MAIL=DEFI_GROUP (reuse =MAIL,
MAILLAGE=MAIL,
CREA_GROUP_MA=_F (NOM=' ACHOC',
UNION= ("ACHOC1", "ACHOC2", "ACHOC3", "ACHOC4",),),
CREA_GROUP_NO=_F (TOUT_GROUP_MA=' OUI',),);
```

*# beams POU1 and POU2 are in 3D, whereas the elements of shock are the discrete ones. One them  
allot characteristics thanks to operator `DEFI_MATERIAU`. In this study, one chose  
to take account of a damping (which acts that there is contact or not). One indicates also the  
coefficient of  
penalization of the shock.*

*(It is pointed out that the effect of damping depends on the step on time.)*

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***MODELE=AFFE\_MODELE (MAILLAGE=MAIL,  
AFFE= (\_F (GROUP\_MA= ("POU1", "POU2"),  
PHENOMENE=' MECANIQUE',  
MODELISATION=' 3D'),  
\_F (GROUP\_MA= ("ACHOC1", "ACHOC2", "ACHOC3", "ACHOC4"),  
PHENOMENE=' MECANIQUE',  
MODELISATION=' DIS\_T'),),),);***

***ACIER=DEFI\_MATERIAU (ELAS=\_F (E=200000000000.0,  
NU=0.3,  
RHO=7800.0),),);  
AMOR=DEFI\_MATERIAU (DIS\_CONTACT=\_F (RIGI\_NOR=1000000000.0,  
AMOR\_NOR=5.0),),);***

***CHMAT=AFFE\_MATERIAU (MAILLAGE=MAIL,  
AFFE= (\_F (GROUP\_MA=' POU1',  
MATER=ACIER),  
\_F (GROUP\_MA=' POU2',  
MATER=ACIER),  
\_F (GROUP\_MA= ("ACHOC1", "ACHOC2", "ACHOC3", "ACHOC4"),  
MATER=AMOR),),),);***

***# For the correct operation of operator DYNA\_NON\_LINE, one must indicate a matrix of stiffness  
for the discrete elements. One chooses null coefficients not to disturb the continuation of calculation.***

***CARELEM=AFFE\_CARA\_ELEM (MODELE=MODELE,  
DISCRET=\_F (GROUP\_MA= ("ACHOC1", "ACHOC2", "ACHOC3", "ACHOC4"),  
CARA=' K\_T\_D\_L',  
VALE= (0.0, 0.0, 0.0),),),);***

...

*# the elements `dis_contact` have a relation of behavior “DIS\_CHOC” which one informs in `COMP_INCR`. Whereas the beams have an elastic behavior.*

```
U0=DYNA_NON_LINE (MODELE=MODELE,  
CHAM_MATER=CHMAT,  
CARA_ELEM=CARELEM,  
EXCIT= (_F (CHARGE=CONDLIM,)),  
COMP_INCR= (_F (RELATION=' ELAS',  
DEFORMATION=' PETIT',  
GROUP_MA= (“POU1”, “POU2”),)),  
_F (RELATION=' DIS_CHOC',  
GROUP_MA= (“ACHOC1”, “ACHOC2”, “ACHOC3”, “ACHOC4”),)),  
ETAT_INIT=_F (VITE=VITINI),  
INCREMENT=_F (LIST_INST=L_INST,  
SUBD_PAS=3,  
SUBD_PAS_MINI=1e-08),  
NEWMARK=_F (ALPHA=0.25,  
DELTA=0.5),  
NEWTON=_F (MATRICE=' TANGENTE',  
REAC_ITER=1),  
SOLVEUR=_F (METHODE=' MULT_FRONT'),  
CONVERGENCE=_F (RESI_GLOB_RELA=1e-05,  
ITER_GLOB_MAXI=60,  
ARRET=' OUI'),  
ARCHIVAGE=_F (LIST_INST=L_ARCH,));
```

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***Note of use of model THM***

***Summary:***

*One details the procedure to be followed here for the realization of a calculation THM.*

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***First of all, it is advisable to define the quite precise framework of calculations Thermo-Hydro-Mechanics.***

***Those have as an exclusive application the study of the porous environments. Knowing that, modelings THM***

***cover L`evolution mechanical of these mediums and the flows in their centre. The latter concern one or two fluids and is governed by the laws of Darcy (fluid darcéens). The problem of complete THM***

***draft thus of the flow of or the fluid (S), the mechanics of the skeleton, as well as thermics: the resolution is entirely coupled (and not chained).***

**1.2 General**

***Calculations are based on families of laws of behavior THM for the saturated porous environments and unsaturated. The mechanics of the porous environments gathers a very exhaustive collection of physical phenomena concerning with the solids and the fluids. It makes the assumption of a coupling enters***

***mechanical evolutions of the solids and the fluids, seen like continuous mediums, with hydraulic evolutions, which regulate the problems of diffusion of fluids within walls or of volumes, and thermal evolutions. The formulation of modeling Thermo-hydro-mechanics (THM) in porous environment such as it is made in Code\_Aster is detailed in [R7.01.11] and [R7.01.10]. All the notations employed here thus refer to it. One recalls however some essential notations thereafter:***

***Concerning the fluids, one considers (the most complete case) two phases (liquid and gas) and two components called by convenience water and air. The following indices then are used:***

***W for liquid water***

***AD for the dissolved air***

***have for the dry air***

***vp for the steam***

***The thermodynamic variables are:***

***· pressures of the components: pw (,***

***X T), pad (,***

$X T$ ),  $pvp$  (  
 $X T$ ),  $not$  (  
 $X T$ ),  
 · the temperature of the medium  $T$  ( $X$ ,  $T$ ).

These various variables are not completely independent. Indeed, if only one is considered component, thermodynamic balance between its phases imposes a relation between the pressure of vapor and pressure of the liquid of this component. Finally, there is only one pressure independent by component, just as there is only one conservation equation of the mass. The number of independent pressures is thus equal to the number of independent components. choice of these pressures varies according to laws' of behaviors.

For the case known as saturated (only one component air or water) we chose the pressure of this single component.

For the case says unsaturated (presence of air and water), we chose like variables independent:

· total pressure of the gas  $p$

,

$X T = p + p$ ,

$gz$  (  
 $) vp$  have

· capillary pressure  $p$

,

$X T = p - p = p - p - p$

$C$  (  
 $) gz$

$lq$

$gz$

$W$

$AD$ .

We will see the Aster terminology thereafter for these variables.

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## **1.3**

### ***Stages of calculations***

*For the stages necessary to the manufacture of a calculation Aster, independently of the aspects purely THM, one will refer to the documentation of each order used.*

*In the whole of this document one will refer to a typical example of file of calculation given in appendix. In any calculation Aster, several key stages must be carried out:*

- Choix of modeling*
- Données materials*
- Initialisation*
- Calcul*
- Post-traitement*

## **2**

### ***Various stages of calculation***

#### **2.1**

##### ***Choice of the model***

*The choice is done by the use of order AFFE\_MODELE as in the example below:*

```
MODELE=AFFE_MODELE (MAILLAGE=MAIL,  
AFFE=_F (TOUT=' OUI',  
PHENOMENE=' MECANIQUE',  
MODELISATION=' AXIS_THH2MD',),,);
```

*The digital processing in THM requires a quadratic grid since the elements are of type P2 in displacement and P1 in pressure and temperature in order to avoid problems of oscillations. The “MECHANICAL” phenomenon is obligatory whatever the selected type of modeling (with or without mechanics).*

*The user must inform here in an obligatory way the key word MODELING. This key word allows to define the type of affected element in a type of mesh. Modelings available in THM are them following:*

## **MODELING Modeling**

### **Phenomena taken into account**

#### **geometrical**

*D\_PLAN\_HM*

*plane*

*Mechanics, hydraulics with an unknown pressure*

*D\_PLAN\_HMD*

*plane*

*Mechanics, hydraulics with an unknown pressure (lumpé)*

*D\_PLAN\_HHM*

*plane*

*Mechanics, hydraulics with two unknown pressures*

*D\_PLAN\_HHMD*

*plane*

*Mechanics, hydraulics with two unknown pressures*

*(lumpé)*

*Plane D\_PLAN\_HH2MD*

*Mechanics, hydraulics with two unknown pressures and*

*two components per phase (lumpé)*

*D\_PLAN\_THH*

*plane*

*Thermics, hydraulics with two unknown pressures*

*D\_PLAN\_THHD*

*plane*

*Thermics, hydraulics with two unknown pressures*

*(lumpé)*

*Plane D\_PLAN\_THH2D*

*Thermics, hydraulics with two unknown pressures and two*

*components by phase (lumpé)*

*D\_PLAN\_THM*

*plane*

*Thermics, mechanics, hydraulics with a pressure*

*unknown factor*

*D\_PLAN\_THVD*

*plane*

*Thermics, mechanics, hydraulics with two pressures*

*unknown factors (2 phases: liquid water and vapor) (lumpé)*

*D\_PLAN\_THMD*

*plane*

*Thermics, mechanics, hydraulics with a pressure*

*unknown factor (lumpé)*

*D\_PLAN\_THHM*

*plane*

*Thermics, mechanics, hydraulics with two pressures*

*unknown factors*

*Plane D\_PLAN\_THHMD*

*Thermics, mechanics, hydraulics with two pressures*

*unknown factors (lumpé)*

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*Plane D\_PLAN\_THH2MD*

*Thermics, mechanics, hydraulics with two pressures*

*unknown factors and two components per phase (lumpé)*

*AXIS\_HM*

*axisymmetric Mechanics,*

*hydraulics with an unknown pressure*

*AXIS\_HMD*

*axisymmetric Mechanics,*

*hydraulics*

*with an unknown pressure (lumpé)*

*AXIS\_HHM*

*axisymmetric Mechanics,*

*hydraulics with two unknown pressures*

*AXIS\_HHMD*

*axisymmetric Mechanics,*

*hydraulics with two unknown pressures*

*(lumpé)*

**AXIS\_HH2MD**

*axisymmetric Mechanics,  
hydraulics  
with two unknown pressures and  
two components per phase (lumpé)*

**AXIS\_THH**

*axisymmetric Thermics,  
hydraulics  
with two unknown pressures*

**AXIS\_THHD**

*axisymmetric Thermics,  
hydraulics with two unknown pressures  
(lumpé)*

**AXIS\_THH2D**

*axisymmetric  
Thermics, hydraulics with two unknown pressures and two  
components by phase (lumpé)*

**AXIS\_THM**

*axisymmetric Thermics,  
mechanics, hydraulics with a pressure  
unknown factor*

**AXIS\_THMD**

*axisymmetric Thermics,  
mechanics, hydraulics with a pressure  
unknown factor (lumpé)*

**AXIS\_THVD**

*axisymmetric Thermics,  
mechanics,  
hydraulics with two pressures  
unknown factors (2 phases: liquid water and vapor) (lumpé)*

**AXIS\_THHM**

*axisymmetric Thermics,  
mechanics,  
hydraulics with two pressures  
unknown factors*

**AXIS\_THHMD**

*axisymmetric Thermics,  
mechanics,  
hydraulics with two pressures  
unknown factors (lumpé)*

**AXIS\_THH2MD**

*axisymmetric Thermics,  
mechanics,*

*hydraulics with two pressures*

*unknown factors and two components per phase (lumpé)*

*3D\_HM*

*3D*

*Mechanics, hydraulics with an unknown pressure*

*3D\_HMD*

*3D*

*Mechanics, hydraulics with an unknown pressure (lumpé)*

*3D\_HHM*

*3D*

*Mechanics, hydraulics with two unknown pressures*

*3D\_HHMD*

*3D*

*Mechanics, hydraulics with two unknown pressures*

*(lumpé)*

*3D\_HH2MD*

*3D*

*Mechanics, hydraulics with two unknown pressures and  
two components per phase (lumpé)*

*3D\_THH*

*3D*

*Thermics, hydraulics with two unknown pressures*

*3D\_THHD*

*3D*

*Thermics, hydraulics with two unknown pressures*

*(lumpé)*

*3D\_THH2D*

*3D*

*Thermics, hydraulics with two unknown pressures and two  
components by phase (lumpé)*

*3D\_THM*

*3D*

*Thermics, mechanics, hydraulics with a pressure  
unknown factor*

*3D\_THMD*

*3D*

*Thermics, mechanics, hydraulics with a pressure  
unknown factor (lumpé)*

*3D\_THVD*

*3D*

*Thermics, mechanics, hydraulics with two pressures  
unknown factors (2 phases: liquid water and vapor) (lumpé)*

*3D\_THHM*

*3D  
Thermics, mechanics, hydraulics with two pressures  
unknown factors*

*3D\_THHMD*

*3D  
Thermics, mechanics, hydraulics with two pressures  
unknown factors (lumpé)*

*3D\_THH2MD*

*3D  
Thermics, mechanics, hydraulics with two pressures  
unknown factors and two components per phase (lumpé)*

*The principal unknown factors which are also the values of the degrees of freedom, are noted in the case of the most complete modeling (thermal, mechanical, hydraulic 3D with two pressures unknown factors).*

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*ux*

*uy*



*U*  
*{U} ddl Z*

=  
*ddl*  
*PRE1*

*ddl*  
*PRE 2*

*ddl*

*T*

*The contents of PRE1 and PRE2 depend on the selected coupling and will be clarified in section 2.2.3. According to modeling chosen, only some of these degrees of freedom exist. The table above summarize the degrees of freedom used for each modeling*

### ***MODELING***

*U*  
*U*  
*U*  
*ddl*  
*X*  
*y*  
*Z*  
*l*  
*PRE*

*ddl*  
*PRE2*  
*ddl*  
*T*

*D\_PLAN\_HM*  
*X X X*  
*D\_PLAN\_HMD*  
*X X X*  
*D\_PLAN\_HHM*  
*X X X X*  
*D\_PLAN\_HHMD*  
*X X X X*

*D\_PLAN\_HH2MD*

*X X X X*

*D\_PLAN\_THH*

*X*

*X*

*X*

*D\_PLAN\_THHD*

*X*

*X*

*X*

*D\_PLAN\_THH2D*

*X*

*X*

*X*

*D\_PLAN\_THM*

*X X X X*

*D\_PLAN\_THMD*

*X X X X*

*D\_PLAN\_THVD*

*X*

*X*

*X*

*D\_PLAN\_THHM*

*X X X X X*

*D\_PLAN\_THHMD*

*X X X X X*

*D\_PLAN\_THH2MD*

*X X X X X*

*AXIS\_HM*

*X X X*

*AXIS\_HMD*

*X X X*

*AXIS\_HHM*

*X X X X*

*AXIS\_HHMD*

*X X X X*

*AXIS\_HH2MD*

*X X X X*

*AXIS\_THH*

*X*

*X*

X  
AXIS\_THHD  
X  
X  
X  
AXIS\_THH2D  
X  
X  
X  
AXIS\_THM  
X X X X  
AXIS\_THMD  
X X X X  
AXIS\_THVD

X  
X  
X  
AXIS\_THHM  
X X X X X  
AXIS\_THHMD  
X X X X X  
AXIS\_THH2MD  
X X X X X  
3D\_HM  
X X X X  
3D\_HMD  
X X X X  
3D\_HHM  
X X X X X  
3D\_HHMD  
X X X X X  
3D\_HH2MD  
X X X X X  
3D\_THH  
X  
X  
X  
3D\_THHD  
X  
X  
X

*3D\_THH2D*

*X*

*X*

*X*

*3D\_THM*

*X X X X X*

*3D\_THMD*

*X X X X X*

*3D\_THVD*

*X*

*X*

*X*

*3D\_THHM*

*X X X X X X*

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***MODELING***

*U*

*U*

*U*

*ddl*

*X*

*y*

Z  
1  
PRE

ddl  
PRE2  
ddl  
T

3D\_THHMD  
X X X X X X  
3D\_THH2MD  
X X X X X X

*The generalized constraints and the variables intern all are indicated in [Annexe 1].  
notations used are those defined in [R7.01.11].*

***Notice concerning the digital processing (key word ending in D):***

*Modelings ending in the letter D indicate that one makes an allowing treatment of diagonaliser (“lumper”) the matrix of mass in order to avoid the oscillations. For that them points of integration are taken at the tops of the elements. One advises highly with the user systematically to choose this type of modeling.*

**2.2**

***Definition of material***

*The material is defined by order DEFI\_MATERIAU as in the example below:*

MATERBO=DEFI\_MATERIAU (ELAS=\_F (E=5.15000000E8,  
NU=0.20,  
RHO=2670.0,  
ALPHA=0.),  
COMP\_THM = “LIQU\_AD\_GAZ\_VAPE”,  
THM\_LIQU=\_F (RHO=1000.0,  
UN\_SUR\_K=0.,  
ALPHA=0.,  
CP=0.0,  
VISC=VISCOLIQ,  
D\_VISC\_TEMP=DVISCOL,),  
THM\_GAZ=\_F (MASS\_MOL=0.01,  
CP=0.0,  
VISC=VISCOGAZ,  
D\_VISC\_TEMP=ZERO,)),

```
THM_VAPE_GAZ=_F (MASS_MOL=0.01,  
CP=0.0,  
VISC=VISCOGAZ,  
D_VISC_TEMP=ZERO,),  
THM_AIR DISS=_F (  
CP=0.0,  
COEF_HENRY=HENRY  
),  
THM_INIT=_F (TEMP=300.0,  
PRE1=0.0,  
PRE2=1.E5,  
PORO=1.,  
PRES_VAPE=1000.0,  
DEGR_SATU=0.4,),  
THM_DIFFU=_F (R_GAZ=8.32,  
RHO=2200.0,  
CP=1000.0,  
BIOT_COEF=1.0,  
SATU_PRES=SATUBO,  
D_SATU_PRES=DSATBO,  
PESA_X=0.0,  
PESA_Y=0.0,  
PESA_Z=0.0,  
PERM_IN=KINTBO,  
PERM_LIQU=UNDEMI,  
D_PERM_LIQU_SATU=ZERO,  
PERM_GAZ=UNDEMI,  
D_PERM_SATU_GAZ=ZERO,  
D_PERM_PRES_GAZ=ZERO,  
FICKV_T=ZERO,  
FICKA_T=FICK,  
LAMB_T=ZERO,  
),);
```

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### ***2.2.1 Key word factor ELAS***

***Definition of the constant linear elastic characteristics or functions of the parameter “TEMP”.***

***E***

***Young modulus. It is checked that  $E \geq 0$ .***

***NAKED***

***Poisson's ratio. That  $-1 \leq \nu \leq 0.5$  are checked.***

***ALPHA***

***Isotropic thermal dilation coefficient of the grains.***

### ***2.2.2 Single-ended spanner word COMP\_THM***

***Allows to select as of the definition of material the mixing rate THM. The possible laws are***

***COMP\_THM = /LIQU\_SATU `,***

***/LIQU\_GAZ `,***

***/GAS `,***

***/LIQU\_GAZ\_ATM `,***

***/LIQU\_VAPE\_GAZ `,***

***/LIQU\_AD\_GAZ\_VAPE `,***

***/LIQU\_VAPE `,***

***/"GAS"***

*Law of reaction of a perfect gas i.e. checking the relation  $P = RT/Mv$  where  $P$  is pressure,  $Mv$  molar mass,  $R$  the constant of perfect gases and  $T$  temperature (cf [R7.01.11] for more details). For an only saturated medium. Data necessary of the field material are provided in operator **DEFI\_MATERIAU**, under the word key **THM\_GAZ**.*

*/“LIQU\_SATU”*

*Law of behavior for porous environments saturated by only one liquid (cf [R7.01.11] for more details). The data necessary of the field material are provided in the operator **DEFI\_MATERIAU**, under key word **THM\_LIQ**.*

*/“LIQU\_GAZ\_ATM”*

*Law of behavior for a porous environment unsaturated with a liquid and gas with pressure atmospheric (cf [R7.01.11] for more details). Data necessary of the field material are provided in operator **DEFI\_MATERIAU**, under key words **THM\_LIQ** and **THM\_GAZ**.*

*/“LIQU\_VAPE\_GAZ”*

*Law of behavior for a porous environment unsaturated water/vapor/dry air with change with phase (cf [R7.01.11] for more details). The data necessary of the field material are provided in operator **DEFI\_MATERIAU**, under key words **THM\_LIQ**, **THM\_VAPE** and **THM\_GAZ**.*

*/“LIQU\_AD\_GAZ\_VAPE”*

*Law of behavior for a porous environment unsaturated water/vapor/dry air/air dissolved with phase shift (cf [R7.01.11] for more details). Data necessary of the field material are provided in operator **DEFI\_MATERIAU**, under key words **THM\_LIQ**, **THM\_VAPE**, **THM\_GAZ** and **THM\_AIR DISS**.*

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**/“LIQU\_VAPE”**

**Law of behavior for porous environments saturated by a component present in liquid form or vapor. with phase shift (cf [R7.01.11] for more details). Data necessary of the field material are provided in operator DEFI\_MATERIAU, under the words keys THM\_LIQ and THM\_VAPE. This law is valid only for modelings of the type THVD.**

**/“LIQU\_GAZ”**

**Law of behavior for a porous environment unsaturated liquid/gas without phase shift (Cf [R7.01.11] for more details). The data necessary of the field material are provided in operator DEFI\_MATERIAU, under key words THM\_LIQ and THM\_GAZ.**

**The table below specifies the obligatory key words for under following orders in function of the selected mixing rate.**

**Legends:**

**O: Obligatory key word**

**T: Obligatory key word in Thermics**

**: Useless key word for this type of mixing rate**

**LIQU\_SATU**

**LIQU\_GAZ**

**GAS**

**LIQU\_GAZ\_AT**

**LIQU\_VAPE\_GAZ LIQU\_AD\_GAZ\_VAPE LIQU\_VAPE**

**M**

**THM\_INIT**

**O**

**O**

**O**

**O**

**O**

*O*

*O*

*PRE1 O*

*O*

*O*

*O*

*O*

*O*

*O*

*PRE2*

*O*

*O*

*O*

*PORO O*

*O*

*O*

*O*

*O*

*O*

*O*

*TEMP T*

*O*

*O*

*T*

*O*

*O*

*O*

*PRES\_VAPE*

*O*

*O*

*O*

*THM\_DIFFU*

*O*

*O*

*O*

*O*

*O*  
*O*  
*O*  
*R\_GAZ*  
  
*O*  
*O*  
  
*O*  
*O*  
*O*  
*RHO O*  
*O*  
*O*  
*O*  
*O*  
*O*  
*O*  
*O*  
*BIOT\_COEF O*  
*O*  
*O*  
*O O*  
*O O*  
*PESA\_X O*  
*O*  
*O*  
*O*  
*O O*  
*O*  
*PESA\_Y O*  
*O*  
*O*  
*O*  
*O O*  
*O*  
*PESA\_Z O*  
*O*  
*O*  
*O*  
*O O*  
*O*  
*SATU\_PRES*  
  
*O*

*I*  
*O*  
*O*  
*O*  
*O*  
*O*  
*D\_SATU\_PRES*

*O*  
*I*  
*O*  
*O*  
*O*  
*O*  
*O*  
*PERM\_LIQU*

*I*  
*O*  
*I*  
*O*  
*O*  
*O*  
*O*  
*O*  
*D\_PERM\_LIQU\_SATU*

*O*  
  
*O*  
*O*  
*O*  
*O*  
*O*  
*PERM\_GAZ*

*O*  
  
  
  
*O*  
*O*  
*O*  
*D\_PERM\_SATU\_GAZ*

*O*

*O*  
*O*  
*O*

*D\_PERM\_PRES\_GAZ*

*O*

*O*

*O*

*O*

*FICKV\_T*

*O*

*O*

*FICKV\_PV*

*FICKV\_PG*

*FICKV\_S*

*D\_FV\_T*

*D\_FV\_PG*

*FICKA\_T*

*O*

*FICKA\_PA*

*FICKA\_PL*

*FICKA\_S*

*D\_FA\_T*

*CP T*

*T*

*T*

*T*

*T*

*T*

*T*

*PERM\_IN/PERM\_END O*

*O O*

*O*

*O*

*O*

*O*

*LAMB\_T T*

*T*

*T*

*T*

*T T*

*T*

*LAMB\_S*

*LAMB\_PHI*

*LAMB\_CT*

*D\_LB\_T*

*D\_LB\_S*

*D\_LB\_PHI*

*THM\_LIQU*

*O*

*O*

*O*

*O*

*O*

*O*

*RHO O*

*O*

*O*

*O*

*O*

*O*

*UN\_SUR\_K O*

*O*

*O O*

*O O*

*VISC O*

*O*

*O*

*O*  
*O*  
*O*

*D\_VISC\_TEMP O*  
*O*

*O*  
*O*  
*O*  
*O*

*ALPHA T*  
*T*

*T*  
*T*  
*T*  
*T*

*CP T*  
*T*

*T*  
*T*  
*T*  
*T*

*THM\_GAZ*

*O*  
*O*  
*O*  
*O*  
*O*

*MASS\_MOL*

*O*  
*O*  
*O O O*

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***VISC***

***O***

***O***

***O***

***O***

***O***

***D\_VISC\_TEMP***

***O***

***O***

***O O***

***O***

***CP***

***T***

***T***

***T***

***T***

***T***

***THM\_VAPE\_GAZ***

***O***

***O***

***O***

***MASS\_MOL***

***O O O***

***CP***

*O*  
*O*  
*O*  
*VISC*

*O*  
*O*  
*O*  
*D\_VISC\_TEMP*

*O*  
*O*  
*O*  
*THM\_AIR\_DISS*

*O*  
*CP*

*O*  
*COEF\_HENRY*

*O*

### ***2.2.3 Key word factor THM\_INIT***

***For all the behaviors Thermo-Hydro-Mechanics, it makes it possible to describe a state of reference of***

*the structure (cf [R7.01.11] and [R7.01.14]). Its syntax is as follows:*

***THM\_INIT = \_F (***

***TEMP =***

***temp***

***,***

***[R]***

***PRE1***

***=***

***pre1***

***,***

***[R]***

***PRE2 =***

***pre2***

***,***

***[R]***

***PORO =***

***poro***

***,***

***[R]***

***PRES\_VAPE =***

***pvap***

***, [R]***

***)***

*For including/understanding these data well, it is necessary to distinguish the unknown factors with the nodes, which we call*

***{ }***

*U ddl and the values defined under key word THM\_INIT which we call pref and T ref.*

*ux*

*uy*

*{U}*

*U*

*ddl*

*Z*

*=*

*ddl*

*PRE1*

*ddl*

*PRE 2*

*ddl*

*T*

*The significance of unknown factors PRE1 and PRE2 varies according to the models. By noting pw pressure*

*of water, pad pressure of dissolved air, plq pressure of liquid  $p = p + p$ ,  $p$ ,  $p$  pressure*

*lq*

*W*

*AD*

*have*

*vp*

*of vapor,  $p$  pressure of dry air and  $p = p + p$  total pressure of gas and  $p = p - p$*

*have*

*G*

*have*

*vp*

*C*

*G*

*lq*

*capillary pressure (also called suction), one has the following significances of unknown factors PRE1*

*and*  
*PRE2*

*Behavior LIQU\_SATU LIQU\_GAZ\_ATM GAS LIQU\_VAPE\_GAZ*  
*KIT*

*PRE1*

*p*  
*- p*  
*p*  
*p = p - p*  
*lq*  
*lq*  
*G*  
*C*  
*G*  
*lq*  
*PRE2*

*pg*

*Behavior LIQU\_GAZ LIQU\_VAPE*  
*LIQU\_AD\_GAZ\_VAPE*  
*KIT*

*PRE1*

*p = p - p p*  
*p = p - p*  
*C*  
*G*  
*lq*  
*lq*  
*C*  
*G*  
*lq*  
*PRE2*

*pg*

*pg*  
*Table 2.2.3-1: contents of PRE1 and PRE2*

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One will be able to refer to [§ 3.3.2.3] of the documentation of order STAT\_NON\_LINE [U4.51.03].

**One then defines the “total” pressures and the temperature by:**

$P$   
 $pddl$   
 $pref$   
;  
 $T$   
 $Tddl$   $Tref$   
=  
+  
=  
+

**All the values in entry or exit (boundary conditions or result of IMPR\_RESU) are nodal unknown factors  $ddl$**

$ddl$

$P$

and  $T$

.

**On the other hand in fact the pressures and the total air temperature are used in the laws of**

$P$

$R$

*D*

*dp*

***behavior***

*T*

*L*

*L*

=

***for perfect gases,***

=

***- 3 dT for the liquid and in***

*M*

*K*

*L*

*L*

*L*

***relation capillary saturation/pressure.***

*Let us note that the nodal values can be initialized by key word ETAT\_INIT of the order STAT\_NON\_LINE (cf 2.3).*

*The user must be very careful in the definition of the values of THM\_INIT: indeed, the definition of several materials with values different from the quantities defined under THM\_INIT leads to discontinuous values initial of the pressure and the temperature, which is not in fact not compatible with the general treatment which is made of these quantities. We thus advise with the user following step:*

- if there is initially a uniform field of pressure or temperature, one informs it directly by key word THM\_INIT,*
- if there is a nonuniform field, one defines for example a reference by the key word THM\_INIT of order DEFI\_MATERIAU, and the initial values compared to this reference by key word ETAT\_INIT of order STAT\_NON\_LINE (cf 2.3).*

***TEMP***

*Temperature of reference ref.*

*T*

.

***The value of the temperature of reference entered behind key word TEMP\_REF of order AFFE\_MATERIAU is ignored.***

***PRE1***

*As seen in table 1:*

*For the behaviors: LIQU\_SATU, and LIQU\_VAPE pressure of liquid of reference.*

*For the behavior: GAS pressure of standard gas.*

*For the behavior: LIQU\_GAZ\_ATM pressure of liquid of changed reference of sign.*

*For the behaviors: LIQU\_VAPE\_GAZ, LIQU\_AD\_GAZ\_VAPE and LIQU\_GAZ pressure capillary of reference.*

*PRE2*

*For the behaviors: LIQU\_VAPE\_GAZ, LIQU\_AD\_GAZ\_VAPE and LIQU\_GAZ and pressure of standard gas.*

***Important remark:***

*One never should take a value of PRE2 equal to zero under penalty of problems numerical.*

*PORO*

*Initial porosity.*

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*PRES\_VAPE*

*Initial steam pressure for the behaviors: LIQU\_VAPE\_GAZ, LIQU\_AD\_GAZ\_VAPE, LIQU\_VAPE and LIQU\_GAZ.*



**Note:**

*The initial vapor pressure must be taken in coherence with the other data. Very often, one leaves the knowledge of an initial state of hygroscoy. The degree hygrometrical is the relationship between the steam pressure and the steam pressure saturating at the temperature considered. One then uses the law of Kelvin which gives pressure of the liquid according to the steam pressure, of the temperature and of*

*0**p**p**R**p**W -**saturating steam pressure:**W =**T ln**vp**ol**sat**. This relation is not**M**W**vp**p (T)**vp*

*valid that for isothermal evolutions. For evolutions with variation of temperature, knowing a law giving the steam pressure saturating to*

*0**T -**5**.**273**2**+**7858**.**sat*

31 559

.  
+ 1354

.  
(OT-  
)

temperature  $T$ , for example:

$p(T)$  10  
, and a degree

$vp$

0

=

5

.  
273

0

from hygroscopy  $HR$ , one deduces from it the steam pressure thanks to  $p(T) = HR \text{ psat}(T)$ .

$vp$

0

$vp$

0

Moreover, one never should take a value of  $PRES\_VAPE$  equalizes to zero.

#### 2.2.4 Key word factor $THM\_LIQU$

**This key word relates to all behaviors  $THM$  utilizing a liquid (cf [R7.01.11]). Its syntax is as follows:**

**$THM\_LIQU = \_F ($**

**$RHO$**

=

**$\rho$**

,

**[R]**

***UN\_SUR\_K***

=

***usk***

,

***[R]***

***ALPHA***

=

***alp***

,

***[R]***

***CP***

=

***CP,***

***[R]***

***VISC =***

***VI,***

***[function***

***\*\*]***

***D\_VISC\_TEMP =***

***dvi***

***, [function***

***\*\*]***

)

***RHO***

***Density of the liquid for the pressure defined under key word PRE1 of the key word factor***

**THM\_INIT.**

**UN\_SUR\_K**

**Opposite of the compressibility of the liquid:  $K_L$ .**

**ALPHA**

**Dilation coefficient of the liquid  $L$**

**If  $p_l$  indicates the pressure of the liquid,  $L$  its density and  $T$  the temperature, it**

**$D$**

**$dp$**

**behavior of the liquid is:**

**$L$**

**$L$**

**=**

**$- 3 dT$**

**$K$**

**$L$**

**$L$**

**$L$**

**CP**

**Specific heat with constant pressure of the liquid.**

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**VISC**

**[function \*\*]**

**Viscosity of the liquid. Function of the temperature.**

**D\_VISC\_TEMP**

**[function \*\*]**

**Derived from the viscosity of the liquid compared to the temperature. Function of the temperature. The user must ensure coherence with the function associated with VISC.**

**2.2.5 Key word factor THM\_GAZ**

**This key word factor relates to all behaviors THM utilizing a gas (cf [R7.01.11]). For the behaviors utilizing at the same time a liquid and a gas, and when one takes into account the evaporation of the liquid, the coefficients indicated here relate to dry gas. Properties of vapor are indicated under key word THM\_VAPE\_GAZ. Its syntax is as follows:**

**THM\_GAZ = \_F (**

**MASS\_MOL**

**=**

**Mgs**

**,**

**[R]**

**CP**

**=**

**CP,**

**[R]**

**VISC =**

**VI,**

**[function**

**\*\*]**

***D\_VISC\_TEMP =***  
***dvi***  
,  
***[function***  
***\*\*]***

)

***MASS\_MOL***

***Mass molar dry gas. M gs***

***If pgs indicates the pressure of dry gas, gs its density, R the constant of gases***

***pgs***

***RT***

***perfect and T the temperature, the reaction of dry gas is: =***

***M***

***gs***

***gs***

***CP***

***Specific heat with constant pressure of dry gas.***

***VISC***

***[function \*\*]***

***Viscosity of dry gas. Function of the temperature.***

***D\_VISC\_TEMP***

***[function \*\*]***

***Derived compared to the temperature from viscosity from dry gas. Function of the temperature.***

***The user must ensure coherence with the function associated with VISC.***

***2.2.6 Key word factor THM\_VAPE\_GAZ***

*This key word factor relates to all behaviors THM utilizing at the same time a liquid and one gas, and fascinating of account the evaporation of the liquid (cf [R7.01.11]). Coefficients indicated here relate to the vapor. Syntax is as follows:*

*THM\_VAPE\_GAZ = \_F*

*(*

*MASS\_MOL =*

*m*

*,*

*[R]*

*CP*

*=*

*CP,*

*[R]*

*VISC =*

*VI,*

*[function*

*\*\*]*

*D\_VISC\_TEMP =*

*dvi*

*, [function*

*\*\*]*

*)*

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**MASS\_MOL**

**Mass molar vapor. Mvp**

**CP**

**Specific heat with constant pressure of the vapor.**

**VISC**

**[function \*\*]**

**Viscosity of the vapor. Function of the temperature.**

**D\_VISC\_TEMP**

**[function \*\*]**

**Derived compared to the temperature from viscosity from the vapor. Function of the temperature. The user must ensure coherence with the function associated with VISC.**

**2.2.7 Key word factor THM\_AIR\_DISS**

**This key word factor relates to fascinating behavior THM THM\_AD\_GAZ\_VAPE of account dissolution of the air in the liquid (cf [R7.01.11]). The coefficients indicated here relate to the air dissolved. Syntax is as follows:**

**THM\_AD\_GAZ\_VAPE = \_F (**



**CP**

=

**CP,**

**[R]**

**COEF\_HENRY**

= **KH**

,

**[function \*\*]**

)

**CP**

*Specific heat with constant pressure of the dissolved air.*

**COEF\_HENRY**

*Constant of Henry K, allowing to connect the molar concentration of dissolved air*

**H**

**ol**

*C (moles/m<sup>3</sup>) with the pressure of dry air:*

**AD**

**p**

**ol**

**have**

**C =**

**AD**

**K H**

**Note:**

*The constant of Henry that we use here expresses in Pa.m<sup>3</sup>.mol<sup>-1</sup>. In the literature it exist various manners of writing the law of Henry. For example in the formulation of the book loads of the platform Alliances [bib2]. The law of Henry is given*

*ol*

*P M*

*by A*

*have*

*have*

=

*with the concentration of air in water that have it can bring back to one*

*L*

*W*

*H M W*

*density such as A*

*=. H is a coefficient which is expressed out of Pa. It will be necessary in*

*L*

*AD*

*M*

*these cases to write equivalence*

*W*

*K = H*

*H*

*W*

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*2.2.8 Key word factor THM\_DIFFU*

**Obligatory for all behaviors THM (cf [R7.01.11]). The user must ensure himself of coherence of the functions and their derivative. Syntax is as follows:**

**THM\_DIFFU = \_F**

(

**R\_GAZ**

=

**rgaz**

,

**[R]**

**RHO**

=

**rho**

,

**[R]**

**CP**

=

**CP,**

**[R]**

**BIOT\_COEF**

=

**bio**

,

**[R]**

**SATU\_PRE**

=

**sp,**

**[function]**

**D\_SATU\_PRE =**

**dsp**

,

**[function]**

**PESA\_X**

=

**px,**

**[R]**

**PESA\_Y**

=

**py,**

**[R]**

**PESA\_Z**

=

**pz,**

**[R]**

**PERM\_IN =**

**perm**

,

**[function]**

**PERM\_LIQU**

=

**perml,**

**[function]**

**D\_PERM\_LIQU\_SATU**

=

**dperm,**

**[function]**

**PERM\_GAZ**

=

**permg,**

**[function]**

**D\_PERM\_SATU\_GAZ**

=  
*dpsg*  
,

*D\_PERM\_PRES\_GAZ*  
=  
*dppg*  
,

*FICKV\_T* =  
*fv*  
,

*FICKV\_PV* =/  
*fv**pv*, [function]

/  
*1*  
,

[DEFECT]  
*FICKV\_PG* =/*fv**pg*, [function]

/

1

,

[DEFECT]

FICKV\_S =/fvs

,

[function]

/

1

,

[DEFECT]

D\_FV\_T

=

/

dfvt,

[function]

/

0

,

[DEFECT]

*D\_FV\_PG =/dfvgp, [function]*

*/*  
*0*

*,*

*[DEFECT]*

*FICKA\_T =*  
*conceited person*

*,*  
*[function]*

*FICKA\_PA =/fapv, [function]*

*/*  
*1*

*,*

*[DEFECT]*

*FICKA\_PL =/fapg, [function]*

/

1

,

*[DEFECT]*

*FICKA\_S =/fas*

,

*[function]*

/

1

,

*[DEFECT]*

*D\_FA\_T*

=

/

*dfat,*

*[function]*

/



0

,

[DEFECT]

LAMB\_T

=

/

lambt

,

[function]

/

0

[DEFECT]

LAMB\_S

=

/

lambs

,

[function]

/

1

,

*[DEFECT]*

*LAMB\_PHI = /lambp, [function]*

/

*1*

,

*[DEFECT]*

*LAMB\_CT = /lambct*  
*, [function]*

/

*0*

,

*[DEFECT]*

*D\_LB\_S*  
*=*  
*/*  
*dlambs*  
*,*  
*[function]*

/  
0  
,  
[DEFECT]

$D_{LB_T}$   
=  
/  
 $dlambt$   
,  
[function]

/  
0  
,  
[DEFECT]

$D_{LB_{PHI}} = /dlambp$   
, [function]

/

,

*[DEFECT]*

*SIGMA\_T =*  
*St,*  
*[function]*

*D\_SIGMA\_T*  
*=*  
*dst*

*[function]*  
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*PERM\_G\_INTR =*  
*pgi*  
*,*

[function]

*CHAL\_VAPO*

=

*cv,*

[function

\*\*]

*EMMAG*

=

*EM,*

[R]

)

*R\_GAZ*

*Constant of perfect gases.*

*RHO*

*For the hydraulic behaviors initial homogenized density [R7.01.11].*

*CP*

*For the thermal behaviors, specific heat with constant constraint of the solid alone (of grains).*

**Note:**

*Attention it acts here of the specific heat only and not of “C”, as it is*

*p*

*fact for other thermal orders. The density of the grains is calculated in the code starting from the homogenized density [R7.01.11].*

*BIOT\_COEF*

*Coefficient of Biot.*

*SATU\_PRES [function \*\*]*

*For the unsaturated material behaviors (LIQU\_VAPE\_GAZ, LIQU\_GAZ, LIQU\_GAZ\_ATM), isotherm of saturation function of the capillary pressure.*

**Note:**

*For numerical reasons, it should be prevented that saturation reaches value 1. Also it is very strongly recommended to multiply the capillary function (generally lain between 0 and 1) by 0,999.comme indicated on the command file given in example in appendix.*

*D\_SATU\_PRES*

*[function \*\*]*

*For the unsaturated material behaviors (LIQU\_VAPE\_GAZ, LIQU\_GAZ, LIQU\_GAZ\_ATM), derived from saturation compared to the pressure.*

*PESA\_X*

*Gravity according to X, used only if the modeling chosen in AFFE\_MODELE includes 1 or 2 variables of pressure.*

**Note:**

*Gravity defined here is that used in the equation of Darcy only. When there is mechanical calculations, gravity is also defined in AFFE\_CHAR\_MECA. Cette notice applies well to for the three components of gravity.*

*PESA\_Y*

*Gravity according to y, used only if the modeling chosen in AFFE\_MODELE includes 1 or 2 variables of pressure.*

*PESA\_Z*

*Gravity according to Z, used only if the modeling chosen in AFFE\_MODELE includes 1 or 2 variables of pressure.*

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*PERM\_IN*

*[function \*\*]*

*Intrinsic permeability: function of porosity.*

*The permeability to the traditional direction  $K$ , whose dimension is that a speed is calculated following way:*

*$K$*

*$K$*

*rel*

*= int*

*$G$*

*$L$*

*$\mu$*

*where  $K_{int}$  is the intrinsic permeability,  $K_{rel}$  the relative permeability,  $\mu$  viscosity,  $L$  density of the liquid and  $G$  the acceleration of gravity.*

*PERM\_LIQ*

*[function \*\*]*

*Permeability relating to the liquid: function of saturation.*

*D\_PERM\_LIQ\_SATU*

*[function \*\*]*

*Derived from the Permeability relating to the liquid compared to saturation: function of saturation.*

*PERM\_GAZ*

*[function \*\*]*

*Permeability relating to gas: function of the saturation and the gas pressure.*

*D\_PERM\_SATU\_GAZ*

*[function \*\*]*

*Derived from the permeability to gas compared to saturation: function of the saturation and of gas pressure.*

*D\_PERM\_PRES\_GAZ*

*[function \*\*]*

*Derived from the permeability to gas compared to the gas pressure: function of the saturation and of gas pressure.*

*FICKV\_T*

*[function \*\*]*

*For behaviors LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE, multiplicative part of coefficient of Fick function of the temperature for the diffusion of the vapor in the mixture gas. The coefficient of Fick which can be a function of saturation, the temperature, pressure gas and the steam pressure, one defines it as a product of 4 functions: FICKV\_T, FICKV\_S, FICKV\_PG, FICKV\_VP. Seul FICKV\_T is obligatory for the behaviors LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE.*

*FICKV\_S*

*[function \*\*]*

*For behaviors LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE, multiplicative part of coefficient of Fick function of saturation for the diffusion of the vapor in the gas mixture. If this function is used, one recommends to take  $FICKV_S(1) = 0$ .*

*FICKV\_PG*

*[function \*\*]*

*For behaviors LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE, multiplicative part of coefficient of Fick function of the gas pressure for the diffusion of the vapor in the mixture gas.*

*FICKV\_PV*

*[function \*\*]*



*For behaviors LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE, multiplicative part of coefficient of Fick function of the steam pressure for the diffusion of the vapor in gas mixture.*

*D\_FV\_T*  
*[function \*\*]*

*For behaviors LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE, derived from the coefficient FICKV\_T compared to the temperature.*

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*D\_FV\_PG*

*[function \*\*]*

*For behaviors LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE, derived from the coefficient FICKV\_PG compared to the gas pressure.*

*FICKA\_T*

*[function \*\*]*

*For the behavior LIQU\_AD\_GAZ\_VAPE, multiplicative part of the coefficient of Fick function temperature for the diffusion of the air dissolved in the liquid mixture. The coefficient of Fick being able to be a function of saturation, the temperature, pressure of dissolved air and pressure of liquid, one defines it as a product of 4 functions: FICKA\_T, FICKA\_S, FICKV\_PA,*

*FICKV\_PL. In the case of LIQU\_AD\_GAZ\_VAPE, only FICKA\_T are obligatory.*

*FICKA\_S*

*[function \*\*]*

*For the behavior LIQU\_AD\_GAZ\_VAPE, multiplicative part of the coefficient of Fick function saturation for the diffusion of the air dissolved in the liquid mixture.*

*FICKA\_PA*

*[function \*\*]*

*For the behavior LIQU\_AD\_GAZ\_VAPE, multiplicative part of the coefficient of Fick function pressure of air dissolved for the diffusion of the air dissolved in the liquid mixture.*

*FICKA\_PL*

*[function \*\*]*

*For the behavior LIQU\_AD\_GAZ\_VAPE, multiplicative part of the coefficient of Fick function pressure of liquid for the diffusion of the air dissolved in the liquid mixture.*

*D\_FA\_T*

*[function \*\*]*

*For behavior LIQU\_AD\_GAZ\_VAPE, derived from coefficient FICKA\_T compared to temperature.*

*LAMB\_T*

*[function \*\*]*

*Multiplicative part of the thermal conductivity of the mixture depend on the temperature (cf [§2.2.9]). This operand is obligatory in the thermal case.*

*LAMB\_S*

*[function \*\*]*

*Multiplicative part (equalizes to 1 per defect) of the thermal conductivity of the mixture dependent on saturation (cf [§2.2.9]).*

*LAMB\_PHI*

*[function \*\*]*

*Multiplicative part (equalizes to 1 per defect) of the thermal conductivity of the mixture dependent on*

*porosity (cf [§2.2.9]).*

*LAMB\_CT*

*[function \*\*]*

*Part of the thermal of the constant mixture and additive conductivity (cf [§2.2.9]). This constant is equal to zero per defect.*

*D\_LB\_T*

*[function \*\*]*

*Derived from the part of thermal conductivity of the mixture depend on the temperature by report/ratio at the temperature.*

*D\_LB\_S*

*[function \*\*]*

*Derived from the part of thermal conductivity of the mixture depend on saturation.*

*D\_LB\_PHI*

*[function \*\*]*

*Derived from the part of thermal conductivity of the mixture depend on porosity.*

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**EMMAG**

*[function \*\*]*

*Coefficient of storage. This coefficient is taken into account only in the cases of modelings without mechanics.*

### **2.2.9 Recapitulation of the functions of couplings and their dependence**

*The tables below points out the various functions and their possible dependences and obligation.*

**Key word factor THM\_LIQU**

**RHO**

*0*

*lq*

*1*

**UN\_SUR\_K**

*Klq*

**ALPHA**

*lq*

**CP**

*p*

*Clq*

**VISC**

*$\mu$  (T*

*lq*

*)*

*$\mu$  (T*

*lq*

*)*

**D\_VISC\_TEMP**

***T***

***Key word factor THM\_GAZ***

***MASS\_MOL***

***ol***

***M have***

***CP***

***p***

***Case***

***VISC***

***μ (T***

***have***

***)***

***μ (T***

***have***

***)***

***D\_VISC\_TEMP***

***T***

***Key word factor THM\_VAPE\_GAZ***

***MASS\_MOL***

***ol***

***M***

***VP***

***CP***

***p***

***C***

***vp***

***VISC***

***μ (T***

***vp***

***)***

$\mu$  (**T**  
**vp**  
)

*D\_VISC\_TEMP*

*T*

**Key word factor** *THM\_AIR\_DISS*

*CP*

*P*

*C*

*AD*

*COEF\_HENRY*

*K*

*H*

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**Key word factor** *THM\_INIT*

*TEMP*

*initT*

*PRE1*

*init 1*

*P*

*PRE2*

*init 2*

*P*

*PORO*

*0*

*PRES\_VAPE*

*0*

*pvp*

### *2.2.9.1 key Word factor THM\_DIFFU*

*R\_GAZ*

*R*

*RHO*

*0*

*R*

*CP*

*S*

*C*

*BIOT\_COEF*

*B*

*SATU\_PRES*

*Slq (PC)*

*S*

*lq (PC)*

*D\_SATU\_PRES*

*P*  
*C*

*PESA\_X*  
*m*  
*Fx*

*PESA\_Y*  
*m*  
*Fy*

*PESA\_Z*  
*m*  
*Fz*

*PERM\_IN*  
*int*  
*K*  
*()*

*PERM\_LIQU*  
*rel*  
*klq (Slq)*

*rel*  
*K*  
*lq (Slq)*

*D\_PERM\_LIQU\_SATU*

*S*  
*lq*

*PERM\_GAZ*  
*rel*  
*kgz (Slq, pgz)*

*rel*  
*K*  
*gz (Slq, pgz)*

*D\_PERM\_SATU\_GAZ*



*S*  
*lq*

*rel*  
*K*  
*gz (Slq, pgz)*

*D\_PERM\_PRES\_GAZ*

*p*  
*gz*

*FICKV\_T*  
*F T (T)*  
*vp*

*FICKV\_S*  
*F S (S)*  
*vp*

*FICKV\_PG*  
*gz*  
*F (P)*  
*vp*  
*G*

*FICKV\_PV*  
*vp*  
*F (P)*  
*vp*  
*vp*

*F T*

*T*  
*( )*

*vp*  
*D\_FV\_T*

*T*

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gz

*F*

(*P*)

vp

gz

*D\_FV\_PG*

*P*

gz

*FICKA\_T*

*F T (T)*

*AD*

*FICKA\_S*

*F S (S)*

*AD*

*FICKA\_PA*

*AD*

*F (P)*

*AD*

*AD*

*FICKA\_PL*

*lq*

*F (P)*

*AD*

*lq*

*F T*

*T*

*( )*

*D\_FA\_T*

*AD*

*T*

*LAMB\_T*

*T*

*(T)*

*T*

*T*

*T*

*( )*

*D\_LB\_T*

*T*

*T*

*LAMB\_PHI*

*T (*

*)*

*T*

*( )*

*D\_LB\_PHI*

*LAMB\_S*

*T*  
*(S)*  
*S*

*T*  
*(S)*

*D\_LB\_S*  
*S*

*S*

*LAMB\_CT*  
*T*

*CT*

**Note:**

*If there is thermics:*

*T*

*is a function of porosity, saturation and temperature and is given under form product of three functions:*

*T*

*T*

*T*

*T*

*T*

*=*

*T*

*(*

*). (S*

*).*

*T*

*() + with*

*(T) (c.a.d*

*S*

*lq*

*T*  
*cte*  
*T*  
*LAMB\_T*) obligatory and others  
functions by defect taken equal to one, except *T*

.  
*cte = 0*

*For the coefficient of Fick of the gas mixture, in case LIQU\_VAPE\_GAZ and*

*vp*  
*gz*  
*T*  
*S*  
*LIQU\_AD\_GAZ\_VAPE*  
*F (P, P, T, S) = F (P). F (P). F (T). F (S) with*

*vp*  
*vp*  
*gz*  
*vp*  
*vp*  
*vp*  
*gz*  
*vp*  
*vp*

*F T (T) obligatory, other functions being taken by defect equal to one, and the derivative*  
*vp*  
*equal to zero. one will neglect the derivative compared to steam pressure and saturation.*

*In case LIQU\_VAPE\_GAZ\_AD, the coefficient of Fick of the liquid mixture will be under*  
*form: F (P, P, T, S) = F AD (P). F lq (P). F T (T). F S (S)*

*F T (T obligatory,*

*AD*  
*AD*  
*lq*  
*AD*  
*AD*  
*AD*  
*AD*  
*lq*  
*AD*  
*AD*  
*, with*  
*)*  
*AD*

*other functions being taken by defect equal to one, and the derivative equalizes to zero. One consider that the derivative compared to the temperature (the others are in any case taken equal to zero).*

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## **2.3**

### ***Initialization of calculation***

***To define an initial state, it is necessary to define a state of stresses (with the elements), unknown factors nodal. and of the internal variables.***

- In key word THM\_INIT of DEFI\_MATERIAU, one defines values of reference for nodal unknown factors.***
- By key word DEPL of the key word factor ETAT\_INIT of order STAT\_NON\_LINE, one affect the fields of initialization of the nodal unknown factors.***
- By key word SIGM of the key word factor ETAT\_INIT. order STAT\_NON\_LINE, the fields of initialization of the constraints are affected.***
- By key word VARI of the key word factor ETAT\_INIT one affects (possibly) it fields of initialization of the internal variables.***

*In order to specify the things, one recalls to which category of variables belong each physical size (these physical sizes existing or not according to selected modeling):*

### ***Unknown factors***

*p, p, p, T, U, U, U*

***nodal***

*C*

*G*

*lq*

*X*

*y*

*Z*

***Constraints***

, , , , , , ,

***at items xx***

*yy*

*zz*

*xy*

*xz*

*yz*

*p*

***of Gauss***

*m, M, MR. M, m, M*

*, M*

*M*

*, m, M*

*, M*

*M*

*,*

*W*

*W X*

*W y*

*W Z*

*vp*

*vp*

*vp*

*vp*

*have*

*have*

*X*

*y*

*Z*

*X*

*have y*

*have Z*

*m*

*m*



*m*  
*m*  
*m, M*  
*, M*  
*M*  
*, H, H, H, H, Q, Q, Q, Q*

*AD*  
*AD X*  
*AD y*  
*AD Z*  
*W*  
*vp*  
*have*  
*AD*  
*X*  
*y*  
*Z*

***Variables***

*, p, S*  
***interns***  
*lq*  
*vp*  
*lq*

*The correspondence between name of component Aster and physical size is clarified in [Annexe 1].*

*The initialization of the nodal unknown factors as well as the difference between initial state and state of reference have*

*summer described and detailed in [2.2.3]. It is pointed out nevertheless that*

*ddl*

*ref.*

*p = p*

*+ p for the pressures*

*ddl*

*PRE1 and PRE2 and*

*ref.*

*T = T*

*+ T for the temperatures, where ref.*

*p and ref.*

*T*

*are defined under the key word*

*THM\_INIT of order DEFI\_MATERIAU.*

Key word *DEPL* of the key word factor *ETAT\_INIT* of order *STAT\_NON\_LINE* defines the values initial of {} *ddl*

*U*

. The initial values of the densities of the vapor and the dry air are defined starting from the initial values of the vapor and gas pressures (values read under the key word *THM\_INIT* of order *DEFI\_MATERIAU*). It is noticed that, for displacements, decomposition

*ddl*

*ref.*

$U = U$

+ *U* is not made: key word *THM\_INIT* of order *DEFI\_MATERIAU* thus does not allow to define initial displacements. The only way of initializing displacements is thus to give them an initial value by the key word factor *ETAT\_INIT* of the order *STAT\_NON\_LINE*.

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Concerning the constraints, the fields to be informed are the constraints indicated in appendix I according to selected modeling.

Initial values of the enthalpi, which belong to the generalized constraints are defined in to leave key word *SIGM* of the key word factor *ETAT\_INIT* of order *STAT\_NON\_LINE*. The introduction

initial conditions is very important, for the enthalpi. In practice, one can reason in considering that one has three states for the fluids:

· the state running,

- *the state of reference: it is that of the fluids in a free state. In this state of reference, one can consider that the enthalpies are null,*
- *the initial state: it must be in thermodynamic balance. For the enthalpies of water and vapor one will have to take:*

*init**init m**pw - ref.**init**pl**pw - p**hw =**=**atm**W**W**init m**vp**H = L (init**T**) = heat**vaporisati**of**latent**one**init m**have**H = 0**init m**AD**H**= 0**and with  $L(T) = 2500800 -$* *(  
 $2443 T - 273.15) \text{ J/kg}$* **Note:***The initial vapor pressure will have to be taken in coherence with these choices (cf [§2.2.3]).*

Concerning the mechanical constraints, the partition of the constraints in constraints total and effective is written:

$$= ' \\ + \mathbf{I} \\ p$$

where is the total constraint, c.a.d that which checks:

$$( \\ \mathbf{Div}) + m \\ RF = 0$$

is the effective constraint. For the laws of effective constraints, it checks:

$$1 \\ D = F ( \\ D - \\ = +T \\ 0dT, ), \text{ where}$$

( $\mathbf{U} \mathbf{U}$ ) and represents the internal variables.

2  
is calculated according to the water pressures. The adopted writing is incremental and, if one

p  
wants that the value of is coherent with value ref.

p ( \\ p \\ PRE1) definite under the key word \\ THM\_INIT, it is necessary to initialize by the key word

p \\ SIGM of the key word factor ETAT\_INIT of the order \\ STAT\_NON\_LINE.

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**Warning:**

*In the case of fields of pressures or temperatures heterogeneous, it is necessary to ensure “manually continuity” enters the fields. That Ci for the moment is not taken into account automatically.*

*In the current state, the degrees of freedom (ddl) to the nodes located at the interface between two meshes take the value of the ddl material initialized in the last as on the figure. Consequently it materials affected in first is found with heterogeneous values of displacements. To ensure continuity, it is necessary to impose on the nodes medium (in grayed on [Figure 2.3-a]) an average value enters*

*two materials. This treatment necessary in is seen of a correct postprocessing but does not have of impact on calculation in him even.*

*Value with the node of the ddl sunken for the mesh*

*M1 (affected in first)*

*M2*

*M1*

*Value with the node of the ddl sunken for the mesh*

*M2 (affected as a second)*

*Value to be modified (average between M1 etM2)*

**Appear 2.3-a: Management of discontinuities between two meshes**

*If one refers to the example presented in [§Annexe 3], the fields of displacements initialized in ETAT\_INIT are then defined for example in the following way:*

```
CHAMNO=CREA_CHAMP (MAILLAGE=MAIL,
OPERATION='AFFE',
TYPE_CHAM='NOEU_DEPL_R',
AFFE= (_F (TOUT='OUI',
NOM_CMP='TEMP',
VALE=0.0,),
_F (GROUP_NO='SURFBO',
NOM_CMP='PRE1',
```

```

VALE=7.E7,),
_F (GROUP_NO=' SURFBG',
NOM_CMP=' PRE1',
VALE=3.E7,),
_F (NOEUD= ("NO300", "NO296"),
NOM_CMP=' PRE1',
VALE=5.E7,),
_F (GROUP_NO=' SURFBO',
NOM_CMP=' PRE2',
VALE=0.0,),
_F (GROUP_NO=' SURFBG',
NOM_CMP=' PRE2',
VALE=0.0,)),);

```

*And stress fields in the following way:*

```

SIGINIT=CREA_CHAMP (MAILLAGE=MAIL,
OPERATION=' AFFE',
TYPE_CHAM=' CART_SIEF_R',
AFFE= (_F (GROUP_MA=' BO',
NOM_CMP=
("SIXX", "SIYY", "SIZZ", "SIXY", "SIXZ",
"SIYZ", "SIP", "M11", "FH11X", "FH11Y", "ENT11",
"M12", "FH12X", "FH12Y", "ENT12",
"QPRIM", "FHTX", "FHTY", "M21",
"FH21X", "FH21Y", "ENT21",
"M22", "FH22X", "FH22Y", "ENT22",),
VALE=
(0.0,0.0,0.0,0.0,0.0,0.0,
0.0,0.0,0.0,0.0,0.0,0.0,
0.0,0.0,0.0, 2500000.0,
0.0,0.0,0.0,0.0,0.0,0.0,0.0,
0.,0.,0.,0.),),);

```

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## **2.4**

### **Loadings and boundary conditions**

*All the boundary conditions or loading are affected via order AFFE\_CHAR\_MECA [U4.44.01]. The loadings are then activated by the key word factor EXCIT of the order STAT\_NON\_LINE.*

*In a traditional way, two types of boundary conditions are possible:*

*· Of the conditions of the Dirichlet type which consist in imposing on part of border of values fixed for principal unknown factors belonging to {} ddl*

*U*

*(and not*

*ddl*

*init*

*U = U + U)*

*for that one uses key word factor DDL\_IMPO of AFFE\_CHAR\_MECA.*

*· Of the conditions of the Neuman type which consist in imposing values on the “quantities dual”, either by not saying anything (null flows), or in their giving a value via the key words FLUN, FLUN\_HYDR1 and FLUN\_HYDR2 of the key word factor FLUX\_THM\_REP of the order AFFE\_CHAR\_MECA. This flow is then multiplied by a function of time (by defect equalizes with 1) in under the word key one EXCIT of order STAT\_NON\_LINE. Mechanical conditions in total constraints .n is they given via PRES\_REP of the order AFFE\_CHAR\_MECA. One will refer to the documentation of this order to know some possibilities.*

*From a syntactic point of view the conditions of Dirichlet thus apply as to the example according to*

*DIRI=AFFE\_CHAR\_MECA (MODELE=MODELE,*

*DDL\_IMPO= (\_F (GROUP\_NO=' GAUCHE',*

*TEMP=0.0,)*

*\_F (TOUT=' OUI',*

*PRE2=0.0,)*

```
_F (GROUP_NO=' GAUCHE',  
PRE1=0.0),  
_F (TOUT=' OUI',  
DX=0.0),  
_F (TOUT=' OUI',  
DY=0.0),  
_F (TOUT=' OUI',  
DZ=0.0),  
,)
```

*For the conditions of Neuman, syntax will be then as on the following example:*

```
NEU1=AFFE_CHAR_MECA (MODELE=MODELE,  
FLUX_THM_REP=_F (GROUP_MA=' DROIT',  
FLUN=200.,  
FLUN_HYDR1=0.0,  
FLUN_HYDR2=0.0),);  
NEU2=AFFE_CHAR_MECA (MODELE=MODELE,  
PRES_REP=_F (GROUP_MA=' DROIT',  
PRES=2.,),);
```

*One defines then the multiplicative function which one wants to apply, for example with NEU1:*

```
FLUX=DEFI_FONCTION (NOM_PARA=' INST',  
VALE=  
(0.0, 386.0,  
315360000.0, 312.0,  
946080000.0,12.6),);
```

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*The loadings are then activated in STAT\_NON\_LINE via key word EXCIT in the manner following:*

```
EXCIT= (
_F (CHARGE=DIRI,)
_F (CHARGE=NEU2,)
_F (CHARGE=NEU1,
FONC_MULT=FLUX,)
),
```

*FLUN corresponds to the value of the heat flow. FLUN\_HYDR1 and FLUN\_HYDR2 correspond to values of the hydraulic flows associated pressures PRE1 and PRE2. If there is no ambiguity for thermics or mechanics, on the other hand unknown factors principal hydraulic PRE1 and PRE2 change according to the selected coupling. As it below is pointed out*

*Behavior*  
*LIQU\_SATU*  
*LIQU\_VAPE LIQU\_GAZ\_ATM*  
*GAS*  
*LIQU\_VAPE\_GAZ*

*LIQU\_GAZ*  
*LIQU\_AD\_GAZ\_VA*  
*EP*  
*PRE1*  
*p*  
*p*  
*- p*  
*p*  
*p = p - p*  
*lq*  
*lq*  
*lq*  
*G*  
*C*  
*G*  
*lq*  
*PRE2*

*pg*

*Associated flows are:*

*For*

*ext.*

*PRE1, FLUN\_HYDR1: (M + M*

*N*

*. = M*

*+ M*

*W*

*vp)*

*ext.*

*W*

*vp*

*For*

*ext.*

*PRE2, FLUN\_HYDR2: (M*

*+ M N*

*. = M*

*+ M*

*AD*

*have)*

*ext.*

*AD*

*have*

*We thus will summarize the various possibilities by distinguishing the case where one imposes values on PRE1 and/or PRE2 and that where one works on combinations of the 2. It is announced that one can well on*

*to have various types of boundary conditions according to the pieces of border (groups of nodes or of meshes) which one treats. For a more complete and more detailed outline in the way in which are treated the boundary conditions in the case unsaturated, one will refer to the note reproduced in appendix 2.*

***· Cas of the boundary conditions utilizing unknown factors principal PRE1 and PRE2***

*One summarizes here the usual case where one imposes value on PRE1 and/or PRE2.*

*- Dirichlet on PRE1 and Dirichlet on PRE2*

*The user imposes a value on PRE1 and PRE2; flows are results of*

calculation.

- Dirichlet on PRE1 and Neuman on PRE2

The user imposes a value on PRE1 and a value with flow associated with PRE2 in saying anything on PRE2 or by giving a value to FLUN\_HYDR2.

- Dirichlet on PRE2 and Neuman on PRE1

The user imposes a value on PRE2 and a value with flow associated with PRE1 in saying anything on PRE1 or by giving a value to FLUN\_HYDR1.

- Neuman on PRE2 and Neuman on PRE1

Two flows are imposed either by not saying anything on PRE1 and/or PRE2 (null flows) maybe by giving a value to FLUN\_HYDR1. et/ou FLUN\_HYDR2

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**· Cas of the boundary conditions utilizing a linear relation between unknown factors principal PRE1 and PRE2**

It is also possible to handle linear combinations of PRE1 and PRE2. It is necessary however to handle that with precaution so as to start from a correctly posed problem. The syntax of this operator is detailed in the documentation of AFFE\_CHAR\_MECA, the example below into famous this type of condition:

```
P_DDL=AFFE_CHAR_MECA (MODELE=MODELE,  
LIAISON_GROUP= (_F (  
GROUP_NO_1= "EDGES",  
GROUP_NO_2= "EDGES",  
DDL_1=' PRE1',
```

```

DDL_2=' PRE2',
COEF_MULT_1 = X,
COEF_MULT_2 = Y.,
COEF_IMPO =z,,),
);

```

*This order means that on the border defined by the group of nodes “EDGES”, the pressures PRE1 and PRE2 are connected by the linear relation*

$$X \text{ PRE1} + y \text{ PRE2} = Z$$

**Note:**

*Flows imposed are scalar quantities which can apply to a line or a surface interns with the modelled solid. In this case, these boundary conditions correspond to a source.*

## 2.5

### **Nonlinear calculation**

*Calculation is carried out by order STAT\_NON\_LINE as in the example below:*

```

U0=STAT_NON_LINE (MODELE=MODELE,
CHAM_MATER=CHMAT0,
EXCIT= (
_F (CHARGE=T_IMP,),
_F (CHARGE=CALINT,
FONC_MULT=FLUX,,),
COMP_INCR=_F (RELATION=' KIT_THHM',
RELATION_KIT= (“ELAS”, “LIQU_GAZ”
, “HYDR_UTIL”)),
RECH_LINEAIRE =_F (RESI_LINE_RELA = 1.E-3,
RHO_MIN = 0.1,
RHO_MAX = 0.2,
ITER_LINE_MAXI = 3,),
ETAT_INIT=_F (DEPL=CHAMNO,
SIGM=SIGINIT),
INCREMENT=_F (LIST_INST=INST1,),
NEWTON=_F (MATRICE=' TANGENTE', REAC_ITER=10,),
CONVERGENCE=_F (RESI_GLOB_MAXI=1.0000000000000001E-05,
ITER_GLOB_MAXI=150,
ARRET=' NON',
ITER_INTE_MAXI=5,),
ARCHIVAGE=_F (PAS_ARCH=1,,);

```

*To this order one assigns the model (key word **MODELS**), le/les materials (key word **CHAM\_MATER**), le/les loadings (key word **EXCIT**) and the initial state (key word **ETAT\_INIT**) which one defined by all orders described previously.*

*For general information concerning this order and his syntax, one will refer to its documentation. It is specified just that the method of calculation is a method of Newton.*

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**Caution:**

*Under the key word factor **NEWTON**, one must put a “**TANGENT**” matrix of the type and not “**ELASTIC**”.*

*One speaks here only about what is specific to calculations **THM** with knowing the key words factors **RELATION** and **RELATION\_KIT** of the key word **COMP\_INCR** which are closely dependent.*

***RELATION** is indicated by relations of the types which make it possible to solve at the same time from two to four equilibrium equations. The equations considered depend on suffix with the following rule:*

***M** indicates the mechanical equilibrium equation,*

***T** indicates the thermal equilibrium equation,*

***H** indicates a hydraulic equilibrium equation.*

***V** indicates the presence of a phase in form vapor (in addition to the liquid)*

*Only one letter H means that the porous environment is saturated (only one variable of pressure p), by example either of gas, or of liquid, or of a liquid mixture/gas (of which the pressure of gas is constant).*

*Two letters H mean that the porous environment is not saturated (two variables of pressure p), by example a liquid mixture/vapor/gas.*

*The presence of two letters HV means that the porous environment is saturated by a component (with practical of water), but that this component can be in liquid form or vapor. There is not whereas one conservation equation of this component, therefore only one degree of freedom pressure, but there is a flow*

*liquid and a flow vapor. The possible relations are then the following ones:*

*/“KIT\_HM”*

*/“KIT\_THM”*

*/“KIT\_HHM”*

*/“KIT\_THH”*

*/“KIT\_THV”*

*/“KIT\_THHM”*

*The table below summarizes to which kit each modeling corresponds:*

*KIT\_HM*

*D\_PLAN\_HM, D\_PLAN\_HMD, AXIS\_HM, AXIS\_HMD, 3D\_HM, 3D\_HMD*

*KIT\_THM*

*D\_PLAN\_THM, D\_PLAN\_THMD, AXIS\_THM, AXIS\_THMD, 3D\_THM, 3D\_THMD*

*KIT\_HHM*

*D\_PLAN\_HHM, D\_PLAN\_HHMD, AXIS\_HHM, AXIS\_HHMD, 3D\_HHM, 3D\_HHMD,*

*D\_PLAN\_HH2MD, AXIS\_HH2MD, 3D\_HH2MD*

*KIT\_THH*

*D\_PLAN\_THH, D\_PLAN\_THHD, AXIS\_THH, AXIS\_THHD, 3D\_THH, 3D\_THHD,*

*D\_PLAN\_THH2D, AXIS\_THH2D, 3D\_THH2D*

*KIT\_THV*

*D\_PLAN\_THVD, AXIS\_THVD, 3D\_THVD*

*KIT\_THHM*

*D\_PLAN\_THHM, D\_PLAN\_THHMD, AXIS\_THHM, AXIS\_THHMD, 3D\_THHM,*

*3D\_THHMD, D\_PLAN\_THH2MD, AXIS\_THH2MD, 3D\_THH2MD*

*For each modelled phenomenon (thermal and/or mechanical and/or hydraulic), one must specify in RELATION\_KIT:*

*· The mechanical model of behavior of the skeleton if there is mechanical modeling (M),*

*/“ELAS”*

*/“CJS”*

*/“LAIGLE”*

/“ELAS\_THM”

/“CAM\_CLAY”

/“DRUCKER\_PRAGER”

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· *The behavior of the liquids/gas, (the same one as that indicated in COMP\_THM under DEF\_MATERIAU, cf [§2.2.2])*

/“LIQU\_SATU”

/“LIQU\_GAZ”

/“GAS”

/“LIQU\_GAZ\_ATM”

/“LIQU\_VAPE\_GAZ”

/“LIQU\_AD\_GAZ\_VAPE”

/“LIQU\_VAPE”

· *Moreover in all the cases, **one must imperatively inform: HYDR\_UTIL** under RELATION\_KIT (this key word makes it possible to inform the curve of saturation and its derivative in function of the capillary pressure as well as the relative permeability and its derivative according to saturation).*

*If one mentions the example above, one deals with in a coupled way a problem thermo-hydro-mechanics for a porous environment unsaturated with LIQU\_GAZ like behavior with the liquid, and a law rubber band like mechanical behavior.*

**Caution:**

*According to chosen, all the behaviors are not licit (for example if one chosen porous environments unsaturated, one cannot affect a behavior of the gas type perfect). all the possible combinations are summarized below*

*For relation KIT\_HM:*

(“ELAS” “GAS”  
“HYDR\_UTIL”)  
 (“CJS”  
“GAS”  
“HYDR\_UTIL”)  
 (“LAIGLE”  
“GAS”  
“HYDR\_UTIL”)  
 (“CAM\_CLAY”  
“GAS”  
“HYDR\_UTIL”)  
 (“ELAS” “LIQU\_SATU”  
“HYDR\_UTIL”)  
 (“CJS”  
“LIQU\_SATU”  
“HYDR\_UTIL”)  
 (“LAIGLE”  
“LIQU\_SATU”  
“HYDR\_UTIL”)  
  
 (“CAM\_CLAY”  
“LIQU\_SATU”  
“HYDR\_UTIL”)  
 (“ELAS” “LIQU\_GAZ\_ATM” “HYDR\_UTIL”)  
 (“CJS”  
“LIQU\_GAZ\_ATM” “HYDR\_UTIL”)  
 (“LAIGLE”  
“LIQU\_GAZ\_ATM” “HYDR\_UTIL”)  
 (“CAM\_CLAY”  
“LIQU\_GAZ\_ATM” “HYDR\_UTIL”)

*For relation KIT\_THM:*

(“ELAS”  
“GAS”



“HYDR\_UTIL”)  
 (“CJS”

“GAS”

“HYDR\_UTIL”)  
 (“LAIGLE”

“GAS”

“HYDR\_UTIL”)  
 (“CAM\_CLAY”

“GAS”

“HYDR\_UTIL”)  
 (“ELAS”

“LIQU\_SATU”

“HYDR\_UTIL”)  
 (“CJS”

“LIQU\_SATU”

“HYDR\_UTIL”)  
 (“LAIGLE”

“LIQU\_SATU”

“HYDR\_UTIL”)  
 (“CAM\_CLAY”

“LIQU\_SATU”

“HYDR\_UTIL”)  
 (“ELAS”

“LIQU\_GAZ\_ATM” “HYDR\_UTIL”)  
 (“CJS”

“LIQU\_GAZ\_ATM” “HYDR\_UTIL”)  
 (“LAIGLE”

“LIQU\_GAZ\_ATM”

“HYDR\_UTIL”)  
 (“CAM\_CLAY”

“LIQU\_GAZ\_ATM”

“HYDR\_UTIL”)

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*For relation KIT\_HHM:*

(“ELAS” “LIQU\_GAZ”

“HYDR\_UTIL”)

(“CJS”

“LIQU\_GAZ”

“HYDR\_UTIL”)  
 (“LAIGLE”  
 “LIQU\_GAZ”

“HYDR\_UTIL”)  
 (“CAM\_CLAY”  
 “LIQU\_GAZ”

“HYDR\_UTIL”)  
 (“ELAS” “LIQU\_VAPE\_GAZ”

“HYDR\_UTIL”)  
 (“CJS”  
 “LIQU\_VAPE\_GAZ”

“HYDR\_UTIL”)  
 (“LAIGLE”  
 “LIQU\_VAPE\_GAZ”

“HYDR\_UTIL”)  
 (“CAM\_CLAY”  
 “LIQU\_VAPE\_GAZ”

“HYDR\_UTIL”)  
 (“ELAS” “LIQU\_AD\_GAZ\_VAPE”

“HYDR\_UTIL”)  
 (“CJS”  
 “LIQU\_AD\_GAZ\_VAPE”  
 “HYDR\_UTIL”)  
 (“LAIGLE”  
 “LIQU\_AD\_GAZ\_VAPE”

“HYDR\_UTIL”)  
(“CAM\_CLAY”  
“LIQU\_AD\_GAZ\_VAPE”  
“HYDR\_UTIL”)

*For relation KIT\_THH:*

(“LIQU\_GAZ”  
“HYDR\_UTIL”)  
(“LIQU\_VAPE\_GAZ”  
“HYDR\_UTIL”)  
(“LIQU\_AD\_GAZ\_VAPE” “HYDR\_UTIL”)

*For relation KIT\_THV:*

(“LIQU\_VAPE”  
“HYDR\_UTIL”)

*For relation KIT\_THHM:*

(“ELAS”  
“LIQU\_GAZ”  
“HYDR\_UTIL”)  
(“CJS”

“LIQU\_GAZ”  
“HYDR\_UTIL”)  
(“LAIGLE”

“LIQU\_GAZ”  
“HYDR\_UTIL”)  
(“CAM\_CLAY”

“LIQU\_GAZ”  
“HYDR\_UTIL”)  
(“ELAS”  
“LIQU\_VAPE\_GAZ”  
“HYDR\_UTIL”)  
(“CJS”

“LIQU\_VAPE\_GAZ” “HYDR\_UTIL”)  
(“LAIGLE”

“LIQU\_VAPE\_GAZ”

“HYDR\_UTIL”)  
(“CAM\_CLAY”

“LIQU\_VAPE\_GAZ” “HYDR\_UTIL”)  
(“ELAS”  
“LIQU\_AD\_GAZ\_VAPE”  
“HYDR\_UTIL”)  
(“CJS”

“LIQU\_AD\_GAZ\_VAPE” “HYDR\_UTIL”)  
(“LAIGLE”

“LIQU\_AD\_GAZ\_VAPE” “HYDR\_UTIL”)  
(“CAM\_CLAY”

“LIQU\_AD\_GAZ\_VAPE” “HYDR\_UTIL”)

**Note:**

*In the event of problem of convergence it can be very useful to activate linear research as indicated in the example given at the head of this section. Linear research do not improve however systematically convergence, it is thus to handle with precaution.*

**2.6**  
**postprocessing**

*The post processing data in THM does not vary a post usual Aster treatment. One recalls just that for any impression of the values which are not the nodal unknown factors, it is necessary to calculate these values by the order CALC\_ELEM whose one gives an example hereafter.*

*For the constraints:*

```
U0=CALC_ELEM (reuse =U0,  
MODELE=MODELE,  
CHAM_MATER=CHMAT0,  
TOUT_ORDRE=' OUI',  
OPTION= (“SIEF_ELNO_ELGA”),  
RESULTAT=U0,);
```

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*For the internal variables:*

```
U0=CALC_ELEM (reuse =U0,  
MODELE=MODELE,  
CHAM_MATER=CHMAT0,  
TOUT_ORDRE=' OUI',  
OPTION= ("VARI_ELNO_ELGA"),  
RESULTAT=U0,);
```

*It should however be recalled that all the values of displacements at exits correspond to ddl*

*U*

*and*

*not*

*ddl*

*ref.*

*U = U*

*+ U.*

*It is also important to know the name of the constraints and the numbers of the internal variables.*

*All that is consigned in appendix I.*

*Thus the following example makes it possible to print the liquid water mass on the HIGH group of nodes to all*

*moments.*

```
TAB1=POST_RELEVE_T (ACTION=_F (INTITULE=' CONT',  
GROUP_NO= ("HIGH"),  
RESULTAT=U0,  
NOM_CHAM=' SIEF_ELNO_ELGA',
```

```
TOUT_ORDRE=' OUI',  
NOM_CMP= ("M11"),  
OPERATION=' EXTRACTION',,);
```

```
IMPR_TABLE (TABLE=TAB1,  
FICHIER=' RESULTAT',  
FORMAT=' AGRAF',  
PAGINATION=' INST',  
NOM_PARA= ("INST", "COOR_X", "M11"),);
```

*The following example makes it possible to print the values of porosity to node 1 and the first moment.*

```
TAB2=POST_RELEVE_T (ACTION=_F (INTITULE=' DEPL',  
NOEUD=' NO1',  
RESULTAT=U0,  
NOM_CHAM=' VARI_ELNO_ELGA',  
NUME_ORDRE=1,  
NOM_CMP= ("V2"),  
OPERATION=' EXTRACTION',,);  
IMPR_TABLE (TABLE=TAB2,  
FICHIER=' RESULTAT',  
FORMAT=' AGRAF',  
PAGINATION=' INST',  
NOM_PARA= ("INST", "COOR_X", "V2"),);
```

*Concerning the layout of isovaleurs IDEAS as GIBI are the two tools used.*

### **2.6.1 Isovaleurs with Gibi**

*A file .cast readable by orders GIBI east creates via order IMPR\_RESU as on the example below:*

```
IMPR_RESU (RESU=_F (FORMAT=' CASTEM',  
RESULTAT=U0,  
MAILLAGE=MAIL,  
NUME_ORDRE=1,)),
```

*The file obtained is then read by a file of treatment. An example of files gibi of treatment data is in [§Annexe 4].*

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## **2.6.2 Isovaleurs with IDEAS**

**A file .unv readable by IDEAS is created via order IMPR\_RESU with format IDEAS as on the example below:**

```
IMPR_RESU (RESU=_F (FORMAT=' IDEAS',  
RESULTAT=U0,  
MAILLAGE=MAIL,  
NUME_ORDRE=1,)),
```

## **3 Bibliography**

**[1]**

**Catsius Clay project. Calculation and testing of behaviour of unsaturated clay have barrier in radioactive waste repositories.**

**[2]**

**Card-index of model of thermal reference Couplage hydraulic ANDRA-CNT ACSS 02-006**

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***Internal appendix 1 generalized Constraints and variables***

***Constraints:***

***Number***

***Name of component Aster***

***Contents Modelings***

***1***

***SIXX***

***So mechanical (. M...)***

***xx***

***2***

***SIYY***

***So mechanical (. M...)***

***yy***

***3***

***SIZZ***

***So mechanical (. M...)***

***zz***

***4***

***SIXY***

***So mechanical (. M...)***

***xy***

***5***

***SIXZ***

***So mechanical (. M...)***

xz

6

*SIYZ*

*So mechanical (. M...)*

yz

7

*SIP*

*So mechanical (. M...)*

p

8

*M11*

m

*In all the cases*

W

9

*FH11X*

M

*In all the cases*

W X

10

*FH11Y*

M

*In all the cases*

W y

11

*FH11Z*

M

*In all the cases*

W Z

12

*ENT11*

m

H

*In all the cases*

W

13

*M12*

m

*If 2 unknown pressures (. .HH...)*

vp

14

*FH12X*

*M*

*If 2 unknown pressures (. .HH...)*

*vp X*

*15*

*FH12Y*

*M*

*If 2 unknown pressures (. .HH...)*

*vp*

*y*

*16*

*FH12Z*

*M*

*If 2 unknown pressures (. .HH...)*

*vp Z*

*17*

*ENT12*

*m*

*H*

*If 2 unknown pressures (. .HH...)*

*vp*

*18*

*M21*

*m*

*If 2 unknown pressures (. .HH...)*

*have*

*19*

*FH21X*

*M*

*If 2 unknown pressures (. .HH...)*

*have X*

*20*

*FH21Y*

*M*

*If 2 unknown pressures (. .HH...)*

*have y*

*21*

*FH21Z*

*M*

*If 2 unknown pressures (. .HH...)*

*have Z*

*22*

*ENT21*

*m*

*H*

*If 2 unknown pressures (. .HH...)*

*have*

*18*

*M22*

*m*

*If modeling of the dissolved air (... HH2...)*

*AD*

*19*

*FH22X*

*M*

*If modeling of the dissolved air (... HH2...)*

*AD X*

*20*

*FH22Y*

*M*

*If modeling of the dissolved air (... HH2...)*

*AD y*

*21*

*FH22Z*

*M*

*If modeling of the dissolved air (... HH2...)*

*AD Z*

*22*

*ENT22*

*m*

*H*

*If modeling of the dissolved air (... HH2...)*

*AD*

*23*

*QPRIM*

*Q'*

*So thermal*

24

*FHTX*

*Q*

*So thermal*

*X*

25

*FHTY*

*Q*

*So thermal*

*y*

26

*FHTZ*

*Q*

*So thermal*

*Z*

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*In the case without mechanics, the variables internal:*

***Number***

***Name component Aster***

***Contents***

*1 VI*

*0*

-

*lq*  
*lq*  
 2 V2  
 0  
 -  
 3 V3  
 0  
*p - p*  
*vp*  
*vp*  
 4 V4  
*S*  
*lq*

*In the case with mechanics the first numbers will be those corresponding to mechanics (V1 in elastic case, V1 and following for plastic models). The number of the variables intern above will have then to be incremented of as much.*

### ***Appendix 2 Example I of command file***

#### ***# EXAMPLE OF CALCULATION AXIS\_THH2MD***

***BEGINNING ();***

***PRE\_GIBI ();***

#####  
 #####  
 #####

***INST1=DEFI\_LIST\_REEL (DEBUT=0.0,  
 INTERVALLE= (  
 \_F (JUSQU\_A=500000000., NOMBRE=50,)  
 \_F (JUSQU\_A=2000000000., NOMBRE=20,)  
 ),);***

***MAIL=LIRE\_MAILLAGE ();***

***MAIL=DEFI\_GROUP (reuse =MAIL,  
 MAILLAGE=MAIL,  
 CREA\_GROUP\_NO= (\_F (GROUP\_MA=' BAS',)  
 \_F (GROUP\_MA=' HAUT',),  
 \_F (GROUP\_MA=' GAUCHE',),***

*\_F (GROUP\_MA=' DROIT',),  
\_F (GROUP\_MA=' BO',),  
,);*

*MODELE=AFFE\_MODELE (MAILLAGE=MAIL,  
AFFE=\_F (TOUT=' OUI',  
PHENOMENE=' MECANIQUE',  
MODELISATION=' AXIS\_THH2MD',),),);  
#  
#*

*UN=DEFI\_CONSTANTE (VALE=1.0,);  
UNDEMI=DEFI\_CONSTANTE (VALE=0.5,);*

*ZERO=DEFI\_CONSTANTE (VALE=0.0,);*

*VISCOLIQ=DEFI\_CONSTANTE (VALE=1.E-3,);*

*VISCOGAZ=DEFI\_CONSTANTE (VALE=1.E-03,);*

*DVISCOL=DEFI\_CONSTANTE (VALE=0.0,);*

*DVISCOG=DEFI\_CONSTANTE (VALE=0.0,);*

*LI2=DEFI\_LIST\_REEL (DEBUT=-1.E9,  
INTERVALLE= (  
\_F (JUSQU\_A=1.E9,  
NOMBRE=500,)),),);*

*LI1=DEFI\_LIST\_REEL (DEBUT=0.10000000000000001,  
INTERVALLE=\_F (JUSQU\_A=0.98999999999999999,  
PAS=1.E-2,)),);*

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*# LIMITATION OF SATURATION MAX (<1)*  
*#CONSTBO = DEFI\_CONSTANTE (VALE: 0.99);*  
*#*

*SLO = FORMULA (REAL = "" (REAL: PCAP) =*  
*0.4"");*

*SATUBO=CALC\_FONC\_INTERP (FONCTION=SLO,*  
*LIST\_PARA=LI2,*  
*NOM\_PARA='PCAP',*  
*PROL\_GAUCHE='LINEAIRE',*  
*PROL\_DROITE='LINEAIRE',*  
*INFO=2,);*

*DSATBO=DEFI\_CONSTANTE (VALE=0.);*  
*#*

*#*  
*# COEF. FICK*  
*#*

*FICK=DEFI\_CONSTANTE (VALE=3.E-10.);*

*KINTBO=DEFI\_CONSTANTE (VALE=9.9999999999999995E-19.);*  
*HENRY=DEFI\_CONSTANTE (VALE=50000.);*

*MATERBO=DEFI\_MATERIAU (ELAS=\_F (E=5.150000000E8,*  
*NU=0.20000000000000000001,*  
*RHO=2670.0,*  
*ALPHA=0.),*  
*COMP\_THM = "LIQU\_AD\_GAZ\_VAPE",*  
*THM\_LIQU=\_F (RHO=1000.0,*

UN\_SUR\_K=0.,  
ALPHA=0.,  
CP=0.0,  
VISC=VISCOLIQ,  
D\_VISC\_TEMP=DVISCOL,),  
THM\_GAZ=\_F (MASS\_MOL=0.01,  
CP=0.0,  
VISC=VISCOGAZ,  
D\_VISC\_TEMP=ZERO,),  
THM\_VAPE\_GAZ=\_F (MASS\_MOL=0.01,  
CP=0.0,  
VISC=VISCOGAZ,  
D\_VISC\_TEMP=ZERO,),  
THM\_AIR\_DISS=\_F (  
CP=0.0,  
COEF\_HENRY=HENRY  
),  
THM\_INIT=\_F (TEMP=300.0,  
PRE1=0.0,  
PRE2=1.E5,  
PORO=1.,  
PRES\_VAPE=1000.0,  
DEGR\_SATU=0.4,),  
THM\_DIFFU=\_F (R\_GAZ=8.32,  
RHO=2200.0,  
CP=1000.0,  
BIOT\_COEF=1.0,  
SATU\_PRES=SATUBO,  
D\_SATU\_PRES=DSATBO,  
PESA\_X=0.0,  
PESA\_Y=0.0,  
PESA\_Z=0.0,  
PERM\_IN=KINTBO,  
PERM\_LIQU=UNDEMI,  
D\_PERM\_LIQU\_SATU=ZERO,  
PERM\_GAZ=UNDEMI,  
D\_PERM\_SATU\_GAZ=ZERO,  
D\_PERM\_PRES\_GAZ=ZERO,  
FICKV\_T=ZERO,  
FICKA\_T=FICK,  
LAMB\_T=ZERO,  
),);

```
CHMAT0=AFFE_MATERIAU (MAILLAGE=MAIL,  
AFFE= (_F (GROUP_MA=' BO',  
MATER=MATERBO,)  
),);
```

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```
CHAMNO=CREA_CHAMP (MAILLAGE=MAIL,  
OPERATION=' AFFE',  
TYPE_CHAM=' NOEU_DEPL_R',  
AFFE= (_F (TOUT=' OUI',  
NOM_CMP=' TEMP',  
VALE=0.0,)  
_F (TOUT=' OUI',  
NOM_CMP=' PRE2',  
VALE=1000.0,)  
_F (TOUT=' OUI',  
NOM_CMP=' PRE1',  
VALE=1.E6,)  
),);
```

```
TIMP=AFFE_CHAR_MECA (MODELE=MODELE,
```

```
DDL_IMPO= (_F (TOUT=' OUI',
```

```
TEMP=0.0,)
```

```

_F (GROUP_NO= ("HIGH", "LOW", "LEFT", "RIGHT"),
DX=0.0,),
_F (GROUP_NO= ("HIGH", "LOW", "LEFT", "RIGHT"),
DY=0.0,),
_F (GROUP_MA=' GAUCHE',
PRE2=15000.),),
_F (GROUP_MA=' GAUCHE',
PRE1=1.E6,),
),
);

```

```

SIGINIT=CREA_CHAMP (MAILLAGE=MAIL,
OPERATION=' AFFE',
TYPE_CHAM=' CART_SIEF_R',
AFFE= (_F (GROUP_MA=' BO',
NOM_CMP=
("SIXX", "SIYY", "SIZZ", "SIXY", "SIXZ",
"SIYZ", "SIP", "M11", "FH11X", "FH11Y", "ENT11",
"M12", "FH12X", "FH12Y", "ENT12",
"QPRIM", "FHTX", "FHTY", "M21",
"FH21X", "FH21Y", "ENT21",
"M22", "FH22X", "FH22Y", "ENT22",),
VALE=
(0.0,0.0,0.0,0.0,0.0,0.0,
0.0,0.0,0.0,0.0,0.0,0.0,
0.0,0.0,0.0, 2500000.0,
0.0,0.0,0.0,0.0,0.0,0.0,0.0,
0.,0.,0.,0.),),
), );

```

```

U0=STAT_NON_LINE (MODELE=MODELE,
CHAM_MATER=CHMAT0,
EXCIT= (
_F (CHARGE=TIMP,)),),
COMP_INCR=_F (RELATION=' KIT_THHM',
RELATION_KIT= ("ELAS", "LIQU_AD_GAZ_VAPE", "THER_POLY", "HYDR_UTIL"),),
ETAT_INIT=_F (DEPL=CHAMNO,
SIGM=SIGINIT,),
INCREMENT=_F (LIST_INST=INST1,
),
NEWTON=_F (MATRICE=' TANGENTE',
REAC_ITER=1,),

```

```
RECH_LINEAIRE=_F (RESI_LINE_RELA=0.10000000000000001,  
ITER_LINE_MAXI=3,),  
CONVERGENCE=_F (  
RESI_GLOB_RELA=1.E-6,  
ITER_GLOB_MAXI=80,  
),  
PARM_THETA=0.8,  
SOLVEUR=_F (METHODE='MULT_FRONT',  
STOP_SINGULIER='NON',),  
);
```

END ();

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***Appendix 3 Example 2 of command files***

```
# EXAMPLE OF CALCULATION AXIS_THHMD FOR A BI-MATERIAUX (BARRIER  
OUVRAGEE AND  
# BARRIER GEOLOGICAL)
```

```
BEGINNING (CODE=_F (NOM='WTNA100A', NIV_PUB_WEB='INTERNET'),);
```

```
MAIL=LIRE_MAILLAGE ();
```

#  
# *LISTS MOMENTS OF CALCULATION*  
#

*INST1=DEFI\_LIST\_REEL (DEBUT=0.0,  
INTERVALLE= (\_F (JUSQU\_A=1.E7, NOMBRE=10),  
\_F (JUSQU\_A=1.E8, NOMBRE=1),  
\_F (JUSQU\_A=1.E9, NOMBRE=9),),),);*

*MAIL=DEFI\_GROUP (reuse =MAIL,  
MAILLAGE=MAIL,  
CREA\_GROUP\_NO= (\_F (GROUP\_MA=' LBABG'),  
\_F (GROUP\_MA=' LBABO'),  
\_F (GROUP\_MA=' LINTBO'),  
\_F (GROUP\_MA=' LINTBG'),  
\_F (GROUP\_MA=' SURFBO'),  
\_F (GROUP\_MA=' SURFBG'),  
\_F (GROUP\_MA=' SURF'),),),);*

*MODELE=AFFE\_MODELE (MAILLAGE=MAIL,  
AFFE=\_F (TOUT=' OUI',  
PHENOMENE=' MECANIQUE',  
MODELISATION=' AXIS\_THHMD'),),);*

#

#

*UN=DEFI\_CONSTANTE (VALE=1.0,);*

*ZERO=DEFI\_CONSTANTE (VALE=0.0,);*

*VISCOLIQ=DEFI\_CONSTANTE (VALE=1.E-3,);*

*VISCOGAZ=DEFI\_CONSTANTE (VALE=1.8E-05,);*

*DVISCOL=DEFI\_CONSTANTE (VALE=0.0,);*

*DVISCOG=DEFI\_CONSTANTE (VALE=0.0,);*

*LI2=DEFI\_LIST\_REEL (DEBUT=0.0,  
INTERVALLE=\_F (JUSQU\_A=1.E9, PAS=1.E6),),);*

*LII=DEFI\_LIST\_REEL (DEBUT=1.E-5,  
INTERVALLE=\_F (JUSQU\_A=1.0, PAS=0.099999,));*

*#  
# PROPERTIES OF BARRIER OUVRAGEE  
#*

*LTBO=DEFI\_CONSTANTE (VALE=0.59999999999999998,);  
LSO = FORMULA (REAL = "" (REAL: SAT) = (0.35\*SAT) "");*

*LSBO=CALC\_FONC\_INTERP (FONCTION=LSO,  
LIST\_PARA=LII,  
NOM\_PARA=' SAT',  
PROL\_GAUCHE=' LINEAIRE',  
PROL\_DROITE=' LINEAIRE',  
INFO=2,);  
DLSBO=DEFI\_CONSTANTE (VALE=0.35,);*

*SL = FORMULA (REAL = "" (REAL: PCAP) = 0.99\* (1. - PCAP\*6.E-9) "");*

*SATUBO=CALC\_FONC\_INTERP (FONCTION=SL,  
LIST\_PARA=LI2,  
NOM\_PARA=' PCAP',  
PROL\_DROITE=' CONSTANT',  
PROL\_GAUCHE=' CONSTANT',*

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*INFO=2,);*

*DSL = FORMULA (REAL = "" (REAL: PCAP) = -6.E-9\*0.99 "");*

*DSATBO=CALC\_FONC\_INTERP (FONCTION=DSL,  
LIST\_PARA=LI2,  
NOM\_PARA=' PCAP',  
PROL\_DROITE=' CONSTANT',  
PROL\_GAUCHE=' CONSTANT',  
INFO=2,);*

*PERM = FORMULA (REAL = "" (REAL: SAT) = SAT "");*

*PERM11BO=CALC\_FONC\_INTERP (FONCTION=PERM,  
LIST\_PARA=LII,  
NOM\_PARA=' SAT',  
PROL\_DROITE=' CONSTANT',  
PROL\_GAUCHE=' CONSTANT',  
INFO=2,);*

*DPERMBO = FORMULA (REAL = "" (REAL: SAT) = 1. "");*

*DPR11BO=CALC\_FONC\_INTERP (FONCTION=DPERMBO,  
LIST\_PARA=LII,  
NOM\_PARA=' SAT',  
PROL\_DROITE=' CONSTANT',  
PROL\_GAUCHE=' CONSTANT',  
INFO=2,);*

*PERM2BO = FORMULA (REAL = "" (REAL: SAT) = 1. - SAT "");*

*PERM21BO=CALC\_FONC\_INTERP (FONCTION=PERM2BO,  
LIST\_PARA=LII,  
NOM\_PARA=' SAT',  
PROL\_DROITE=' CONSTANT',  
PROL\_GAUCHE=' CONSTANT',  
INFO=2,);*

*DPERM2BO = FORMULA (REAL = "" (REAL: SAT) = -1. "");*

*DPR21BO=CALC\_FONC\_INTERP (FONCTION=DPERM2BO,*



*LIST\_PARA=LII,*  
*NOM\_PARA=' SAT',*  
*PROL\_DROITE=' CONSTANT',*  
*PROL\_GAUCHE=' CONSTANT',*  
*INFO=2,);*  
*#*  
*# CONDUCTIVITY THERMAL OF THE BO*  
*#*

*DM8=DEFI\_CONSTANTE (VALE=9.999999999999995E-08,);*

*KINTBO=DEFI\_CONSTANTE (VALE=9.999999999999995E-21,);*

*MATERBO=DEFI\_MATERIAU (ELAS=\_F (E=1.9E+20,*  
*NU=0.20000000000000001,*  
*RHO=2670.0,*  
*ALPHA=0.),*  
*COMP\_THM = "LIQU\_GAZ",*  
*THM\_LIQU=\_F (RHO=1000.0,*  
*UN\_SUR\_K=5.0000000000000003E-10,*  
*ALPHA=1.E-4,*  
*CP=4180.0,*  
*VISC=VISCOLIQ,*  
*D\_VISC\_TEMP=DVISCOL,),*  
*THM\_GAZ=\_F (MASS\_MOL=0.02896,*  
*CP=1000.0,*  
*VISC=VISCOGAZ,*  
*D\_VISC\_TEMP=ZERO,),*  
*THM\_VAPE\_GAZ=\_F (MASS\_MOL=0.017999999999999999,*  
*CP=1870.0,*  
*VISC=VISCOGAZ,*  
*D\_VISC\_TEMP=ZERO,),*  
*THM\_INIT=\_F (TEMP=293.0,*  
*PRE1=0.0,*  
*PRE2=1.E5,*  
*PORO=0.34999999999999998,*

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*PRES\_VAPE=2320.0,*

*DEGR\_SATU=0.57420000000000004,)*,

*THM\_DIFFU=\_F (R\_GAZ=8.3149999999999995,*

*RHO=2670.0,*

*CP=482.0,*

*BIOT\_COEF=1.0,*

*SATU\_PRES=SATUBO,*

*D\_SATU\_PRES=DSATBO,*

*PESA\_X=0.0,*

*PESA\_Y=0.0,*

*PESA\_Z=0.0,*

*PERM\_IN=KINTBO,*

*PERM\_LIQU=PERM11BO,*

*D\_PERM\_LIQU\_SATU=DPR11BO,*

*PERM\_GAZ=PERM21BO,*

*D\_PERM\_SATU\_GAZ=DPR21BO,*

*D\_PERM\_PRES\_GAZ=ZERO,*

*LAMB\_T=LTBO,*

*LAMB\_S=LSBO,*

*D\_LB\_S=DLSBO,*

*LAMB\_CT=0.728,);*

*#*

*# PROPERTIES OF THE GEOLOGICAL BARRIER*

*#*

*KINTBG=DEFI\_CONSTANTE (VALE=9.9999999999999998E-20,);*

*LTBG=DEFI\_CONSTANTE (VALE=0.59999999999999998,);*

*LSG = FORMULA (REAL = "" (REAL: SAT) =*

(0.05\*SAT) ''');

LSBG=CALC\_FONC\_INTERP (FONCTION=LSG,  
LIST\_PARA=LII,  
NOM\_PARA='SAT',  
PROL\_GAUCHE='LINEAIRE',  
PROL\_DROITE='LINEAIRE',  
INFO=2,);  
DLSBG=DEFI\_CONSTANTE (VALE=0.05,);

MATERBG=DEFI\_MATERIAU (ELAS=\_F (E=1.9E+20,  
NU=0.200000000000000001,  
RHO=2670.0,  
ALPHA=0.0,),  
COMP\_THM = "LIQU\_GAZ",  
THM\_LIQU=\_F (RHO=1000.0,  
UN\_SUR\_K=5.0000000000000003E-10,  
ALPHA=1.E-4,  
CP=4180.0,  
VISC=VISCOLIQ,  
D\_VISC\_TEMP=DVISCOL,),  
THM\_GAZ=\_F (MASS\_MOL=0.02896,  
CP=1000.0,  
VISC=VISCOGAZ,  
D\_VISC\_TEMP=ZERO,),  
THM\_VAPE\_GAZ=\_F (MASS\_MOL=0.017999999999999999,  
CP=1870.0,  
VISC=UN,  
D\_VISC\_TEMP=ZERO,),  
THM\_INIT=\_F (TEMP=293.0,  
PRE1=0.0,  
PRE2=1.E5,  
PORO=0.050000000000000003,  
PRES\_VAPE=2320.0,  
DEGR\_SATU=0.81179999999999997,),  
THM\_DIFFU=\_F (R\_GAZ=8.3149999999999995,  
RHO=2670.0,  
CP=706.0,  
BIOT\_COEF=1.0,  
SATU\_PRES=SATUBO,  
D\_SATU\_PRES=DSATBO,  
PESA\_X=0.0,  
PESA\_Y=0.0,

PESA\_Z=0.0,  
PERM\_IN=KINTBG,  
PERM\_LIQU=PERM11BO,  
D\_PERM\_LIQU\_SATU=DPR11BO,  
PERM\_GAZ=PERM21BO,  
D\_PERM\_SATU\_GAZ=DPR21BO,  
D\_PERM\_PRES\_GAZ=ZERO,  
LAMB\_T=LTBG,  
LAMB\_S=LSBG,  
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D\_LB\_S=DLSBG,  
LAMB\_CT=1.539),);

CHMAT0=AFFE\_MATERIAU (MAILLAGE=MAIL,  
AFFE= (\_F (GROUP\_MA='SURFBO',  
MATER=MATERBO,),  
\_F (GROUP\_MA='SURFBG',  
MATER=MATERBG,)),);

#  
# ASSIGNMENT OF L INITIAL STATE  
#

CHAMNO=CREA\_CHAMP (MAILLAGE=MAIL,  
OPERATION='AFFE',

```
TYPE_CHAM=' NOEU_DEPL_R',
AFFE= (_F (TOUT=' OUI',
NOM_CMP=' TEMP',
VALE=0.0,),
_F (GROUP_NO=' SURFBO',
NOM_CMP=' PRE1',
VALE=7.E7,),
_F (GROUP_NO=' SURFBG',
NOM_CMP=' PRE1',
VALE=3.E7,),
_F (NOEUD= ("NO300", "NO296"),
NOM_CMP=' PRE1',
VALE=5.E7,),
_F (GROUP_NO=' SURFBO',
NOM_CMP=' PRE2',
VALE=0.0,),
_F (GROUP_NO=' SURFBG',
NOM_CMP=' PRE2',
VALE=0.0,)),);
# EVOLUTIONARY FLOW IMPOSES IN INTERNAL P.
#
```

```
FLUX=DEFI_FONCTION (NOM_PARA=' INST',
VALE=
(0.0, 386.0,
315360000.0, 312.0,
946080000.0,12.6),);
```

```
CALEXT=AFFE_CHAR_MECA (MODELE=MODELE,
DDL_IMPO= (_F (TOUT=' OUI',
TEMP=0.0,),
_F (TOUT=' OUI',
PRE2=0.0,),
_F (TOUT=' OUI',
DX=0.0,),
_F (TOUT=' OUI',
DY=0.0,)),);
```

```
CALINT=AFFE_CHAR_MECA (MODELE=MODELE,
FLUX_THM_REP=_F (GROUP_MA=' LINTBO',
FLUN=1.0,
FLUN_HYDR1=0.0,
FLUN_HYDR2=0.0,)),);
```

```
SIGINIT=CREA_CHAMP (MAILLAGE=MAIL,  
OPERATION='AFFE',  
TYPE_CHAM='CART_SIEF_R',  
AFFE= (_F (GROUP_MA='SURFBO',  
NOM_CMP=  
("SIXX", "SIYY", "SIZZ", "SIXY", "SIXZ", "SIYZ", "SIP", "M11", "FH11X",  
  
"FH11Y", "ENT11", "M12", "FH12X", "FH12Y", "ENT12", "M21", "FH21X", "FH21Y",  
"ENT21", "QPRIM",  
"FHTX", "FHTY"),  
VALE=  
(0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,-70000.0,0.0,0.0,0.0,  
2450000.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,)),  
_F (GROUP_MA='SURFBG',  
NOM_CMP=  
("SIXX", "SIYY", "SIZZ", "SIXY", "SIXZ", "SIYZ", "SIP", "M11", "FH11X",  
  
"FH11Y", "ENT11", "M12", "FH12X", "FH12Y", "ENT12", "M21", "FH21X", "FH21Y",  
"ENT21", "QPRIM",  
"FHTX", "FHTY"),  
VALE=  
(0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,-29900.0,0.0,0.0,0.0,  
2450000.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,)),),);  
  
U0=STAT_NON_LINE (MODELE=MODELE,  
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```

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```
CHAM_MATER=CHMAT0,  
EXCIT= (  
_F (CHARGE=CAEXT,),  
_F (CHARGE=CALINT,  
FONC_MULT=FLUX,),  
),  
COMP_INCR=_F (RELATION='KIT_THHM',  
RELATION_KIT= ("ELAS", "LIQU_GAZ", "THER_POLY", "HYDR_UTIL"),),  
ETAT_INIT=_F (DEPL=CHAMNO,  
SIGM=SIGINIT),  
INCREMENT=_F (LIST_INST=INST1,),  
NEWTON=_F (MATRICE='TANGENTE',  
REAC_ITER=10,),  
CONVERGENCE=_F (RESI_GLOB_MAXI=1.0000000000000001E-05,  
ITER_GLOB_MAXI=150,  
ARRET='NON',  
ITER_INTE_MAXI=5,),  
PARAM_THETA=0.56999999999999995,  
ARCHIVAGE=_F (PAS_ARCH=1,);
```

```
U0=CALC_ELEM (reuse =U0,  
MODELE=MODELE,  
CHAM_MATER=CHMAT0,  
TOUT_ORDRE='OUI',  
OPTION= ("SIEF_ELNO_ELGA", "VARI_ELNO_ELGA"),  
RESULTAT=U0,);
```

```
TRB=POST_RELEVE_T (ACTION=_F (INTITULE='DEPL',
```

*GROUP\_NO*= (“LBABG”, “LBABO”),  
*RESULTAT*=U0,  
*NOM\_CHAM*= ' DEPL',  
*NUME\_ORDRE*= (1,10,11,20),  
*NOM\_CMP*= (“PRE1”),  
*OPERATION*= ' EXTRACTION',,);

*TRB2*=*POST\_RELEVE\_T* (*ACTION*=\_F (*INTITULE*= ' CONT',  
*GROUP\_NO*= (“LBABG”, “LBABO”),  
*RESULTAT*=U0,  
*NOM\_CHAM*= ' SIEF\_ELNO\_ELGA',  
*TOUT\_ORDRE*= ' OUI',  
*NOM\_CMP*= (“M11”, “FH11X”, “FH11Y”),  
*OPERATION*= ' EXTRACTION',,);

*ZTRB3*=*POST\_RELEVE\_T* (*ACTION*=\_F (*INTITULE*= ' DEPL',  
*NOEUD*= (“NO294”, “NO295”, “NO299”, “NO300”, “NO304”, “NO305”, “NO309”),  
*RESULTAT*=U0,  
*NOM\_CHAM*= ' VARI\_ELNO\_ELGA',  
*TOUT\_ORDRE*= ' OUI',  
*NOM\_CMP*= (“V2”),  
*OPERATION*= ' EXTRACTION',,);  
*IMPR\_TABLE* (*TABLE*=*TRB*,  
*FICHER*= ' RESULTAT',  
*FORMAT*= ' AGRAF',  
*PAGINATION*= ' INST',  
*NOM\_PARA*= (“INST”, “COOR\_X”, “PRE1”),,);

*IMPR\_TABLE* (*TABLE*=*ZTRB*,  
*FICHER*= ' RESULTAT',  
*FORMAT*= ' AGRAF',  
*PAGINATION*= ' INST',  
*NOM\_PARA*= (“INST”, “COOR\_X”, “PRE1”),,);

#  
# V2 density of the liquid  
#

*IMPR\_TABLE* (*TABLE*=*ZTRB3*,  
*FICHER*= ' RESULTAT',  
*FORMAT*= ' AGRAF',  
*PAGINATION*= ' INST',



*NOM\_PARA= (“INST”, “COOR\_X”, “V2”),);*

*END ();*

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## ***Appendix 4 Post treatment GIBI***

***\* FILE DESIGN CONTAINING THE RESULTS***

***\* -----***

***OPTI REST FORM “visuthmtbtcas3-1.cast”;***

***REST FORM;***

***\*OPTI TRAC PSC;***

***\* trace of the grid***

***trac ALL;***

***\* Creation of contours (to be able to trace the isovaleurs***

***\* without the elements: necessary if very fine grid)***

***contout = contour all;***

***trac contout;***

***\* list of the moments has to strip***

***lis0 = lect 0 1 2 3 4 5 6 7 8 9 10;***

***\* model selection***

***moc = (EMAIL ELEM QUA8);***  
***\* and (EMAIL ELEM SEG3);***  
***\****  
***Mandeleivium = moc MODE MECHANICAL RUBBER BAND;***

*\* Looping over the moments*

*\* -----*

*N = dime lis0;*

*to repeat loop1 N;*

*I = (extr lis0 &loop1) + 1;*

*p = U0. I. inst;*

*\* Deformation*

*depla = U0. I. DEPL;*

*titrate "TBT cas3-1: Deformation Time = ' p' seconds";*

*def1 = DEFORMS ALL depla 5. red;*

*init1 = DEFORMS ALL depla 0. blue;*

*TRAC (def1 and init1);*

*TRAC def1;*

*def1s = DEFORMS red SAND depla 1.;*

*init1s = DEFORMS SAND depla 0. blue;*

*titrate "TBT cas3-1: Deformation Sands Time = ' p' seconds";*

*TRAC (def1s and init1s);*

*titrate "TBT cas3-1: Deformation BO Temps = ' p' seconds";*

*def1bo = DEFORMS (BO1 and BO2) depla 5. red;*

*init1bo = DEFORMS (BO1 and BO2) depla 0. blue;*

*TRAC (def1bo and init1bo);*

*\* (the chpoint depla is transf in chamelem for the temperatures)*

*cham2 = CHAN CHAM depla Mandeleivium NODE;*

*\* Visualization of the temperatures with THM*

*chtemp = EXCO TEMP cham2;*

*titrate "TBT cas3-1: Temperature Time = ' p' seconds";*

*\* trac chtemp Mandeleivium 14 WHOLE;*

*trac chtemp Mandeleivium 14 contout;*

*\* Visualization of the pressure of pores*

*chpre1 = EXCO PRE1 cham2;*

*titrate "TBT cas3-1: Pressure of pores Time = ' p' seconds";*

*\* trac chpre1 Mandeleivium 14 WHOLE;*

*\* Visualization of the increase in gas pressure*

*chpre2 = EXCO PRE2 cham2;*

*titrate "TBT cas3-1: Increase in Pgz Time = ' p' seconds";*

*trac chpre2 Mandeleivium 14 contout;*

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*\* Constraints*

*sig = U0. I. SIEF;*

*sigxx = EXCO SMXX sig;*

*sigyy = EXCO SMYY sig;*

*sigzz = EXCO SMZZ sig;*

*sigp = EXCO SIP sig;*

*\* Calculation forced Total*

*sixxt = sigxx + sigp;*

*siyyt = sigyy + sigp;*

*sizzt = sigzz + sigp;*

*TITRATE "TBT cas3-1: Constraint Sxx Time = ' p' seconds";*

*\*trac sigxx Mandeleivium 14 WHOLE;*

*trac sigxx Mandeleivium 14 contout;*

*\*TITRE "TBT cas3-1: Cont. total Sxx Time = ' p' seconds";*

*\*trac sixxt Mandeleivium 14 contout;*

*TITRATE "TBT cas3-1: Constraint Syy Time = ' p' seconds";*

*\*trac sigyy Mandeleivium 14 WHOLE;*

*trac sigyy Mandeleivium 14 contout;*

*\*TITRE "TBT cas3-1: Cont. total Syy Time = ' p' seconds";*

*\*trac siyyt Mandeleivium 14 contout;*

*TITRATE "TBT cas3-1: Constraint Szz Time = ' p' seconds";*

*\*trac sigzz Mandeleivium 14 WHOLE;*

*trac sigzz Mandeleivium 14 contout;*

```
*TITRE "TBT cas3-1: Cont. total Szz Time = ' p' seconds";
*trac sizzt Mandeleivium 14 contout;
TITRATE "TBT cas3-1: Pressure SIP Time = ' p' seconds";
trac sigp Mandeleivium 14 contout;

* variable internal
VAR = U0. I. VARI;
var1 = EXCO V1 VAR;
var2 = EXCO V2 VAR;
var3 = EXCO V3 VAR;
var4 = EXCO V4 VAR;
TITRATE "TBT cas3-1: Increase porosity has T = ' p' seconds";
* trac var1 Mandeleivium 14 WHOLE;
trac var1 Mandeleivium 14 contout;
TITRATE "TBT cas3-1: Accroissement RhoLiq has T = ' p' seconds";
* trac var2 Mandeleivium 14 WHOLE;
trac var2 Mandeleivium 14 contout;
TITRATE "TBT cas3-1: Accroissement Pvp has T = ' p' seconds";
* trac var3 Mandeleivium 14 WHOLE;
trac var3 Mandeleivium 14 contout;
TITRATE "TBT cas3-1: Saturation has T = ' p' seconds";
* trac var4 Mandeleivium 14 WHOLE;
trac var4 Mandeleivium 14 contout;

* One reduces to sand
*sigb=REDU sig sand;
*sigxx = EXCO SMXX sigb;
*TITRE "TBT cas3-1: SiXX SANDS t=' p' seconds";
*trac sigxx Mandeleivium 14 SANDS;
end loop1;
```

opti donn 5;

end;

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**Appendix 5 additional Elements on the conditions with limits in THM**

*In what follows one does not take into account the dissolved air (the index lq corresponds then to that of water W) and one stick to the case unsaturated.*

*We point out here the choice of the unknown factors of pressure.*

**Behavior**

**LIQU\_GAZ and LIQU\_VAPE\_GAZ**

PRE1

Capillary pressure:  $p = p - p$

C

gz

lq

PRE2

Gas p pressure =

+

gz

vp

p

not

**A5.1 variational Formulation of the conservation equations**

*One refers here to [R7.01.11]. These equations are*

lq

m + vp

$m + \text{Div} (Mlq + Mvp) = 0$

& &

*éq A5.1-1*

*have*

$$m + \text{Div}(\text{Farmhouse}) = 0$$

*&*

*éq A5.1-2*

*The deduced variational formulation is given by*

-

*M*

*M*

*(m*

*+ m*

*D +*

*+*

*. D =*

*lq*

*vp) 1*

*(lq*

*vp)*

*1*

*& &*

*éq*

*A5.1-3*

*M*

*M*

*(*

*+*

*. D*  
*P*  
*lq*  
*vp*  
*ext.*  
*ext.) 1*  
*1*  
*lad*

*- m D + Mr. D =*

*have*  
*2*  
*have*  
*2*  
*&*

*éq A5.1-4*  
*M*  
*. D*  
*P*

*have ext.*  
*2*  
*2*  
*2 AD*

*The capillary pressures and of gas are related to the pressure of water, vapor and dry air by the relations:*

$$PC = pgz - plq$$

*éq A5.1-5*

$$pgz = pvp + not$$

**éq A5.1-6**  
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**The steam pressure is not an independent variable. It is connected to the pressure of liquid  $lq$   $p$  by relations**

**$dp$**   
 **$dp$**   
 **$vp$**   
 **$lq$**   
**=**  
**+ ( $hm$**   
 **$m$**   
**-**  
 **$vp$**   
 **$lq$ )  $dT$**   
 **$H$**



*éq A5.1-7*

$$\begin{aligned}
 &T \\
 &v_p \\
 &l_q \\
 &dp \\
 &m \\
 &p \\
 &= \\
 &+ 1- \\
 &l_q \\
 &dh \\
 &C dT \\
 &3 \\
 &T \\
 &l_q \\
 &( \\
 & ) l_q \\
 &l_q
 \end{aligned}$$

*éq A5.1-8*

$$\begin{aligned}
 &l_q \\
 &dh_m = C_p dT \\
 &v_p \\
 &v_p
 \end{aligned}$$

*éq A5.1-9*

*These relations show that the steam pressure is given completion not the knowledge of  $l_q$*

*p*  
*plq - 0*  
*p*  
  
*lq*  
*R*  
*p*

*(and of its evolution). Often, these relations are used to establish the law of Kelvin,*

*vp*  
  
*=*  
*T ln*  
*,*

*ol*  
*sat*

*lq*  
*Mvp*  
*p (T)*  
*vp*

*but this law is not used directly in Aster.*

*The reference documents Aster do not say anything on what are variables 1 and 2. But two elements can put to us on the track:*

*· On the one hand, P and P whereas P and P are spaces of membership of PRE1*

*1*  
*1ad*  
*2*  
*2ad*  
*1ad*  
*2ad*

*and PRE2 (thus including their boundary conditions).*

*· In addition, in chapter 7. of [R7.01.10], one sees that the virtual deformation*

*\**  
*E elg = (v, (v),*  
*is related to the vector of virtual displacement nodal*

*1 ,*  
*1 ,*  
*2 ,*  
*2 , )*

\*

$$U_{el} = (v,$$

by the same operator

$el$

$Q$  that that which connects between them the deformation

$1,$

$2)$

$G$

$el$

$$E = U, U,$$

and nodal displacement

$el$

$$U = (U, p, p, T:$$

$1$

$2$

)

$1$

,

,

$1$

$2$

,

$2$

$G$

$$((p p p p T T)$$

-

$el$

$el$

\*

$el$

\*

$$E G = Q U$$

$G$

-

$el$

$el$

$el$

$$E = Q U$$

$G$

$G$

It is then clear that and are virtual variations of  $p$  and  $p$

1  
2  
1  
2

*From where the table:*

\*  
 $p = p = p$   
 $= p$   
1  
C  
1  
C  
C  
\*  
 $p = p = p$   
 $= p$   
1  
lq  
1  
lq  
lq  
\*  
 $p = p = p$

$= p$   
2  
gz  
2  
gz  
gz

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## ***A5.2 Case of boundary conditions utilizing unknown factors principal***

***What we say in this paragraph and the following relates to part of the border***

***D on which***

***conditions are prescribed: nothing prevents of course that these conditions are not the same ones on parts of different borders. We treat in this chapter the usual case where one imposes conditions on PRE1 and/or PRE2, in opposition to the following chapter where we will speak about linear relations between unknown factors.***

***imp***

$$***PC = pgz - plq = p***$$

***C***

***imp***

$$***pgz = not + pvp = p***$$

***gz***

***Flows are then computation results by [éq A5.1-3] and [éq A5.1-4]***

***· Dirichlet PRE1, neuman PRE2***

***It is the case where one imposes a value on PRE1 and a value with flow associated with PRE2, by not saying anything on PRE2***

***or by giving a value to FLUN\_HYDR2 of FLUX\_THM\_REP in AFFE\_CHAR\_MECA. Let us call M***

***2ext this***

***imposed quantity, which will be worth 0 if nothing is known as relative with PRE2. We will note***

***imp***

***p***

***p***

***l =***

***the condition***

***l***

***imposed on PRE1***

*This corresponds to:*

*imp*

$$PC = pgz - plq = PC$$

*imp*

*imp*

*p*

*= p*

*1*

*C*

*To make the demonstration within the nonhomogeneous framework, it would be necessary to introduce a raising of the condition*

*imp*

*p*

*p*

*1 =*

*(c.à.d a particular field checking this condition). That weighs down the writings and does not bring anything, one*

*1*

*within the homogeneous framework imp is thus placed*

*p*

*= 0*

*1*

*In [éq A5.1-3] and [éq A5.1-4], one can thus take and unspecified and checking = 0 on*

*One*

*2*

*1*

*1*

*D*

*then start to take = 0 and = 0 on all the edge*

*and one obtains [éq A5.1-1] and [éq A5.1-2] with*

*1*

*2*

*feel distributions. One multiplies then [éq A5.1-1] by such as = 0 on*

*one multiplies [éq A5.1-2]*

*1*

*1*

*D*

*by unspecified, one integrates by part, one takes account of [éq A5.1-3] and [éq A5.1-4] and one obtains, in*

*2*

indicating by  $\mathbf{N}$  *the* normal at the edge:

**Mr.**

$\mathbf{N}$

$\mathbf{M}$

have

$D =$

ext.  $D =$

2

$D$

2

2

2

$D$

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One deduces some

$\mathbf{M} . \mathbf{N} = \mathbf{M}$

on

2

have  
ext.  
D

· **Dirichlet PRE2, neuman PRE1**

It is the case where one imposes a value on PRE2 and a value with flow associated with PRE1, by not saying anything on PRE1 or by giving a value to FLUN\_HYDR1 of FLUX\_THM\_REP in AFFE\_CHAR\_MECA. Let us call **M1ext** this

imposed quantity, which will be worth 0 if nothing is known as relative with PRE2. We will note

imp  
p  
p  
2 =  
the condition  
2

imposed on PRE2

This corresponds to:

imp  
pgz = not + pvp = p gz  
imp  
imp  
p  
= p  
2  
gz

The demonstration is the same one as in the preceding paragraph and leads to:

(**M** + **M** .n =M on

1

lq  
vp)  
ext.  
D

**A5.3 Case of boundary conditions utilizing relations linear between principal unknown factors**



*Code\_Aster makes it possible to introduce like boundary conditions of the relations between degrees of freedom, carried by the same node or different nodes. This possibility is reached via key word LIAISON\_DDL of order AFFE\_CHAR\_MECA.*

*That is to say imp*

*p*

*the value which one wants to impose on the pressure of liquid on*

*D. Taking into account [éq A5.1-5], and*

*lq*

*choice of the principal unknown factors for this behavior, one writes:*

*imp*

*p - p = p*

*éq A5.3-1*

*2 - p1 = p*

*gz*

*C*

*lq*

*The linear relations are treated in Aster by introduction of multipliers of Lagrange. This corresponds in the species with the following formulation:*

*To find 1*

*p, p2, μ such as:*

*- m*

*m*

*D*

*M*

*M*

*D*

*m*

*D*

*M*

*D*

*(lq +*

*vp)*

+  
***lq*** +  
 .  
***vp***  
 -  
***have***  
 +  
 .  
***have***  
 +  
***1***  
 (  
 ) ***1***  
  
***2***  
  
***2***  
***& &***  
***&***  
***éq***  
***A5.3-2***  
 +  
 \*  
***μ p - p - imp***  
***p***  
  
***D*** +  
 -  
***- imp***  
***p***  
  
***D***  
  
***D***  
 (  
***μ***  
  
***, μ***  
***2***  
***1***  
***lq***)  
***D (2 1 lq)***  
 \*  
***1***

2

*To make the demonstration within the nonhomogeneous framework, it would be necessary to introduce a raising of the condition*

*$p - p - imp$*

*$p$*

*$= 0$*

*2*

*1*

*(c.a.d of the particular fields checking this condition). That weighs down the writings and*

*$lq$*

*do not bring anything, one thus places within the homogeneous framework  $imp$*

*$p$*

*$= 0$*

*$lq$*

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*One then starts to take  $= 0$  and  $= 0$  on all the edge and one obtains [éq A5.1-1] and [éq A5.1-2] with*

*1*

*2*

*feel distributions. One multiplies then [éq A5.1-1] by unspecified one multiplies [éq A5.1-2] by*

*1*

*2*

*unspecified, one integrates by part, one carries the results found in [éq A5.3-2] and one obtains:*

***M***

***M***

***ND***

***MN***

***D***

***lq +***

***+***

***+***

***(***

***). .***

***..***

***1***

***2***

***D***

***have***

***D***

***vp***

***éq***

***A5.3-3***

***\****

***μ p - p***

***D +***

***-***

***D***

***=***

***(***

***μ***

***0***

***, μ***

***2***

***1)***

***D***

***( 2 1)***

***\****

***1***

2  
D

*It is clear that [éq A5.3-3] p gives again well - p = imp*

*p*  
*= 0*

2  
1

*lq*

*While taking moreover - = 0, one find:*

2  
1

**M**  
**M**  
**M**  
**N D**

*lq +*  
*vp +*  
*have*  
*=*

*D (*  
*).*  
*0*

1  
1

*From where one deduces:*

*(M +M +M .n =0*  
*on*

**éq A5.3-4**

*lq*  
*vp*  
*have)*

*D**A5.4 nonlinear cases*

*We do not make here that to tackle more difficult questions consisting in imposing either the steam pressure or pressure of dry air. Taking into account the relations [éq A5.1-7], [éq A5.1-8] and [éq A5.1-9] to impose a value on steam pressure amounts imposing a nonlinear relation on the pressure of liquid. In the same way to impose one pressure of dry air.*

*As example, we approach the case of a pressure of dry air imposed for a behavior LIQU\_VAPE\_GAZ, and we suppose that we can write the nonlinear relation connecting the pressure of vapor and pressure of liquid.*

*The relation to be imposed is thus:  
imp  
 $p = p - p = p$*

*éq A5.4-1**2 - p**= p**have**gz**vp**vp**have*

*By differentiating this relation, one will find a condition on the virtual variations of pressures:*

*p**p**vp**vp**dp = dp -**dp = dp -*

*dp - dp*

*have*

*gz*

*lq*

*gz*

*(gz c)*

*p*

*p*

*lq*

*lq*

*That is to say still*

*p*

*p*

*p*

*dp = dp*

*vp*

*-*

*dp - dp*

*vp*

*=*

*dp + 1*

*vp*

*-*

*dp*

*have*

*2*

*(2*

*1 )*

*1*

*2*

*p*

*p*

*p*

*lq*

*lq*

*lq*

*The variational formulation would be then:*

*- m*  
*m*  
*D*  
*M*  
*M*  
*D*  
*m*  
*D*  
*M*  
*D*  
*(lq +*  
*vp)*  
*+*  
*lq +*  
*.*  
*vp*  
*-*  
*have*  
*+*  
*.*  
*have*  
*+*  
*1*  
*(*  
*) 1*  
*2*  
  
*2*  
*& &*  
*&*  
  
*p*  
  
*p*  
  
*imp*  
*vp*



+  
\*

$\mu$

$p - p$

$p$

$D$

$D$

$vp -$

+

+ -  $vp$

$D$

(

$\mu$

1

,  $\mu$

2

have)

\*

1

2

1

2

$p$

$p$

$lq$

$lq$

$D$

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And one would find:

$p$

$p$

$vp$

$M$

$M$

$ND$

$MN$

$D$

$D$

$lq +$

$+$

$+$

$+ - vp$

$=$

$($

$). .$

..

$\mu$

1

0

,

1

2

1

2

1

2

*D*

*have*

*D*

*vp*

*p*

*p*

*lq*

*lq*

*D*

*p*

*p*

*vp*

*While taking*

*+ 1 - vp = 0 one would find:*

1

2

*p*

*p*

*lq*

*lq*

*p*

*p*

*vp*

*l-*

**(M**

***éq A5.4-2***

*lq + M vp) .n -*

*vp M .n*

*have*

*= 0*

*p*

*p*

*lq*

*lq*

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*Organization (S): EDF-DIS/SEPTEN, EDF-R & D /MMC, ENS Cachan*

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***Document: U2.04.06***

***How to dig a tunnel: methodology  
of excavation***

***Summary:***

***This note proposes a methodology to simulate the digging of an underground gallery with***

**Code\_Aster.**

*The basic method is a method usually used in this kind of studies: method “convergence containment”.*

*After a recall on the principle of the method, the principal stages of the command file Code\_Aster are described. Various numerical examples make it possible to validate the procedure.*

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**1 How to simulate the digging of a tunnel with**  
**Code\_Aster?**

**1.1**

**Principle of the method, implemented and validation**

**Context**

**The studies of géomechanics are generally based on a simulation of roadway drivage underground. Examples of application can be quoted:**

- to evaluate the zone damaged by excavation (EDZ) around a gallery of storage;**
- to study the resaturation of an cell of storage by water of the site.**

**A certain number of studies were already carried out by department AMA on this subject, with Code\_Aster. However, few elements practise are available in documentations for to reproduce this type of calculation. Department MMC undertook such a modeling with Code\_Aster, in order to adapt the procedure of application of the method classically used for this kind of calculation: method “convergence containment”. It comes out from this experiment that this application is not completely commonplace that it is necessary to raise some questions techniques practise of implementation. To capitalize this experiment for the future users is appeared like rather important, in the collective interest of the studies on storage in particular.**

**Objective**

*This note has as a principal objective to provide some preliminary technical councils to users of Code\_Aster wishing to model an underground excavation.*

## ***Methodology***

*This note presents an application to a command file of Code\_Aster of the method convergence containment. After a short recall on the principle of the method, a description practical and operational of the orders to be used is given. The method is illustrated by calculations of validation of Code\_Aster, whose command files are provided in appendix.*

## ***Result***

*Thanks to the application of the protocol suggested, two calculations of validation of Code\_Aster were implemented. The relative difference between numerical results and analytical solution is lower than 2%.*

## ***Outlines***

*The method can be extended to the calculations nonlinear (plasticity, damage) and coupled in THM, in particular within the framework of studies intended for the storage of nuclear waste.*

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## ***2 Introduction***

***For several years, studies have been carried out with Code\_Aster in order to model it***

*behavior of works geotechnics (earth dams, tunnels, barriers worked for storage of waste...).*

*Code\_Aster was already used in particular to simulate the well or roadway drivage, in tally of Stockage the geological project of nuclear waste HAVL (T4-01-10) or at the time of studies former on major storage. Reports/ratios written until now (for example [bib6], [bib7] or [bib4]) focus themselves naturally on the results, in order to answer the precise technical question who justified the study. However to simulate an excavation using a code finite elements is not inevitably an easy thing, and even if the general principles are recalled in the documents referred to above, one finds finally few elements on the structure of the command files which served as support with calculations.*

*In order to help the engineers in load of the future studies of underground excavation with Code\_Aster, this note indicates some useful recommendations to begin in the realization from this type of calculation.*

*Indeed, within the framework of the Storage project, MMC decided to adapt the step completely implementation by AMA in 2000 and 2001. For that purpose, all the step was reproduced with version 6 of Code\_Aster, on the basis of grid new and by exploring some alternatives. MMC also profited from the assistance of the agents of AMA. In addition, this work led to one validation of Code\_Aster according to traditional analytical formulas in linear elasticity (formulas kirsch and method convergence-containment, [bib5]).*

*This report/ratio thus presents:*

- traditional method of simulation of an underground excavation in 2D by means of a code finite elements;*
- different the option available to apply this method with Code\_Aster;*
- two case-tests of validation of Code\_Aster for the problems of underground excavations.*

*Thenecessary one with an advantageous reading of this note is the basic training with the use of Code\_Aster as well as a minimum of familiarisation to the software package. The detail of the various orders used is given by the user's documentation of Code\_Aster (<http://www.code-aster.org>).*

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***3***

***A method to simulate the digging of a gallery with  
to start from a model 2D***

***: the method convergence  
containment***

***3.1 Principle  
general***

***This part is inspired largely by [bib5]. Let us announce that the CIH and TEGG also carried out one certain number of studies with this method (for example, [bib2]). It is advised with the reader of to defer to these documents for more information on the principle of the method. The paragraphs which follow summarize only the essence of the step.***

***The method convergence-containment is usually used in engineering of the works undergrounds. Its objective is to obtain an order of magnitude of displacements of the walls of the tunnel as well as the efforts taken again by the rock and supporting. This method makes it possible to simplify calculation of a three-dimensional work by a two-dimensional calculation, the introduction of a parameter adimensional called "rate of déconfinement". It rests on the following assumptions:***

- plane deformations with assumption of small disturbances;***
- the tunnel is supposed of circular section and horizontal axis;***
- homogeneous ground of infinite extension;***
- massive according to a linear or elastoplastic elastic behavior;***
- initial state of the constraints presumedly isotropic and homogeneous;***
- deep tunnel: no significant variation of constraints on the height of the gallery. In practical, if  $H$  is the average depth of the work and  $R$  its ray, this assumption is***

*presumedly satisfied if  $H/R > 10$ ;*

*· quasi-static balance (not of terms of acceleration).*

*One is interested in a section located in a plan perpendicular to the axis of the tunnel and one wishes to carry out a two-dimensional calculation. The parameter is supposed to take into account the mechanical influence*

*proximity of the coal face to this section, i.e. of a phenomenon whose origin is out of the plan considered by calculation. depends on several parameters (rock, supporting, length of nonconstant tunnel behind the coal face...) and its determination is not inevitably immediate (many publications on the subject, for example [bib1]). This problem of analytical determination rate of déconfinement leaves the framework of this document.*

*In fact, one introduces to consider a fictitious tensor of the constraints in the ground, which is one fraction of the initial constraint  $\sigma_0$*

*:*

*= (1 -  $\nu$ )  $\sigma_0$*

*. with  $\nu = 1$*

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*[Figure 3.1-a] below the evolution of and the radial constraint illustrates  $R$  for a tunnel not supported.*

*=0*

*=1*

**0>>1**

**R=0**

**R=0**

**R= (1) .0**

**Appear 3.1-a: Evolution of the rate of déconfinement and the radial constraint R**

**in the case of a nonconstant tunnel**

**Let us notice that = 1 corresponds to déconfinement total of the rock: the influence of the coal face on the behavior of the section of tunnel disappeared and the tunnel is comparable to a very thick tube.**

**Since a part, even the totality of the constraints initially present within the solid mass disappear (it is precisely the phenomenon of déconfinement), the walls of the excavation go to tend to approach to reach a new mechanical balance. It is the phenomenon of “convergence”. This phenomenon can lead to the ruin of the work if the structure does not arrive to to find a state of steady balance following the excavation.**

**If, for reasons of safety or stability, one decides to pose a supporting or a coating to the wall of the tunnel, those go, from their mechanical stiffness, to be opposed to the natural phenomenon**

**convergence. In this case, final balance thus depends on the mechanical interaction between the rock and it**

**coating. Generally, this balance does not allow the constraints in the rock solid mass to cancel itself like in the case of the nonconstant tunnel. It is said whereas the ground is confined, from where it**

**name of the method “convergence-containment”.**

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*Graphically, the application of this method amounts seeking the point of intersection of the curve of convergence, deduced from the behavior of the ground, and curve of containment, deduced from behavior of supporting [Figure 3.1-b].*

*Appear 3.1-b: Example of curves of convergence and containment*

*Equations of the method “convergence-containment” in the case of a linear elastic solid mass are provided in [Annexe 1].*

*That it is for analytical or numerical calculations, this method allows, using simple model 2D, to deal with the 3D problem which the simulation of an excavation constitutes.*

**3.2 Application of the method for a numerical calculation by elements finished**

*A characteristic of calculations of excavation by finite elements is the need for implementing several models (in the broad sense).*

*Indeed, a traditional course of modeling can be summarized by the following stages:*

- stage 1: initialization of in situ constraints;*
- stage 2: calculation of the nodal reactions on the level of the walls of the excavation;*
- stage 3: déconfinement solid mass to simulate the progressive excavation and the distance of coal face;*
- stage 4: possible installation of a supporting/coating and end of déconfinement.*

*If the study requires it, the sequence of stages 2, 3 and 4 can be repeated (case of an excavation in divided sections, for example).*

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***In the majority of the cases, the sequence of calculations is thus done on the basis of four configuration [Figure 3.2-a].***

***Solid mass of ground***

***Solid mass of ground***

***Excavation of***

***Pose***

***Initialization of***

***gallery***

***coating concrete***

***constraints***

***Calculation of the reactions***

***nodal***

***1***

***2***

***3***

***4***

***Appear 1.2-a: Typical example of sequence of a calculation of excavation with a computer code***

***The first configuration is used for:***

- to initialize the constraints of origin geostatics;***
- to initialize the hydrostatic pressure due to the possible presence of water and the temperature ( present note does not discuss this precise item in detail);***

***The second configuration makes it possible to calculate the reactions to the nodes representing the edge of the excavation.***

***At these stages of modeling, all the elements of the grid thus correspond to a material of ground type or rock. One thus obtains a solid mass of ground in which reign a state of stresses***



*corresponds to the state of in situ stresses in the plan perpendicular to the axis of the gallery. One knows*

*also nodal reactions at the edge of the excavation, which will allow déconfinement partial or total of the solid mass in the stages which follow.*

*The third configuration is dedicated to déconfinement: one decreases the nodal reactions at the edge of*

*the excavation in order to simulate the digging of the tunnel. At the time of the realization of this stage, the elements*

*stop in the area corresponding inside the gallery do not have to take part more in the rigidity of model. As it further will be seen, this can be taken into account in several ways in practice.*

*One possibly passes to a fourth stage if one wants to simulate the installation of a supporting concrete in the course of déconfinement for example. In this case, one adds elements with characteristics of concrete and one continues the reduction in the nodal reactions calculated in the stage  $n \cdot 1$*

*to complete calculation.*

*It is thus noticed that certain parts of the initial model will be seen affecting successively properties of ground, “concrete vacuum” then. In this sequence is the source of some intrinsic difficulties with this kind of calculation.*

*The application of this step by means of Code\_Aster is covered in the following chapters. It is based on a simple case.*

**4**

*Before attacking card-indexing of Code\_Aster order...*

*This chapter relates to some particular points of modeling which it seems important of to comment before being interested in the command files themselves. It is made up of one continuation of paragraphs treating each one a question which an engineer can put when it carries out one*

*traditional calculation of excavation using a standard code finite elements like Code\_Aster.*

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**4.1**

***How to define the models starting from a simple grid?***

***The grid chosen in this study represents a quarter of model representing a gallery cylindrical in infinite medium. The ray of the gallery is 1,50 meter, the thickness of concrete is 0,30 measure and the grid is a square of 20 side meters. According to the usual rules of modeling, it relationship between the ray excavated R and dimension characteristic of the grid L is sufficient for to consider that the boundary conditions do not disturb the behavior of the excavation (L 10 X R).***

***Ground***

***Ground, empty***

***or concrete***

***Ground or vacuum***

***Appear 2.1-a: Grid used and materials***

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*From the point of view of the models (with the Code\_Aster direction), it is necessary to distinguish some particular zones from grid (in addition to the other more traditional zones, like the edges of the grid) and to create the objects following (the names refer to the command files presented in Appendix):*

- the excavated edge where will be applied the nodal reactions to simulate déconfinement (called EDGE);*
- the two points which are located at the ends of this curve, which are concerned at the same time by the loading of déconfinement and by the boundary conditions at the edge of the solid mass.*

*Appear 4.1-b: Points and of points particular to identify together in the Code\_Aster models*

*One can thus define (for example, because several configurations are possible):*

- a model GROUND, in which all the grid is affected finite elements;*
- a model SOL\_REST which does not include/understand the meshes which correspond to the excavated part (they are not affected finite elements);*
- a model SOL\_REST0 which includes/understands SOL\_REST and the meshes corresponding to the coating out of concrete affected of finite elements.*

*Note:*

*The use of such a geometry to make a real calculation of excavation is partially criticizable, because symmetry suggested risk to generate a nonphysical loading. In case of application of the actual weight for example, this one would be directed upwards in the part lower of the tunnel!*

*Gravity*

*Part with a grid*

*Tunnel*

*Gravity induced by*

*boundary conditions*

*Part nonwith a grid but*

*simulated by symmetry*

*Appear 4.1-c: Example of aberration which the use of a quarter of model can generate in the simulation of a tunnel*

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*For a realistic study where one would wish to initialize the constraints using a loading in weight clean, it would be thus necessary “to net the ground” to the rigid substratum (rock considered indeformable), or all at least until a sufficient depth to be been free from the problem evoked above. One thus nets a half-model in this case there.*

*However, within the framework of our study, this constraint of grid did not obstruct us, since we took into account neither the actual weight, nor couplings THM. The simulated loading is very with fact compatible with the analytical solutions tested.*

## 4.2

### ***How to initialize the constraints?***

*In situ constraints are generally represented by a tensor of order 2 of which directions principal correspond to the vertical and the horizontal one. The vertical constraint is generally equalize with the weight of the various formations located above the point considered and the constraint horizontal is proportional to the vertical constraint:*

$$v = .z$$

$$H = K 0$$

$$. v$$

*with the voluminal weight of the overlying ground (in kN/m<sup>3</sup> for example) and K0 a coefficient without dimension. K0 can be determined by in situ measurements or be estimated by relations more or less empirical. In the case of a semi-infinite solid mass subjected to an external constraint on its higher edge or to its actual weight, the theory of linear elasticity provides a value of K0 according to Poisson's ratio:*

*K0 =*

*1-*

*Two methods were tested with Code\_Aster to initialize the constraints in the ground boxing:*

- realization of a calculation (order STAT\_NON\_LINE) with a fictitious material equipped with one Poisson's ratio allowing to obtain desired the K0 report/ratio. This calculation is carried out on model which takes again all the grid of the study (for example, the model called GROUND in preceding chapter). In this case, K0 1 (case of linear elasticity). There are the numerous ones case where K0 1 (if the ground is subjected to tectonic constraints, for example). In this case, the following method becomes obligatory;*
- to directly assign the constraints to all the elements of the grid by the order CREA\_CHAMP (option: OPERATION = "AFFE");*

*The first solution requires to define a fictitious material and to implement a calculation moreover. However, if the loading is the actual weight (what is not the case of the case-test only us let us propose), this method appeared at the same time intuitive to us and simple. In the case of a field of constraints uniform, the use of CREA\_CHAMP is unquestionably the most interesting method: it saves time computing and its call is even simpler. For distributions of more complex constraints, CREA\_CHAMP also functions but we did not use it (it paragraph [§ 3.5.3.1] of documentation [U4.72.04] B1 index gives an example adaptable to our problem).*

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### **4.3 How to calculate the nodal reactions at the edge of the “future one” gallery?**

To calculate the nodal reactions at the edge of the gallery, it is necessary to block this part of grid. This operation should not generate nonphysical constraints by incompatibility with the loading applied at the time of the phase of initialization. A possibility offered consists to impose the same loading as at the time of the initialization of the constraints by blocking the nodes of edge of the gallery only during this stage of calculation. This operation is without effect on total result, which remains identical to that of the preceding stage, but the “temporary” blocking of nodes of the edge of the gallery makes it possible to evaluate the nodal reactions there.

Even loading  
that at the stage  
the preceding one  
Blocked nodes  
 $U = 0$

#### **Appear 4.3-a: Blocking of the nodes of the edge of the gallery to calculate there nodal reactions**

Concretely, this relative blocking of the edge of the gallery is possible thanks to option DIDI (for Dirichlet

Differential) of key word EXCIT of operator STAT\_NON\_LINE (Doc. Aster [U4.51.03] F4 index, paragraph [§3.2.2]). The blocking of these nodes applies only to the increment of displacement considered and not on total displacement (one imposes  $U = 0$  and not  $U = 0$ ).

The initial state of this calculation (key word ETAT\_INIT of operator STAT\_NON\_LINE) is defined by the field constraints obtained at the end of the preceding stage.

Once this intermediate calculation carried out, the calculation of the nodal reactions is carried out simply by the call to an order CALC\_NO provided with the option OPTION = “REAC\_NODA”. It is appropriate then of to provide to order CALC\_NO all the loadings having produced the result from which one calculate the nodal reactions, without omitting the loading voluminal if they exist (not taken in count in the examples treated here).

One then builds a vector of loading by the recovery of the nodal reactions (CREA\_CHAMP with the key words TYPE\_CHAM = “NOEU\_DEPL\_R”, NOM\_CHAM = “REAC\_NODA” and OPERATION = “EXTR”). It should be noted that according to the paragraph [§3.1.1] of the user's documentation of

*Code\_Aster [U4.72.04] index B1, the option TYPE\_CHAM = "NOEU\_DEPL\_R" of the order CREA\_CHAMP is in fact without effect here (but nevertheless obligatory from the syntactic point of view), since an extraction is carried out. This vector is then defined by order AFFE\_CHAR\_MECA with key word VECT\_ASSE as a loading for the call following to order STAT\_NON\_LINE (corresponding to the progressive excavation of the gallery). This loading is associated a function (operator DEFI\_FONCTION) describing the evolution of the rate of déconfinement progressively with progression of the digging.*

*Also let us notice that all the nodal reactions are extracted: those which act on the edge gallery as those which act on the other edges of the model. Since these last act on points blocked with all the stages of the calculation of excavation, their injection as loading in the following STAT\_NON\_LINE is without effect on the constraints and the deformations with centre of the structure.*

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## **4.4**

### ***How to simulate the creation of a "vacuum" in the solid mass and the installation concrete?***

*Once carried out the calculation of the nodal reactions the question of the "elimination" of the part arises*

*excavated digital model so that its rigidity does not block the convergence of the tunnel. For y to arrive, we adopted two methods [Figure 4.4-a]:*



- *method a: quasi-cancellation of the mechanical properties of the elements located in the zone excavated (example:  $E = 0,0001 \text{ Pa}$ ), then introduction of more realistic properties at the time of pose supporting or coating. This method makes it possible to simplify the file of order Code\_Aster and gives correct results for the simple case that we have studied (small circular gallery, excavated in only one section in an elastic solid mass). For to undertake more elaborate studies where the digital processing could be affected by presence of element with very low rigidity, it seems nevertheless preferable to us to rest on following method;*
- *method b: initialization of the constraints directly by creation of fields at the points of Gauss resulting from a calculation concerning a preceding stage.*

*Method A*

*Method B*

*Ground*

*“Vacuum”*

*Concrete*

*1*

*2*

*3*

#### ***Appear 4.4-a: Various principles of modeling to simulate déconfinement solid mass***

*Other methods which we did not test can undoubtedly be applied to the problem studied (as the creation of double nodes at the borders between materials which make it possible to bind or not two structures).*

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#### **4.4.1 Method**

##### **With**

*Method A does not call for a particular observation: it is enough to affect characteristics very weak mechanics with the meshes becoming “empty” during calculation of déconfinement.*

*One proceeds in two times:*

- a first order STAT\_NON\_LINE, which makes it possible to reinject the made up loading vector of the nodal reactions and boundary conditions. “Empty” meshes thus correspond to a very soft material;*
- a second call to STAT\_NON\_LINE which introduces supporting or the concrete pavement by assigning to the corresponding meshes realistic characteristics for such a material.*

*With each call, the initialization of calculation takes again the entirety of the fields resulting from preceding calculations (operand EVOL\_NOLI for key word ETAT\_INIT).*

#### **4.4.2 Method**

##### **B**

*This procedure is based on the sequence of several models (with the Code\_Aster direction). Calculation be carried out by copying certain fields from one model to another.*

*The fields to be assigned to the model corresponding at the B-3 stage of [Figure 4.4-a] are formally linear combination of two fields:*

- fields resulting from the preceding stage of calculation (B-2) and which relates to only the model corresponding to the solid mass of private ground of the excavated zone;*
- fields assigned to the elements of the group of mesh which represent the voussoirs in concrete, in the model which includes/understands the solid mass and the gallery lining. In our case, these fields must be initialized to 0 in B-3. For that, one can for example affect one null weight with their contribution in the linear combination. Thus these fields can in fact to be obtained by an intermediate calculation without real physical significance, for example the simple application of the boundary conditions.*

*One uses order CREA\_CHAMP with the option ADZE to assign to the points of Gauss third models the linear combination of fields resulting from preceding calculations.*

## **4.5**

### **Summary of the methods suggested**

*To initialize the constraints, one can call upon two methods:*

- *Méthode I: to make a calculation (call to STAT\_NON\_LINE) on fictitious material;*
- *Méthode II: to create the stress field wished by CREA\_CHAMP.*

*To simulate the digging and the installation of the voussoirs, there are the choice between:*

- *Méthode a: which consists in mechanically affecting “flexible” characteristics very in the excavated zone;*
- *Méthode b: which makes the use of several models which are connected and which is more near to the physical reality of the modelled structure, materials appearing and disappearing by activation from one model to another.*

*A synthetic flow chart is proposed in [§Annexe2].*

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## **5** **Examples of command files**

*This part presents examples of structures of command file Code\_Aster concerning a circular excavation in infinite and elastic medium linear, within the framework of a study purely mechanics (not of coupling THM).*

*Three calculation cases are presented in this part:*

- an excavation without supporting with initialization by a bearing calculation on a fictitious material to obtain the stress field wished (method I);
- an excavation with supporting, initialization of the constraints by a call to CREA\_CHAMP and followed method A for déconfinement and poses it voussoirs (methods II + A);
- an excavation with supporting, initialization of the constraints by a call to CREA\_CHAMP and followed method B for déconfinement and voussoirs (methods II + B) poses it.

For cases 2 and 3, the scenario of digging is as follows: excavation, déconfinement to 50% (= 0,5), poses voussoirs of 30 cm thickness and end of déconfinement. These two cases are the object of case-test of validation of Code\_Aster (implemented planned for the beginning of 2003).

## 5.1

### **The dealt with problem**

The geometry of the grid is listed in the paragraph [§4.1]. It contains 8477 nodes and 3304 elements. The ray of the gallery is 1,50 meter, the thickness of concrete is 0,30 meter and the grid is a square of 20 meters of with dimensions. The other data are summarized in the following table.

### **Material Parameter**

#### **Value**

*K0*

1

#### **Rock**

$\nu = H$

5 MPa

*E*

4

GPa

0,3

#### **Concrete**

*E* 20

GPa

0,2

### **Table 5.1-1: Data of the cases tests suggested**

The boundary conditions and the loading are illustrated by the following figure:

Unclaimed rock pressure known (5 MPa)

$U_x = 0$

$U_x = 0$

*Déconfinement*

$U_y = 0$

### ***Appear 5.1-a: Boundary conditions imposed and loading***

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.  
2 G

*At the end of the process of déconfinement, =*

.  $U R = 69$

,

0

.

.

0 R

*An example of file of grid in language gibiane (mail.dgib) is presented in [Annexe 3].*

### ***5.2 Case n° 1: excavation without supporting with initialization of constraints by a calculation and “softening” of the elements “excavated”***

*This example is relatively simple: it is a question of simulating an excavation without installation of supporting,*

*with déconfinement total at the edge of the gallery. One thus uses one model for all calculation.*

*The initial state is generated by a calculation (STAT\_NON\_LINE) which relates to the whole of the grid. properties of the elements are affected according to the state of stresses which one wants to reach (here  $K0 = 1$  thus = 0,4999, the value of 0,5 meaning the incompressibility of the rock not being able to be used).*

*Following calculation relates to the nodal reactions at the edge of the future gallery. It is initialized from constraints resulting from the first call to STAT\_NON\_LINE.*

*The last call to STAT\_NON\_LINE is used to reinject the nodal reactions in a model where mechanical properties of the excavated elements were very strongly weakened (E tends towards 0.). One déconfiner then completely the ground while making tighten these reactions towards 0.*

*The corresponding command file is presented in [Annexe 4].*

### **5.3 Case n°2: excavation with supporting with initialization of constraints by call to CREA\_CHAMP and déconfinement according to method A**

*One follows the scenario of excavation described above. One uses that only one model for all calculation. One order additional STAT\_NON\_LINE allows to introduce the voussoirs with a rigidity realistic after déconfinement of 50%.*

*The corresponding command file is presented in [Annexe 5].*

### **5.4 Case n°3: excavation with supporting with initialization of constraints by call to CREA\_CHAMP and déconfinement according to method B**

*One always follows the scenario of excavation describes higher. This time, three models are used and one intermediate calculation (without physical reality, called “can”) is necessary to transfer them fields of variables from one model to another at the time of the installation of the voussoirs afterwards déconfinement of 50%.*

*The corresponding command file is presented in [Annexe 6].*

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## **6 Validation**

***Code\_Aster on an example of excavation in linear springy medium***

*The validation of Code\_Aster rests on the comparison of the numerical results resulting from the cases n°1, 2*

*and 3 listed above with the analytical solution of [Annexe 1]. For each calculation, one presents them results obtained on the level of the keystone and the oven wall of the gallery, in term of constraint radial R, forced orthoradiale and radial displacement U R ([Table 6-1], [Table 6-2] and Table 6-3). [Annexe 7] presents two graphs describing the space evolution of the constraints it length of the vertical axis of the model, with the right of the excavation. The good agreement between analytical solution and*

*numerical results makes that the difference between these curves is hardly visible.*

*R (y)*

*With*

*R*

*U R*

*B*

***Appear 6-a: Sizes compared for the validation of Code\_Aster***

*Not A*

*Not B*

*Analytical variable*

*Aster Variation  
relative Analytical*

*Aster  
Variation  
relative*

*(Pa)  
0.  
-8.411 E3  
One checks*

*0. -1.625  
E4  
It is checked that*

*R  
that  
|| << ||  
R*

*|| << ||  
R*

*(Pa)  
- 1. E7  
-9.883 E6 1,2%*

*- 1. E7  
-1.011 E7  
1,1 %*

*Ur (m)  
- 0.0024375 - 0.0024772*

*1,7 %  
- 0.0024375 - 0.0023982*

*1,6 %  
**Table 6-1: Case n°1, analytical comparison solution/Code\_Aster results for  
constraints radial and orthoradiale and for radial displacement in A and B***

*Not A  
Not B  
Analytical variable*

*Aster Variation  
relative Analytical  
Aster  
Variation  
relative*



(Pa)  
- 1.52821  
-1.52974 E6  
0,1%  
- 1.52821  
-1.52652 E6  
0,1 %  
R  
E6  
E6  
  
-8.40987 E6  
0,7 %  
- 8.47179  
-8.52586 E6 0,6%  
(Pa)  
- 8.47179  
E6  
E6  
Ur (m)  
- 0.0016925 - 0.0017218  
1,7 %  
- 0.0016925 - 0.0016664  
1,5 %

**Table 6-2: Case n°2, analytical comparison solution/Code\_Aster results for constraints radial and orthoradiale and for radial displacement in A and B**

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*Not A*

*Not B*

*Analytical variable*

*Aster Variation*

*relative Analytical*

*Aster*

*Variation*

*relative*

*(Pa)*

- 1.52821

- 1.52943

0,1 %

- 1.52821

- 1.53171

0,2 %

*R*

*E6*

*E6*

*E6*

*E6*

-8.40822 E6

0,8 %

- 8.47179

- 8.52418

0,6 %

*(Pa)*

- 8.47179

*E6*

*E6*

*E6*

*Ur (m)*

- 0.0016925 - 0.0017211

1,7 %

- 0.0016925 - 0.0016658

1,6 %

***Table 6-3: Case n°3, analytical comparison solution/Code\_Aster results for constraints radial and orthoradiale and for radial displacement in A and B***

*The maximum difference between analytical and numerical results is lower than 2%, with share for the constraint radial at the edge of the gallery excavated in the case n°1, where the theoretical value is 0. The validity of calculation is checked by considering that the radial constraint is quite negligible in front of the constraint orthoradiale.*

*Of course, all these variations can be reduced if the grid is still refined.*

## **7** ***As a conclusion: councils and prospects***

*This note proposes a methodology which makes it possible to carry out calculations of excavation using Code\_Aster. Several scénarii of excavation reviewed and several methods are proposed.*

*The method and the software package are validated in the case of a circular gallery, dug in a solid mass infinite constituted by a linear elastic material. Code\_Aster reproduces way completely satisfactory the behavior of such an underground structure, with or without taking into account of supporting and/or of the coating.*

*From the point of view of the user, it seems more practical and more rapid to initialize the constraints by one call to order CREA\_CHAMP rather than by a calculation on fictitious material.*

*If one seeks to model a purely mechanical behavior and if the phasage of the excavation is relatively simple, to work with only one model appears to be the easiest method. It is enough to assign very weak material properties to the meshes becoming "empty". In the cases more complicated, the implementation of several models used successively can prove more reliable from the point of view of implementation the practical (error of modeling) and from the numerical point of view (miscalculation), in spite of the intermediate procedures of transfer of the fields (forced, displacements, pressures, temperatures, variables intern...) from one model to another.*

*A later stage of validation of Code\_Aster could be done on the linear coupled problems (THM in saturated and elastic medium) or coupled and/or nonlinear (being connected model CJS 1 with model of Mohr Coulomb, short-term excavation in not drained to compare with [bib3]).*

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**Appendix**

***1 analytical Formulas to apply the method  
convergence-containment with the case of a rock solid mass  
and of a supporting rubber bands and linear***

*The medium is supposed to be elastic linear isotropic and subjected to an also isotropic stress field  
initial  
( $K0 = 1$ ).*

***Radial constraint, forced orthoradiale and radial displacement with the wall of the tunnel in springy  
medium  
subjected toa rate of déconfinement***

$R$

. 2

0

$R = 1$

.

2

$R$

$$R \\ . 2 \\ = I + \\ 0$$

2 .

R

$$R^2 \\ 0$$

$$U R =$$

$$R \\ G \\ 2$$

*G is given by the following relation:*

$$= \\ E \\ G$$

$$2 I \\ ( + )$$

***Behavior of supporting:***

***Either K S the stiffness of supporting, it is given by the following relation if it is considered that supporting is comparable to a thick or thin tube (vb is the Poisson's ratio of the concrete):***

$$E_b E$$

***if R > 10th***

$$(1 - 2 \\ b) R \\ K_s = \\ 2$$

2

***Eb (Re - IH)***  
***if R 10th***

2

2

(1+

1 2

b) (

***[- B) Re +Ri]***

***That is to say S***

***P confining pressure defined on the following figure***

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*One thus has:*

$P R = E$

$S$

$B$

$K$

*If  $K$*

$S$

$S =$

*represent rigidity relating and the rate of déconfinement to the installation of*

$2 G$

$D$

*supporting, then the pressure of supporting and radial displacement in wall are given by:*

$k_s$

$0$

$PS =$

$(1 - D)$

$I + k_s$

$I +$

$0$

$D k_s$

$U R =$



*R*

*1+ ks*

*2 G*

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**Appendix**

**2**

***Flow chart of synthesis on the methods***

***allowing to simulate an excavation in***

***Code\_Aster***

***Notations***

***The names of the objects are those of the command files presented in the appendices following.***

***SNL means STAT\_NON\_LINE; DC means CREA\_CHAMP; CL means boundary conditions***

***Stage I: Initialization of the constraints***

***I: SNL1 with the actual loading of weight II: assignment by order DC of the field***

***or of pressure wished and a desired equipped material***

***of a Poisson's ratio possibly***

***fiction***

***GROUND***

**Stage 2: Recovery of the nodal reactions at the edge of the future gallery**  
**DC to extract the constraints resulting from SNL 1 with CL out of SNL 1 with CL on the object**

**SNL1**  
**the EDGE object in DIDI EDGE in DIDI on**  
**SNL 2 with CL on the EDGE object in DIDI**  
**on model GROUND**  
**model SOL\_REST**  
**SOL\_REST**  
**Recovery of the reactions**  
**Recovery of**  
**Recovery of**  
**reactions**  
**reactions**  
**EDGE**

**Stage 3: Déconfinement**  
**SNL 3 with**  
**SNL 2 (model GROUND) SNL 2 (only one material**

**loading of**  
**with the loading and model SOL\_REST)**  
**vector of the SOL\_REST**  
**vector of**  
**with the loading of**  
**SOL\_REST**  
**nodal reactions and**  
**nodal reactions and vector of the reactions**  
**a “soft” material**  
**a “soft” material nodal**  
**in the place of**  
**in the place of the “vacuum”**  
**“vacuum”**  
**EDGE**  
**EDGE**

**Soft elements**

**Stage 4: Pose supporting**  
**SNL 4 with 3**  
**SNL 3 with 3 DC to extract them**

**materials:**  
**rock,**  
**materials:**  
**rock, results of SNL 2**  
**concrete and vacuum**  
**SOL\_REST**  
**concrete and vacuum**  
**SNL 3 on model**  
**SOL\_REST**  
**(method A) for**  
**(method A) for SOL\_REST + CONCRETE)**  
**to complete it**  
**to complete it**  
**for calculation intermédiaire**  
**déconfinement**  
**déconfinement**  
**Combianson of the fields**  
**EDGE**  
**DC**  
**EDGE**  
**SNL 4 to complete it**  
**déconfinement**  
**Soft elements**

**CONCRETE**

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**Appendix 3 File of grid carried out with GIBI**

\*\*\*\*\*

**\* SAFEGUARD IN A FILE .MGIB AFTER COMPILATION \***

\*\*\*\*\*

**OPTION SAUV FORM "mail.mgib";**

\*\*\*\*\*

**\* OPTION OF MODELING \***

\*\*\*\*\*

**OPTI DIME 2 ELEM QUA8;**

\*\*\*\*\*

**\* POINTS \***

\*\*\*\*\*

**E1 = 0. 0. ;**

**E2 = 0.9 0. ;**

**E3 = 0.7.0.7;**

**E4 = 0. 0.9;**

**B1 = 1.2 0. ;**

**B2 = 0. 1.2;**

**S1 = 1.5 0. ;**

**S2 = 20. 0. ;**

**S3 = 20. 20. ;**

**S4 = 0. 20. ;**

**S5 = 0. 1.5;**

**S6 = (1.5 \* (SIN 45)) (1.5 \* (COS 45)) ;**

\*\*\*\*\*

**\* RIGHT-HAND SIDES \***

\*\*\*\*\*

**E1E2 = E1 DROI 16 E2;**

**E2E3 = E2 DROI 16 E3;**

**E3E4 = E3 DROI 16 E4;**

**E4E1 = E4 DROI 16 E1;**

**B1S1 = B1 DROI 4 S1;  
S5B2 = S5 DROI 4 B2;  
E2B1 = E2 DROI 4 B1;  
B2E4 = B2 DROI 4 E4;**

**S1S2 = S1 DROI -70 S2 DINI 0.01 DFIN 0.50;  
S2S3 = S2 DROI 16 S3;  
S3S4 = S3 DROI 16 S4;  
S2S3S4 = S2S3 AND S3S4;  
S4S5 = S4 DROI -70 S5 DINI 0.50 DFIN 0.01;  
S3S6 = S3 DROI -70 S6 DINI 0.70 DFIN 0.001;**

\*\*\*\*\*

**\* ARCS \***

\*\*\*\*\*

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**S1S5 = 32 CERC S1 E1 S5;  
S5S6 = 16 CERC S5 E1 S6;  
S6S1 = 16 CERC S6 E1 S1;  
B2B1 = 32 CERC B2 E1 B1;**

\*\*\*\*\*

**\* DEFINITION OF THE GROUPS OF MESH \***

\*\*\*\*\*

**EDGE = SIS5;**  
**MA\_HAUT = S3S4;**  
**BAS\_BETO = B1S1;**  
**LEFT\_BET = S5B2;**  
**NO\_DROIT = S2S3;**  
**NO\_LEFT2 = S4S5;**  
**NO\_BAS2 = SIS2;**  
**NO\_LEFT3 = NO\_LEFT2 AND LEFT\_BET;**  
**NO\_BAS3 = BAS\_BETO AND NO\_BAS2;**  
**NO\_LEFT1 = NO\_LEFT3 AND B2E4 AND E4E1;**  
**NO\_BAS1 = E1E2 AND E2B1 AND NO\_BAS3;**

\*\*\*\*\*

**\* SURFACES \***

\*\*\*\*\*

\*-----\*

**\* EXCAVATION PART \***

\*-----\*

**EXCAV1 = DALL E1E2 E2E3 E3E4 E4E1;**  
**TRAC EXCAV1;**

**E4E3E2 = (INVE E3E4) AND (INVE E2E3);**  
**EXCAV2 = DALL E2B1 (INVE B2B1) B2E4 E4E3E2;**  
**TRAC EXCAV2;**

**EXCAV = EXCAV1 AND EXCAV2;**  
**ELIM .005 EXCAV;**  
**TRAC EXCAV;**

\*-----\*

**\* CONCRETE PART \***

\*-----\*

**CONCRETE = DALL BAS\_BETO "PLANE" EDGE LEFT\_BET B2B1;**  
**ELIM .005 CONCRETE;**  
**TRAC CONCRETE;**

\*-----\*

**\* PART SOL\_REST \***

\*-----\*

**SOL1 = "PLANE" DALL NO\_BAS2 NO\_DROIT S3S6 S6S1;  
TRAC SOL1;**

**SOL2 = DALL MA\_HAUT NO\_LEFT2 S5S6 (INVE S3S6) "PLANE";  
TRAC SOL2;**

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**SOL\_REST = SOL1 AND SOL2;**

**ELIM .025 SOL\_REST;**

**TRACE SOL\_REST;**

**\*-----\***

**\* PART SOL\_RES0 \***

**\*-----\***

**SOL\_RES0 = CONCRETE AND SOL\_REST;**

**ELIM .005 SOL\_RES0;**

**TRAC SOL\_RES0;**

**\*-----\***

**\* TOTALITY = GROUND \***

**\*-----\***

**GROUND = SOL\_REST AND CONCRETE AND EXCAV;**

**ELIM 0.015 GROUND;**

**TRACE GROUND;**

\*\*\*\*\*

**\* SAFEGUARD FORMAT \***

\*\*\*\*\*

**SAUV FORMAT GROUND;**

**END;**

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**Appendix 4 Excavation without supporting, on the basis of one only model (case n°1). Command file Code\_Aster**

**BEGINNING ();**

**#####**

**# READING GRID GIBI**

**#####**

**PRE\_GIBI ();**

**MAIL=LIRE\_MAILLAGE ();**



```
#####  
# MODELING Of an EXCAVATION WITHOUT SUPPORTING Of a TUNNEL IN D.P  
#####  
# DEFINITION OF THE GROUPS OF NODES FOR WHICH THERE WILL BE  
# OF DISPLACEMENTS IMPOSE  
#  
# NO_BAS1: GROUP NODES OF THE LOWER EDGE OF ALL THE SOLID MASS  
# BEFORE EXCAVATION.  
# NO_BAS2: GROUP NODES OF THE LOWER EDGE AFTER EXCAVATION,  
# BUT BEFORE INSTALLATION OF THE VOUSSOIRS.  
# NO_BAS3: GROUP NODES OF THE LOWER EDGE AFTER EXCAVATION,  
# AND POSES VOUSSOIRS.  
#  
# NO_DROIT: GROUP NODES OF THE FLAT RIM.  
#  
# NO_HAUT: GROUP NODES OF THE HIGHER EDGE.  
#  
# NO_LEFT1: GROUP NODES OF THE LEFT EDGE OF ALL THE SOLID MASS  
# BEFORE EXCAVATION.  
# NO_LEFT2: GROUP NODES OF THE LEFT EDGE OF ALL THE SOLID MASS  
# AFTER EXCAVATION, BUT BEFORE INSTALLATION OF THE VOUSSOIRS.  
# NO_LEFT2: GROUP NODES OF THE LEFT EDGE AFTER EXCAVATION  
# AND POSES VOUSSOIRS.  
#####
```

```
#####  
# DEFINITION OF THE GROUPS OF NEOUDS  
#####  
# OPTION "DIFFE" MAKES IT POSSIBLE TO INSULATE  
# Of the BORD_SOL the NEOUDS N1 AND N8359  
#####
```

*EMAIL = DEFI\_GROUP (reuse=MAIL,*

*MAILLAGE=MAIL,*

*CREA\_GROUP\_NO= (\_F (GROUP\_MA=' SOL'),*

*\_F (GROUP\_MA=' SOL\_REST'),*

***\_F (GROUP\_MA=' EXCAV'),***

***\_F (NOM=' NO\_HAUT',***

***GROUP\_MA=' MA\_HAUT'),***

***\_F (GROUP\_MA=' NO\_DROIT'),***

***\_F (GROUP\_MA=' NO\_LEFT1'),***

***\_F (GROUP\_MA=' NO\_LEFT2'),***

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***\_F (GROUP\_MA=' NO\_LEFT3'),***

***\_F (GROUP\_MA=' NO\_BAS1'),***

***\_F (GROUP\_MA=' NO\_BAS2'),***

***\_F (GROUP\_MA=' NO\_BAS3'),***

***\_F (GROUP\_MA=' LEFT\_BET'),***

*\_F (GROUP\_MA=' BAS\_BETO'),*

*\_F (GROUP\_MA=' BORD'),*

*\_F (NOM=' NOEUD1',*

*NOEUD=' NI'),*

*\_F (NOM=' NOEUD8359',*

*NOEUD=' N8359'),*

*\_F (NOM=' BORD\_SOL',*

*DIFFE= ("EDGE", "NOEUD1", "NOEUD8359"),),),),*

*#####*

*# MODELS GROUND BEFORE L EXCAVATION FOR the STAGE  
# Of INITIALISATION OF the STRESS FIELD*

*#####*

*# ' MA\_HAUT' APPEARS IN THE MODEL CONSIDERING THAT ONE  
# APPLIES THE TOP A LOADING*

*#####*

*MO=AFFE\_MODELE (MAILLAGE=MAIL,  
AFFE= (\_F (GROUP\_MA= ("GROUND", "MA\_HAUT"),  
PHENOMENE=' MECANIQUE',  
MODELISATION=' D\_PLAN',),),),);*

*#####*

*# GROUND TO INITIALIZE THE CONSTRAINTS*

*#####*

*SOL0=DEFI\_MATERIAU (ELAS=\_F (E=4.0E9,  
NU=0.4999,  
RHO=2000.0,  
ALPHA=0.0),),);*

#####  
# MATERIAL UNMADE GROUND (DATA OF CALCULATION)  
#####

SOL=DEFI\_MATERIAU (ELAS=\_F (E=4.0E9,  
NU=0.3000,  
RHO=2000.0,  
ALPHA=0.0,)),);

#####  
# MECHANICAL PROPERTIES OF THE ELEMENTS EXCAVATE  
#####

VIDE=DEFI\_MATERIAU (ELAS=\_F (E=0.0001,  
NU=0.2,  
RHO=0.0,  
ALPHA=0.0,)),);

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#####  
# MATERIAL ELASTIC DESIGN ==> CHMAT0  
#####

CHMAT0=AFFE\_MATERIAU (MAILLAGE=MAIL,  
AFFE= (\_F (GROUP\_MA=' SOL',  
MATER=SOLO,)),);

#####  
**# MATERIAL WITH THE DATA OF L STUDY ==> CHMAT1**  
 #####

**CHMAT1=AFPE\_MATERIAU (MAILLAGE=MAIL,  
 AFPE= (\_F (GROUP\_MA=' SOL\_REST',  
 MATER=SOL,),  
 \_F (GROUP\_MA=' EXCAV',  
 MATER=VIDE,),  
 \_F (GROUP\_MA=' BETON',  
 MATER=VIDE,)),);**

#####  
**# LISTS MOMENTS OF CALCULATION**  
 #####  
**# OF 0 A 1 ==> FOR the PHASE Of INITIALIZATION**  
**# OF 1 A 10 ==> FOR THE BLOCKING OF THE EDGE OF THE GALLERY**  
**# 10 CORRESPONDS A A TIME OF DECONFINEMENT = 0**  
**# 500 CORRESPONDS A A TIME OF DECONFINEMENT = 50%**  
**# 1000 CORRESPONDS A A TIME OF DECONFINEMENT = 100%**  
 #####

**LI=DEFI\_LIST\_REEL (DEBUT=0,  
 INTERVALLE= (\_F (JUSQU\_A=1.0,  
 NOMBRE=1,),  
 \_F (JUSQU\_A=10.0,  
 NOMBRE=1,),  
 \_F (JUSQU\_A=500.0,  
 NOMBRE=1,),  
 \_F (JUSQU\_A=1000,  
 NOMBRE=1,)),);**

#####  
**# FO MULTIPLYING FUNCTION FOR THE DECONFINEMENT**  
 #####

**F0=DEFI\_FONCTION (NOM\_PARA=' INST',  
 VALE= (10.0, 1.0,  
 500.0,0.5,  
 1000.0,0.0,)),);**

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```
#####
# BOUNDARY CONDITIONS IN DISPLACEMENTS:
# SYMMETRY ON THE DIMENSIONS SIDE => DX=0
# CONTINUITY ON THE LOWER PART => DY=0
# WEIGHT OF THE GROUNDS ON THE HIGHER FACE => NEAR
#####
```

```
CH0=AFFE_CHAR_MECA (MODELE=MO,
DDL_IMPO= (_F (GROUP_NO=' NO_DROIT',
DX=0.0,),
_F (GROUP_NO=' NO_LEFT1',
DX=0.0,),
_F (GROUP_NO=' NO_BAS1',
DY=0.0,)),
PRES_REP=_F (GROUP_MA=' MA_HAUT',
PRES=5.0E6,));
```

```
#####
# FIRST STAT NOT LINE #
#####
# 1st PHASE: INITIALIZATION OF THE FIELD OF THE CONSTRAINTS
#####
```

```
RESU1=STAT_NON_LINE (MODELE=MO,
CHAM_MATER=CHMAT0,
```

**EXCIT= (\_F (CHARGE=CH0,)),  
COMP\_INCR= (\_F (RELATION=' ELAS',  
GROUP\_MA=' SOL',)),  
INCREMENT=\_F (LIST\_INST=LI,  
INST\_INIT=0.,  
INST\_FIN =1.,),  
NEWTON=\_F (MATRICE=' TANGENTE',  
REAC\_ITER=10,),  
CONVERGENCE=\_F (ITER\_GLOB\_MAXI=10,  
ITER\_INTE\_MAXI=5,),  
PARM\_THETA=0.57,);**

**#####  
# EXTRACTION OF THE CONSTRAINTS  
#####**

**RES1=CREA\_CHAMP (TYPE\_CHAM=' ELGA\_SIEF\_R',  
OPERATION=' EXTR',  
RESULTAT=RESU1,  
NOM\_CHAM=' SIEF\_ELGA',  
INST=1,);**

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#####  
**# BLOCKING OF THE NODES AT THE EDGE OF PART EXCAVEE => DX+DY=0**  
 #####

**CH210=AFFE\_CHAR\_MECA (MODELE=MO,  
 DDL\_IMPO= (\_F (GROUP\_NO=' BORD\_SOL',  
 DX=0.0,  
 DY=0.0,)  
 \_F (NOEUD= ("N1"),  
 DX=0.0,)  
 \_F (NOEUD= ("N8359"),  
 DY=0.0,)),);**

#####  
**# BOUNDARY CONDITIONS IN DISPLACEMENTS:  
 # SYMMETRY ON THE DIMENSIONS SIDE => DX=0  
 # CONTINUITY ON THE LOWER PART => DY=0  
 # WEIGHT OF THE GROUNDS ON THE HIGHER FACE => NEAR**  
 #####

**CH220=AFFE\_CHAR\_MECA (MODELE=MO,  
 DDL\_IMPO= (\_F (GROUP\_NO=' NO\_DROIT',  
 DX=0.0,)  
 \_F (GROUP\_NO=' NO\_LEFT2',  
 DX=0.0,)  
 \_F (GROUP\_NO=' NO\_BAS2',  
 DY=0.0,)  
 \_F (GROUP\_NO= ("BAS\_BETO"),  
 DY=0.0,)  
 \_F (GROUP\_NO= ("LEFT\_BET"),  
 DX=0.0,)),  
 PRES\_REP=\_F (GROUP\_MA=' MA\_HAUT',  
 PRES=5.0E6,)),**

#####  
**# SECOND STAT NOT LINE #**  
 #####  
**# 2nd PHASE BLOCKING OF the EDGE OF the GALLERY IN DIDI**  
 #####  
**# RMQ: DIDI ==> DELTA U = 0**  
 #####



**RESU1=STAT\_NON\_LINE (reuse =RESU1,  
MODELE=MO,  
CHAM\_MATER=CHMAT0,  
EXCIT= (\_F (CHARGE=CH210,  
TYPE\_CHARGE=' DIDI'),  
\_F (CHARGE=CH220,)),  
COMP\_INCR= (\_F (RELATION=' ELAS',  
GROUP\_MA=' SOL',)),  
ETAT\_INIT=\_F (SIGM=RES1),  
INCREMENT=\_F (LIST\_INST=LI,  
INST\_INIT=1,  
INST\_FIN=10,)),  
NEWTON=\_F (MATRICE=' TANGENTE',  
REAC\_ITER=1),  
CONVERGENCE=\_F (RESI\_GLOB\_RELA=5.E-6,  
ITER\_GLOB\_MAXI=200,  
ITER\_INTE\_MAXI=50,**

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*ITER\_INTE\_PAS=-40,)*

*PARAM\_THETA=0.57,);*

#####

*# BOUNDARY CONDITIONS IN DISPLACEMENTS:*

*# SYMMETRY ON THE DIMENSIONS SIDE => DX=0*

*# CONTINUITY ON THE LOWER PART => DY=0*

*# WEIGHT OF THE GROUNDS ON THE HIGHER FACE => NEAR*

#####

*CH51=AFFE\_CHAR\_MECA (MODELE=MO,*

*DDL\_IMPO= (\_F (GROUP\_NO=' NO\_DROIT',*

*DX=0.0,)*

*\_F (GROUP\_NO=' NO\_LEFT3',*

*DX=0.0,)*

*\_F (NOEUD=' N1',*

*DY=0.0,)*

*\_F (GROUP\_NO= ("NO\_BAS3"),*

*DY=0.0,)*

*\_F (NOEUD=' N8359',*

*DX=0.0,)),*

*PRES\_REP=\_F (GROUP\_MA=' MA\_HAUT',*

*PRES=5.0E6,));*

#####

*# CALCULATION OF THE REACTIONS*

#####

RESU1=CALC\_NO (reuse =RESU1,  
RESULTAT=RESU1,  
INST=10.,  
OPTION=' REAC\_NODA',  
MODELE=MO,  
CHAM\_MATER=CHMATO,  
EXCIT=\_F (CHARGE=CH220,));

#####  
# RECOVERY OF THE NODAL REACTIONS  
#####

REANODA=CREA\_CHAMP (TYPE\_CHAM=' NOEU\_DEPL\_R',  
OPERATION=' EXTR',  
RESULTAT=RESU1,  
NOM\_CHAM=' REAC\_NODA',  
INST=10.);

#####  
# CONSTITUTION D A VECTOR LOADING OBTAINED CONSTITUTES REACTIONS  
#####

CH3=AFFE\_CHAR\_MECA (MODELE=MO,  
VECT\_ASSE=REANODA);

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```
#####  
# THIRD STAT NOT LINE #  
#####  
# 3rd PHASE: RE-INJECTION OF THE REACTION  
#####
```

```
RESU1=STAT_NON_LINE (reuse =RESU1,  
MODELE=MO,  
CHAM_MATER=CHMAT1,  
EXCIT= (_F (CHARGE=CH3,  
FONC_MULT=F0),  
_F (CHARGE=CH51,)),  
COMP_INCR= (_F (RELATION=' ELAS',  
GROUP_MA=' SOL_REST'),  
_F (RELATION=' ELAS',  
GROUP_MA=' EXCAV'),  
_F (RELATION=' ELAS',  
GROUP_MA= ("CONCRETE"),),),  
ETAT_INIT=_F (EVOL_NOLI=RESU1,),  
INCREMENT=_F (LIST_INST=LI,  
INST_INIT=10,  
INST_FIN=1000,),  
NEWTON=_F (MATRICE=' TANGENTE',  
REAC_ITER=1,),  
CONVERGENCE=_F (RESI_GLOB_RELA=5.E-6,  
ITER_GLOB_MAXI=500,  
ITER_INTE_MAXI=100,  
ITER_INTE_PAS=-10,),  
PARAM_THETA=0.57,);
```

```
#####  
# CALCULATIONS AND POST TREATMENT  
#####
```

```
RESU1=CALC_ELEM (reuse =RESU1,  
MODELE=MO,  
GROUP_MA=' SOL_REST',  
CHAM_MATER=CHMAT1,  
OPTION= ("SIEF_ELNO_ELGA"),  
RESULTAT=RESU1,);
```

RESU1=CALC\_NO (reuse=RESU1,  
CHAM\_MATER=CHMAT1,  
OPTION= (“SIEF\_NOEU\_ELGA”),  
RESULTAT=RESU1)

#####  
# IMPRESSION OF THE RESULTS IN FORMAT CASTEM  
# FOR VISUALIZATION OF THE ISOVALEURS  
#####

IMPR\_RESU (MODELE=MO,  
RESU=\_F (FORMAT=' CASTEM',  
MAILLAGE=MAIL,  
RESULTAT=RESU1,));

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#####  
# TABLES OF POSTPROCESSING  
#####

#-----  
# DISPLACEMENTS NODE N1 FUNCTION OF the DECONFINEMENT

#-----

DEP\_1=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' DEPL\_FONC\_DECONF\_N1',  
NOEUD=' N1',  
RESULTAT=RESU1,  
NOM\_CHAM=' DEPL',  
TOUT\_ORDRE=' OUI',  
TOUT\_CMP=' OUI',  
OPERATION=' EXTRACTION',,));

IMPR\_TABLE (TABLE=DEP\_1,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("INST", "DX", "DY",,));

#-----

# FORCED NODE N1 FUNCTION OF the DECONFINEMENT

#-----

SIG\_1=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' SIEF\_FONC\_DECONF\_N1',  
NOEUD=' N1',  
RESULTAT=RESU1,  
NOM\_CHAM=' SIEF\_ELNO\_ELGA',  
TOUT\_ORDRE=' OUI',  
NOM\_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',,));

IMPR\_TABLE (TABLE=SIG\_1,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("INST", "SIXX", "SIYY",,));

#-----

# DISPLACEMENTS NODE N8359 FUNCTION OF the DECONFINEMENT

#-----

DEP\_8359=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' DEPL\_FONC\_DECONF\_N8359',  
NOEUD=' N8359',  
RESULTAT=RESU1,  
NOM\_CHAM=' DEPL',  
TOUT\_ORDRE=' OUI',  
TOUT\_CMP=' OUI',  
OPERATION=' EXTRACTION',,));

*IMPR\_TABLE (TABLE=DEP\_8359,  
FICHIER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("INST", "DX", "DY",),);*

*#-----  
# FORCED NODE N8359 FUNCTION OF the DECONFINEMENT  
#-----*

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*SIG\_8359=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' SIEF\_FONC\_DECONF\_N8359',  
NOEUD=' N8359',  
RESULTAT=RESU1,  
NOM\_CHAM=' SIEF\_ELNO\_ELGA',  
TOUT\_ORDRE=' OUI',  
NOM\_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',),);*

*IMPR\_TABLE (TABLE=SIG\_8359,  
FICHIER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("INST", "SIXX", "SIYY",),);*

*#-----  
# DISPLACEMENTS NO\_LEFT2 == => 50%*

#-----

*DEP\_L50=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' DEPL\_LEFT2\_50%',  
GROUP\_NO=' NO\_LEFT2',  
RESULTAT=RESU1,  
NOM\_CHAM=' DEPL',  
INST= (500),  
TOUT\_CMP=' OUI',  
OPERATION=' EXTRACTION',),),);*

*IMPR\_TABLE (TABLE=DEP\_L50,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("NODE", "COOR\_X", "COOR\_Y", "DX", "DY",),),);*

#-----

*# DISPLACEMENTS NO\_LEFT2 == => 100%*

#-----

*DEP\_L100=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' DEPL\_LEFT2\_100%',  
GROUP\_NO=' NO\_LEFT2',  
RESULTAT=RESU1,  
NOM\_CHAM=' DEPL',  
INST= (1000),  
TOUT\_CMP=' OUI',  
OPERATION=' EXTRACTION',),),);*

*IMPR\_TABLE (TABLE=DEP\_L100,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("NODE", "COOR\_X", "COOR\_Y", "DX", "DY",),),);*

#-----

*# FORCED NO\_LEFT2 URGENT == => 50%*

#-----

*SIG\_L50=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' SIEF\_ELNO\_ELGA\_NO\_LEFT2\_50%',  
GROUP\_NO=' NO\_LEFT2',  
RESULTAT=RESU1,  
NOM\_CHAM=' SIEF\_ELNO\_ELGA',  
INST= (500),  
NOM\_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',),),);*



*IMPR\_TABLE (TABLE=SIG\_L50,  
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*FICHER=' RESULTAT',*

*FORMAT=' AGRAF',*

*NOM\_PARA= ("NODE", "COOR\_X", "COOR\_Y", "SIXX", "SIYY"),);*

*#-----*

*# FORCED NO\_LEFT2 URGENT == => 100%*

*#-----*

*SIG\_L100=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' SIEF\_ELNO\_ELGA\_NO\_LEFT2\_100%',*

*GROUP\_NO=' NO\_LEFT2',*

*RESULTAT=RESU1,*

*NOM\_CHAM=' SIEF\_ELNO\_ELGA',*

*INST= (1000),*

*NOM\_CMP= ("SIXX", "SIYY"),*

*OPERATION=' EXTRACTION',);*

*IMPR\_TABLE (TABLE=SIG\_L100,*

*FICHER=' RESULTAT',*

*FORMAT=' AGRAF',*

*NOM\_PARA= ("NODE", "COOR\_X", "COOR\_Y", "SIXX", "SIYY"),);*

*#-----*

*# DISPLACEMENTS NO\_BAS2 == => 50%*

#-----

```
DEP_B50=POST_RELEVE_T (ACTION=_F (INTITULE=' DEPL_NO_BAS2_50%',  
GROUP_NO=' NO_BAS2',  
RESULTAT=RESU1,  
NOM_CHAM=' DEPL',  
INST= (500),  
TOUT_CMP=' OUI',  
OPERATION=' EXTRACTION',),);
```

```
IMPR_TABLE (TABLE=DEP_B50,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM_PARA= ("NODE", "COORD_X", "COORD_Y", "DX", "DY",),);
```

#-----

```
# DISPLACEMENTS NO_BAS2 ==> 100%
```

#-----

```
DEP_B100=POST_RELEVE_T (ACTION=_F (INTITULE=' DEPL_NO_BAS2_100%',  
GROUP_NO=' NO_BAS2',  
RESULTAT=RESU1,  
NOM_CHAM=' DEPL',  
INST= (1000),  
TOUT_CMP=' OUI',  
OPERATION=' EXTRACTION',),);
```

```
IMPR_TABLE (TABLE=DEP_B100,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM_PARA= ("NODE", "COORD_X", "COORD_Y", "DX", "DY",),);
```

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#-----  
# FORCED NO\_BAS2 URGENT ==> 50%  
#-----

SIG\_B50=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' SIEF\_ELNO\_ELGA\_NO\_BAS2\_50%',  
GROUP\_NO=' NO\_BAS2',  
RESULTAT=RESU1,  
NOM\_CHAM=' SIEF\_ELNO\_ELGA',  
INST= (500),  
NOM\_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',,));

IMPR\_TABLE (TABLE=SIG\_B50,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("NODE", "COOR\_X", "COOR\_Y", "SIXX", "SIYY"),);

#-----  
# FORCED NO\_BAS2 URGENT ==> 100%  
#-----

SIG\_B100=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' SIEF\_ELNO\_ELGA\_NO\_BAS2\_100%',  
GROUP\_NO=' NO\_BAS2',  
RESULTAT=RESU1,  
NOM\_CHAM=' SIEF\_ELNO\_ELGA',  
INST= (1000),  
NOM\_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',,));

IMPR\_TABLE (TABLE=SIG\_B100,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("NODE", "COOR\_X", "COOR\_Y", "SIXX", "SIYY"),);  
END ();

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**Appendix 5 Excavation with supporting, method A (case n°2).**

**Command file Code\_Aster**

*BEGINNING ();*

```
#####  
# READING GRID GIBI  
#####
```

*PRE\_GIBI ();*

*MAIL=LIRE\_MAILLAGE ();*

```
#####  
# MODELING Of an EXCAVATION WITH SUPPORTING Of a TUNNEL IN D.P  
#####  
# DEFINITION OF THE GROUPS OF NODES FOR WHICH THERE WILL BE  
# OF DISPLACEMENTS IMPOSE  
#  
# NO_BAS1: GROUP NODES OF THE LOWER EDGE OF ALL THE SOLID MASS  
# BEFORE EXCAVATION.  
# NO_BAS2: GROUP NODES OF THE LOWER EDGE AFTER EXCAVATION,
```

*# BUT BEFORE INSTALLATION OF THE VOUSSOIRS.  
# NO\_BAS3: GROUP NODES OF THE LOWER EDGE AFTER EXCAVATION,  
# AND POSES VOUSSOIRS.  
#  
# NO\_DROIT: GROUP NODES OF THE FLAT RIM.  
#  
# NO\_HAUT: GROUP NODES OF THE HIGHER EDGE.  
#  
# NO\_LEFT1: GROUP NODES OF THE LEFT EDGE OF ALL THE SOLID MASS  
# BEFORE EXCAVATION.  
# NO\_LEFT2: GROUP NODES OF THE LEFT EDGE OF ALL THE SOLID MASS  
# AFTER EXCAVATION, BUT BEFORE INSTALLATION OF THE VOUSSOIRS.  
# NO\_LEFT2: GROUP NODES OF THE LEFT EDGE AFTER EXCAVATION  
# AND POSES VOUSSOIRS.  
#####*

*#####  
# DEFINITION OF THE GROUPS OF NEOUDS  
#####  
# OPTION "DIFFE" MAKES IT POSSIBLE TO INSULATE  
# OF the BORD\_SOL the NEOUDS N1 AND N8359  
#####*

*EMAIL = DEFI\_GROUP (reuse=MAIL,  
MAILLAGE=MAIL,  
CREA\_GROUP\_NO= (\_F (GROUP\_MA=' SOL'),  
\_F (GROUP\_MA=' SOL\_REST'),  
\_F (GROUP\_MA=' EXCAV'),  
\_F (NOM=' NO\_HAUT',  
GROUP\_MA=' MA\_HAUT'),  
\_F (GROUP\_MA=' NO\_DROIT'),  
\_F (GROUP\_MA=' NO\_LEFT1'),  
\_F (GROUP\_MA=' NO\_LEFT2'),  
\_F (GROUP\_MA=' NO\_LEFT3'),*

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```

_F (GROUP_MA=' NO_BAS1'),
_F (GROUP_MA=' NO_BAS2'),
_F (GROUP_MA=' NO_BAS3'),
_F (GROUP_MA=' LEFT_BET'),
_F (GROUP_MA=' BAS_BETO'),
_F (GROUP_MA=' BORD'),
_F (NOM=' NOEUD1',
NOEUD=' N1'),
_F (NOM=' NOEUD8359',
NOEUD=' N8359'),
_F (NOM=' BORD_SOL',
DIFFE= ("EDGE", "NOEUD1", "NOEUD8359"),),),

```

```

#####
# MODELS GROUND BEFORE L EXCAVATION FOR the STAGE
# Of INITIALISATION OF the STRESS FIELD
#####
# ' MA_HAUT' APPEARS IN THE MODEL CONSIDERING THAT ONE
# APPLIES THE TOP A LOADING
#####

```

```

MO=AFFE_MODELE (MAILLAGE=MAIL,
AFFE= (_F (GROUP_MA= ("GROUND", "MA_HAUT"),
PHENOMENE=' MECANIQUE',
MODELISATION=' D_PLAN',),),);

```

```

#####
# GROUND FOR CALCULATION NODAL REACTIONS
#####

```

```

SOL=DEFI_MATERIAU (ELAS=_F (E=4.0E9,
NU=0.4999,
RHO=2000.0,
ALPHA=0.0,),);

```

#####  
# MATERIAL UNMADE GROUND  
#####

SOL2=DEFI\_MATERIAU (ELAS=\_F (E=4.0E9,  
NU=0.3000,  
RHO=2000.0,  
ALPHA=0.0,)),);

#####  
# EMPTY  
#####

VIDE=DEFI\_MATERIAU (ELAS=\_F (E=0.001,  
NU=0.2,  
RHO=0.0,  
ALPHA=0.0,)),);

#####  
# MECHANICAL PROPERTIES OF THE CONCRETE VOUSOIRS  
#####

BETON1=DEFI\_MATERIAU (ELAS=\_F (E=2.E10,  
NU=0.2,  
RHO=0.0,  
ALPHA=0.0,)),);

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```
#####  
# MATERIAL ELASTIC DESIGN ==> CHMAT0  
#####
```

```
CHMAT0=AFFE_MATERIAU (MAILLAGE=MAIL,  
AFFE= (_F (GROUP_MA=' SOL',  
MATER=SOL,)),);
```

```
#####  
# MATERIAL WITH THE DATA OF L STUDY ==> CHMAT2  
#####
```

```
CHMAT2=AFFE_MATERIAU (MAILLAGE=MAIL,  
AFFE= (_F (GROUP_MA=' SOL_REST',  
MATER=SOL2,)  
_F (GROUP_MA=' EXCAV',  
MATER=VIDE,)  
_F (GROUP_MA=' BETON',  
MATER=VIDE,)),);
```

```
#####  
# MATERIAL WITH THE DATA OF L STUDY ==> CHMAT3  
#####
```

```
CHMAT3=AFFE_MATERIAU (MAILLAGE=MAIL,  
AFFE= (_F (GROUP_MA=' SOL_REST',  
MATER=SOL2,)  
_F (GROUP_MA=' EXCAV',  
MATER=VIDE,)  
_F (GROUP_MA=' BETON',  
MATER=BETON1,)),);
```

```
#####  
# LISTS MOMENTS OF CALCULATION  
#####  
# OF 0 A 1 ==> FOR the PHASE Of INITIALIZATION  
# OF 1 A 10 ==> FOR THE BLOCKING OF THE EDGE OF THE GALLERY  
# 10 CORRESPONDS A A TIME OF DECONFINEMENT = 0  
# 500 CORRESPONDS A A TIME OF DECONFINEMENT = 50%  
# 1000 CORRESPONDS A A TIME OF DECONFINEMENT = 100%
```



#####

LI=DEFI\_LIST\_REEL (DEBUT=0,  
INTERVALLE= (\_F (JUSQU\_A=1.0,  
NOMBRE=1,)),  
\_F (JUSQU\_A=10.0,  
NOMBRE=1,)),  
\_F (JUSQU\_A=500,  
NOMBRE=1,)),  
\_F (JUSQU\_A=1000,  
NOMBRE=1,)),);

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#####  
*# FO MULTIPLYING FUNCTION FOR THE DECONFINEMENT*  
#####

F0=DEFI\_FONCTION (NOM\_PARA=' INST',  
VALE= (10.0, 1.0,  
500.0,0.5,  
1000.0,0.0,)),);

#####  
*# CREATED FIELD BY OPERATOR "AFFE"*

```
#####  
# 1st PHASE: INITIALIZATION OF THE CONSTRAINTS  
#####
```

```
RES1=CREA_CHAMP (TYPE_CHAM=' ELNO_SIEF_R',  
OPERATION=' AFFE',  
MODELE=MO,  
AFFE= (_F (TOUT=' OUI',  
NOM_CMP= ("SIXX", "SIYY", "SIZZ", "SIXY"),  
VALE= (5.0E6,5.0E6,0., 0.),),),)
```

```
#####  
# BLOCKING OF THE NODES AT THE EDGE OF PART EXCAVEE => DX+DY=0  
#####
```

```
CH210=AFFE_CHAR_MECA (MODELE=MO,  
DDL_IMPO= (_F (GROUP_NO=' BORD_SOL',  
DX=0.0,  
DY=0.0,),  
_F (NOEUD= ("N1"),  
DX=0.0,),  
_F (NOEUD= ("N8359"),  
DY=0.0,)),);
```

```
#####  
# BOUNDARY CONDITIONS IN DISPLACEMENTS:  
# SYMMETRY ON THE DIMENSIONS SIDE => DX=0  
# CONTINUITY ON THE LOWER PART => DY=0  
# WEIGHT OF THE GROUNDS ON THE HIGHER FACE => NEAR  
#####
```

```
CH220=AFFE_CHAR_MECA (MODELE=MO,  
DDL_IMPO= (_F (GROUP_NO=' NO_DROIT',  
DX=0.0,),  
_F (GROUP_NO=' NO_LEFT2',  
DX=0.0,),  
_F (GROUP_NO=' NO_BAS2',  
DY=0.0,),  
_F (GROUP_NO= ("BAS_BETO"),  
DY=0.0,),  
_F (GROUP_NO= ("LEFT_BET"),  
DX=0.0,)),)
```

*PRES\_REP=\_F (GROUP\_MA=' MA\_HAUT',  
PRES=5.0E6,)),*

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#####

# FIRST STAT NOT LINE #

#####

# 2nd PHASE BLOCKING OF the EDGE OF the GALLERY IN DIDI

#####

# RMQ: DIDI ==> DELTA U = 0

#####

RESU1=STAT\_NON\_LINE (MODELE=MO,

CHAM\_MATER=CHMAT0,

EXCIT= (\_F (CHARGE=CH210,

TYPE\_CHARGE=' DIDI'),

\_F (CHARGE=CH220,)),

COMP\_INCR= (\_F (RELATION=' ELAS',

GROUP\_MA=' SOL',)),

ETAT\_INIT=\_F (SIGM=RES1,),

INCREMENT=\_F (LIST\_INST=LI,

INST\_INIT=1,

INST\_FIN=10,),

NEWTON=\_F (MATRICE=' TANGENTE',

REAC\_ITER=1,),

CONVERGENCE=\_F (RESI\_GLOB\_RELA=5.E-6,

ITER\_GLOB\_MAXI=200,

ITER\_INTE\_MAXI=50,

ITER\_INTE\_PAS=-40,),

PARM\_THETA=0.57,);

```
#####  
# EXTRACTION OF THE CONSTRAINTS  
#####
```

```
RES2=CREA_CHAMP (TYPE_CHAM=' ELGA_SIEF_R',  
OPERATION=' EXTR',  
RESULTAT=RESU1,  
NOM_CHAM=' SIEF_ELGA',  
INST=10,);
```

```
#####  
# BOUNDARY CONDITIONS IN DISPLACEMENTS:  
# SYMMETRY ON THE DIMENSIONS SIDE => DX=0  
# CONTINUITY ON THE LOWER PART => DY=0  
# WEIGHT OF THE GROUNDS ON THE HIGHER FACE => NEAR  
#####
```

```
CH51=AFFE_CHAR_MECA (MODELE=MO,  
DDL_IMPO= (_F (GROUP_NO=' NO_DROIT',  
DX=0.0,),  
_F (GROUP_NO=' NO_LEFT3',  
DX=0.0,),  
_F (NOEUD=' N1',  
DY=0.0,),  
_F (GROUP_NO= ("NO_BAS3"),  
DY=0.0,),  
_F (NOEUD=' N8359',  
DX=0.0,)),  
PRES_REP=_F (GROUP_MA=' MA_HAUT',  
PRES=5.0E6,));
```

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#####

# CALCULATION OF THE REACTIONS

#####

RESU1=CALC\_NO (reuse =RESU1,  
RESULTAT=RESU1,  
INST=10.,  
OPTION=' REAC\_NODA',  
MODELE=MO,  
CHAM\_MATER=CHMAT0,  
EXCIT=\_F (CHARGE=CH220,));

#####

# RECOVERY OF THE NODAL REACTIONS

#####

REANODA=CREA\_CHAMP (TYPE\_CHAM=' NOEU\_DEPL\_R',  
OPERATION=' EXTR',  
RESULTAT=RESU1,  
NOM\_CHAM=' REAC\_NODA',  
INST=10.);

#####

# CONSTITUTION D A VECTOR LOADING OBTAINED CONSTITUTES REACTIONS

#####

CH3=AFFE\_CHAR\_MECA (MODELE=MO,  
VECT\_ASSE=REANODA,);

#####

# SECOND STAT NOT LINE #

#####

# 3rd PHASE: RE-INJECTION OF THE REACTION

#####

*RESU1=STAT\_NON\_LINE (reuse =RESU1,  
MODELE=MO,  
CHAM\_MATER=CHMAT2,  
EXCIT= (\_F (CHARGE=CH3,  
FONC\_MULT=F0),  
\_F (CHARGE=CH51,)),  
COMP\_INCR= (\_F (RELATION=' ELAS',  
GROUP\_MA=' SOL\_REST'),  
\_F (RELATION=' ELAS',  
GROUP\_MA=' EXCAV'),  
\_F (RELATION=' ELAS',  
GROUP\_MA= ("CONCRETE"),),),  
ETAT\_INIT=\_F (EVOL\_NOLI=RESU1),  
INCREMENT=\_F (LIST\_INST=LI,  
INST\_INIT=10,  
INST\_FIN=500),  
NEWTON=\_F (MATRICE=' TANGENTE',  
REAC\_ITER=1),  
CONVERGENCE=\_F (RESI\_GLOB\_RELA=5.E-6,  
ITER\_GLOB\_MAXI=500,  
ITER\_INTE\_MAXI=100,  
ITER\_INTE\_PAS=-10),  
PARAM\_THETA=0.57,);*

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#####

# *THIRD STAT NOT LINE* #

#####

# *4th PHASE: ACTIVATION OF THE CONCRETE*

#####

*RESU1=STAT\_NON\_LINE (reuse =RESU1,**MODELE=MO,**CHAM\_MATER=CHMAT3,**EXCIT= (\_F (CHARGE=CH3,**FONC\_MULT=F0),**\_F (CHARGE=CH51,)),**COMP\_INCR= (\_F (RELATION=' ELAS',**GROUP\_MA=' SOL\_REST',),**\_F (RELATION=' ELAS',**GROUP\_MA=' EXCAV',),**\_F (RELATION=' ELAS',**GROUP\_MA= ("CONCRETE"),),),**ETAT\_INIT=\_F (EVOL\_NOLI=RESU1),**INCREMENT=\_F (LIST\_INST=LI,**INST\_INIT=500,**INST\_FIN=1000),**NEWTON=\_F (MATRICE=' TANGENTE',**REAC\_ITER=1),**CONVERGENCE=\_F (RESI\_GLOB\_RELA=5.E-6,**ITER\_GLOB\_MAXI=500,**ITER\_INTE\_MAXI=100,**ITER\_INTE\_PAS=-10),**PARAM\_THETA=0.57,);*

#####

# *CALCULATIONS AND POST TREATMENT*

#####

*RESU1=CALC\_ELEM (reuse = RESU1,**MODELE=MO,**CHAM\_MATER=CHMAT2,**GROUP\_MA=' SOL\_REST',**OPTION= ("SIEF\_ELNO\_ELGA"),**RESULTAT=RESU1,);**RESU1=CALC\_NO (reuse = RESU1,**CHAM\_MATER=CHMAT2,**OPTION= ("SIEF\_NOEU\_ELGA"),**RESULTAT=RESU1)*



```
#####
# IMPRESSION OF THE RESULTS IN FORMAT CASTEM
# FOR VISUALIZATION OF THE ISOVALEURS
#####
```

```
#IMPR_RESU (MODELE=MO2,
# RESU=_F (FORMAT=' CASTEM',
# MAILLAGE=MAIL,
# RESULTAT=RESU1,);
```

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```
#####
# TABLES OF POSTPROCESSING
#####
```

```
#-----
# DISPLACEMENTS NODE N1 FUNCTION OF the DECONFINEMENT
#-----
```

```
DEP_I=POST_RELEVE_T (ACTION=_F (INTITULE=' DEPL_FONC_DECONF_N1',
NOEUD=' N1',
RESULTAT=RESU1,
```

*NOM\_CHAM=' DEPL',  
TOUT\_ORDRE=' OUI',  
TOUT\_CMP=' OUI',  
OPERATION=' EXTRACTION',),,);*

*IMPR\_TABLE (TABLE=DEP\_1,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("INST", "DX", "DY",),,);*

*#-----  
# FORCED NODE N1 FUNCTION OF the DECONFINEMENT  
#-----*

*SIG\_1=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' SIEF\_FONC\_DECONF\_N1',  
NOEUD=' N1',  
RESULTAT=RESU1,  
NOM\_CHAM=' SIEF\_ELNO\_ELGA',  
TOUT\_ORDRE=' OUI',  
NOM\_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',),,);*

*IMPR\_TABLE (TABLE=SIG\_1,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("INST", "SIXX", "SIYY",),,);*

*#-----  
# DISPLACEMENTS NODE N8359 FUNCTION OF the DECONFINEMENT  
#-----*

*DEP\_8359=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' DEPL\_FONC\_DECONF\_N8359',  
NOEUD=' N8359',  
RESULTAT=RESU1,  
NOM\_CHAM=' DEPL',  
TOUT\_ORDRE=' OUI',  
TOUT\_CMP=' OUI',  
OPERATION=' EXTRACTION',),,);*

*IMPR\_TABLE (TABLE=DEP\_8359,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("INST", "DX", "DY",),,);*

#-----  
# *FORCED NODE N8359 FUNCTION OF the DECONFINEMENT*  
#-----

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*SIG\_8359=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' SIEF\_FONC\_DECONF\_N8359',  
NOEUD=' N8359',  
RESULTAT=RESU1,  
NOM\_CHAM=' SIEF\_ELNO\_ELGA',  
TOUT\_ORDRE=' OUI',  
NOM\_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',),),);*

*IMPR\_TABLE (TABLE=SIG\_8359,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("INST", "SIXX", "SIYY"),);*

#-----  
# *DISPLACEMENTS NO\_LEFT2 ==> 50%*  
#-----

*DEP\_L50=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' DEPL\_LEFT2\_50%',  
GROUP\_NO=' NO\_LEFT2',  
RESULTAT=RESU1,*

```
NOM_CHAM=' DEPL',  
INST= (500),  
TOUT_CMP=' OUI',  
OPERATION=' EXTRACTION',,);
```

```
IMPR_TABLE (TABLE=DEP_L50,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM_PARA= ("NODE", "COORD_X", "COORD_Y", "DX", "DY",,));
```

```
#-----  
# DISPLACEMENTS NO_LEFT2 ==> 100%  
#-----
```

```
DEP_L100=POST_RELEVE_T (ACTION=_F (INTITULE=' DEPL_LEFT2_100%',  
GROUP_NO=' NO_LEFT2',  
RESULTAT=RESU1,  
NOM_CHAM=' DEPL',  
INST= (1000),  
TOUT_CMP=' OUI',  
OPERATION=' EXTRACTION',,);
```

```
IMPR_TABLE (TABLE=DEP_L100,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM_PARA= ("NODE", "COORD_X", "COORD_Y", "DX", "DY",,));
```

```
#-----  
# FORCED NO_LEFT2 URGENT ==> 50%  
#-----
```

```
SIG_L50=POST_RELEVE_T (ACTION=_F (INTITULE=' SIEF_ELNO_ELGA_NO_LEFT2_50%',  
GROUP_NO=' NO_LEFT2',  
RESULTAT=RESU1,  
NOM_CHAM=' SIEF_ELNO_ELGA',  
INST= (500),  
NOM_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',,);
```

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*IMPR\_TABLE (TABLE=SIG\_L50,  
FICHIER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("NODE", "COORD\_X", "COORD\_Y", "SIXX", "SIYY"),);*

*#-----  
# FORCED NO\_LEFT2 URGENT ==> 100%  
#-----*

*SIG\_L100=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' SIEF\_ELNO\_ELGA\_NO\_LEFT2\_100%',  
GROUP\_NO=' NO\_LEFT2',  
RESULTAT=RESU1,  
NOM\_CHAM=' SIEF\_ELNO\_ELGA',  
INST= (1000),  
NOM\_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',););*

*IMPR\_TABLE (TABLE=SIG\_L100,  
FICHIER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("NODE", "COORD\_X", "COORD\_Y", "SIXX", "SIYY"),);*

*#-----  
# DISPLACEMENTS NO\_BAS2 ==> 50%  
#-----*

*DEP\_B50=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' DEPL\_NO\_BAS2\_50%',  
GROUP\_NO=' NO\_BAS2',  
RESULTAT=RESU1,*

```
NOM_CHAM=' DEPL',
INST= (500),
TOUT_CMP=' OUI',
OPERATION=' EXTRACTION',,);

IMPR_TABLE (TABLE=DEP_B50,
FICHER=' RESULTAT',
FORMAT=' AGRAF',
NOM_PARA= ("NODE", "COORD_X", "COORD_Y", "DX", "DY",,));
```

```
#-----
# DISPLACEMENTS NO_BAS2 ==> 100%
#-----
```

```
DEP_B100=POST_RELEVE_T (ACTION=_F (INTITULE=' DEPL_NO_BAS2_100%',
GROUP_NO=' NO_BAS2',
RESULTAT=RESU1,
NOM_CHAM=' DEPL',
INST= (1000),
TOUT_CMP=' OUI',
OPERATION=' EXTRACTION',,));
```

```
IMPR_TABLE (TABLE=DEP_B100,
FICHER=' RESULTAT',
FORMAT=' AGRAF',
NOM_PARA= ("NODE", "COORD_X", "COORD_Y", "DX", "DY",,));
```

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```
#-----  
# FORCED NO_BAS2 URGENT ==> 50%  
#-----
```

```
SIG_B50=POST_RELEVE_T (ACTION=_F (INTITULE=' SIEF_ELNO_ELGA_NO_BAS2_50%',  
GROUP_NO=' NO_BAS2',  
RESULTAT=RESU1,  
NOM_CHAM=' SIEF_ELNO_ELGA',  
INST= (500),  
NOM_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',),);
```

```
IMPR_TABLE (TABLE=SIG_B50,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM_PARA= ("NODE", "COOR_X", "COOR_Y", "SIXX", "SIYY"),);
```

```
#-----  
# FORCED NO_BAS2 URGENT ==> 100%  
#-----
```

```
SIG_B100=POST_RELEVE_T (ACTION=_F (INTITULE=' SIEF_ELNO_ELGA_NO_BAS2_100%',  
GROUP_NO=' NO_BAS2',  
RESULTAT=RESU1,  
NOM_CHAM=' SIEF_ELNO_ELGA',  
INST= (1000),  
NOM_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',),);
```

```
IMPR_TABLE (TABLE=SIG_B100,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM_PARA= ("NODE", "COOR_X", "COOR_Y", "SIXX", "SIYY"),);
```

END ();

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***Appendix 6 Excavation with supporting, method B (case n°3).***

***Command file Code\_Aster***

*BEGINNING ();*

#####  
# *READING GRID GIBI*  
#####

*PRE\_GIBI ();*

*MAIL=LIRE\_MAILLAGE ();*

#####  
# *MODELING Of an EXCAVATION WITH SUPPORTING Of a TUNNEL IN D.P*  
#####  
# *DEFINITION OF THE GROUPS OF NODES FOR WHICH THERE WILL BE*  
# *OF DISPLACEMENTS IMPOSE*  
#  
# *NO\_BAS1: GROUP NODES OF THE LOWER EDGE OF ALL THE SOLID MASS*  
# *BEFORE EXCAVATION.*  
# *NO\_BAS2: GROUP NODES OF THE LOWER EDGE AFTER EXCAVATION,*  
# *BUT BEFORE INSTALLATION OF THE VOUSOIRS.*  
# *NO\_BAS3: GROUP NODES OF THE LOWER EDGE AFTER EXCAVATION,*  
# *AND POSES VOUSOIRS.*  
#  
# *NO\_DROIT: GROUP NODES OF THE FLAT RIM.*



#  
# *NO\_HAUT: GROUP NODES OF THE HIGHER EDGE.*  
#  
# *NO\_LEFT1: GROUP NODES OF THE LEFT EDGE OF ALL THE SOLID MASS*  
# *BEFORE EXCAVATION.*  
# *NO\_LEFT2: GROUP NODES OF THE LEFT EDGE OF ALL THE SOLID MASS*  
# *AFTER EXCAVATION, BUT BEFORE INSTALLATION OF THE VOUSSOIRS.*  
# *NO\_LEFT2: GROUP NODES OF THE LEFT EDGE AFTER EXCAVATION*  
# *AND POSES VOUSSOIRS.*  
#####

#####  
# *DEFINITION OF THE GROUPS OF NEOUDS*  
#####  
# *OPTION "DIFFE" MAKES IT POSSIBLE TO INSULATE*  
# *OF the BORD\_SOL the NEOUDS N1 AND N8359*  
#####

*EMAIL = DEFI\_GROUP (reuse=MAIL,*  
*MAILLAGE=MAIL,*  
*CREA\_GROUP\_NO= (\_F (GROUP\_MA=' SOL'),*  
*\_F (GROUP\_MA=' SOL\_REST'),*  
*\_F (NOM=' NO\_HAUT',*  
*GROUP\_MA=' MA\_HAUT'),*  
*\_F (GROUP\_MA=' NO\_DROIT'),*  
*\_F (GROUP\_MA=' NO\_LEFT1'),*  
*\_F (GROUP\_MA=' NO\_LEFT2'),*  
*\_F (GROUP\_MA=' NO\_LEFT3'),*  
*\_F (GROUP\_MA=' NO\_BAS1'),*

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```

_F (GROUP_MA=' NO_BAS2'),
_F (GROUP_MA=' NO_BAS3'),
_F (GROUP_MA=' LEFT_BET'),
_F (GROUP_MA=' BAS_BETO'),
_F (GROUP_MA=' BORD'),
_F (NOM=' NOEUD1',
NOEUD=' N1'),
_F (NOM=' NOEUD8359',
NOEUD=' N8359'),
_F (NOM=' BORD_SOL',
DIFFE= ("EDGE", "NOEUD1", "NOEUD8359"),),),),

```

```

#####
# MODELS GROUND BEFORE L EXCAVATION FOR the STAGE
# Of INITIALISATION OF the STRESS FIELD
#####
# ' MA_HAUT' APPEARS IN THE MODEL CONSIDERING THAT ONE
# APPLIES THE TOP A LOADING
#####

```

```

MO=AFFE_MODELE (MAILLAGE=MAIL,
AFFE= (_F (GROUP_MA= ("GROUND", "MA_HAUT"),
PHENOMENE=' MECANIQUE',
MODELISATION=' D_PLAN',),),);

```

```

#####
# MODEL SOL_REST
#####

```

```

MO1=AFFE_MODELE (MAILLAGE=MAIL,
AFFE= (_F (GROUP_MA= ("SOL_REST", "MA_HAUT"),
PHENOMENE=' MECANIQUE',
MODELISATION=' D_PLAN',),),);

```

```

#####
# MODELS GROUND AFTER L EXCAVATION
#####

```

```
MO2=AFFE_MODELE (MAILLAGE=MAIL,  
AFFE= (_F (GROUP_MA=' BETON',  
PHENOMENE=' MECANIQUE',  
MODELISATION=' D_PLAN',),  
_F (GROUP_MA= ("SOL_REST", "MA_HAUT"),  
PHENOMENE=' MECANIQUE',  
MODELISATION=' D_PLAN',),),),);
```

```
#####  
# GROUND FOR CALCULATION NODAL REACTIONS  
#####
```

```
SOLO=DEFI_MATERIAU (ELAS=_F (E=4.0E9,  
NU=0.4999,  
RHO=2000.0,  
ALPHA=0.0,)),);
```

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```
#####  
# MATERIAL UNMADE GROUND (DATA OF CALCULATION)  
#####
```

```
SOL=DEFI_MATERIAU (ELAS=_F (E=4.0E9,  
NU=0.30,
```

*RHO=2000.0,  
ALPHA=0.0,);*

*#####  
# MECHANICAL PROPERTIES OF THE CONCRETE VOUSSOIRS  
#####*

*BETON=DEFI\_MATERIAU (ELAS=\_F (E=2.E10,  
NU=0.2,  
RHO=0.0,  
ALPHA=0.0,));*

*#####  
# MATERIAL ELASTIC DESIGN ==> CHMAT0  
#####*

*CHMAT0=AFFE\_MATERIAU (MAILLAGE=MAIL,  
AFFE= (\_F (GROUP\_MA=' SOL',  
MATER=SOLO,)),);*

*#####  
# MATERIAL PHASE D INITIALIZATION ==> CHMAT  
#####*

*CHMAT=AFFE\_MATERIAU (MAILLAGE=MAIL,  
AFFE= (\_F (GROUP\_MA=' SOL\_REST',  
MATER=SOLO,)),);*

*#####  
# MATERIAL PHASE OF RE-INJECTION OF THE REACTION ==> CHMAT1  
#####*

*CHMAT1=AFFE\_MATERIAU (MAILLAGE=MAIL,  
AFFE= (\_F (GROUP\_MA=' SOL\_REST',  
MATER=SOL,)),);*

*#####  
# MATERIAL WITH THE DATA OF L STUDY ==> CHMAT2  
#####*

*CHMAT2=AFFE\_MATERIAU (MAILLAGE=MAIL,*

```
AFFE= (_F (GROUP_MA=' SOL_REST',  
MATER=SOL,)  
_F (GROUP_MA=' BETON',  
MATER=BETON,)),);
```

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#####

*# LISTS MOMENTS OF CALCULATION*

#####

*# OF 0 A 1 ==> FOR the PHASE Of INITIALIZATION*

*# OF 1 A 10 ==> FOR THE BLOCKING OF THE EDGE OF THE GALLERY*

*# 10 CORRESPONDS A A TIME OF DECONFINEMENT = 0*

*# 500 CORRESPONDS A A TIME OF DECONFINEMENT = 50%*

*# 1000 CORRESPONDS A A TIME OF DECONFINEMENT = 100%*

#####

*LI=DEFI\_LIST\_REEL (DEBUT=0,*

*INTERVALLE= (\_F (JUSQU\_A=1.0,*

*NOMBRE=1,),*

*\_F (JUSQU\_A=10.0,*

*NOMBRE=1,),*

*\_F (JUSQU\_A=500.0,*

*NOMBRE=1,),*

*\_F (JUSQU\_A=1000,*

*NOMBRE=1,)),);*

#####

*# LISTS MOMENTS FOR CALCULATION CAN FOR*

*# TO INITIALIZE FIELDS A 0 DAL'S CONCRETE*

#####

*LII=DEFI\_LIST\_REEL (DEBUT=0,*

*INTERVALLE= (\_F (JUSQU\_A=1.E6,  
NOMBRE=1),),);*

*#####  
# FO MULTIPLYING FUNCTION FOR THE DECONFINEMENT  
#####*

*F0=DEFI\_FONCTION (NOM\_PARA=' INST',  
VALE= (10.0, 1.0,  
500.0,0.5,  
1000.0,0.0),);*

*#####  
# CREATED FIELD BY OPERATOR "AFFE"  
#####  
# 1st PHASE: INITIALIZATION OF THE CONSTRAINTS  
#####*

*RES1=CREA\_CHAMP (TYPE\_CHAM=' ELNO\_SIEF\_R',  
OPERATION=' AFFE',  
MODELE=MO,  
AFFE= (\_F (TOUT=' OUI',  
NOM\_CMP= ("SIXX", "SIYY", "SIZZ", "SIXY"),  
VALE= (5.0E6,5.0E6,0., 0.),),),),*

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```
#####
# BLOCKING OF THE NODES AT THE EDGE OF PART EXCAVEE => DX+DY=0
# RQ = ONE WORKS NOW WITH MODEL MO2
#####
```

```
CH210=AFFE_CHAR_MECA (MODELE=MO1,
DDL_IMPO= (_F (GROUP_NO=' BORD_SOL',
DX=0.0,
DY=0.0,),
_F (NOEUD= ("N1"),
DX=0.0,),
_F (NOEUD= ("N8359"),
DY=0.0,)),);
```

```
#####
# BOUNDARY CONDITIONS IN DISPLACEMENTS =
# SYMMETRY ON THE DIMENSIONS SIDE => DX=0
# CONTINUITY ON THE LOWER PART => DY=0
# WEIGHT OF THE GROUNDS ON THE HIGHER FACE => NEAR
#####
```

```
CH220=AFFE_CHAR_MECA (MODELE=MO1,
DDL_IMPO= (_F (GROUP_NO=' NO_DROIT',
DX=0.0,),
_F (GROUP_NO=' NO_LEFT2',
DX=0.0,),
_F (GROUP_NO=' NO_BAS2',
DY=0.0,)),),
PRES_REP=_F (GROUP_MA=' MA_HAUT',
PRES=5.0E6,)),
```

```
#####
# FIRST STAT NOT LINE #
#####
# 2nd PHASE BLOCKING OF the EDGE OF the GALLERY IN DIDI
#####
```

```
RESU1=STAT_NON_LINE (MODELE=MO1,
CHAM_MATER=CHMAT,
EXCIT= (_F (CHARGE=CH210,
```



```
TYPE_CHARGE=' DIDI'),
_F (CHARGE=CH220,)),
COMP_INCR= (_F (RELATION=' ELAS',
GROUP_MA=' SOL_REST',)),
ETAT_INIT=_F (SIGM=RES1),
INCREMENT=_F (LIST_INST=LI,
INST_INIT=1,
INST_FIN=10,),
NEWTON=_F (MATRICE=' TANGENTE',
REAC_ITER=1,),
CONVERGENCE=_F (RESI_GLOB_RELA=5.E-6,
ITER_GLOB_MAXI=200,
ITER_INTE_MAXI=50,
ITER_INTE_PAS=-40,),
PARM_THETA=0.57,);
```

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```
#####
# EXTRACTION OF THE CONSTRAINTS
#####
```

```
RES2=CREA_CHAMP (TYPE_CHAM=' ELGA_SIEF_R',
OPERATION=' EXTR',
RESULTAT=RESU1,
```

NOM\_CHAM='SIEF\_ELGA',  
INST=10,);

#####  
# BOUNDARY CONDITIONS IN DISPLACEMENTS =  
# SYMMETRY ON THE DIMENSIONS SIDE => DX=0  
# CONTINUITY ON THE LOWER PART => DY=0  
#####

CH51=AFFE\_CHAR\_MECA (MODELE=MO2,  
DDL\_IMPO= (\_F (GROUP\_NO='NO\_DROIT',  
DX=0.0,)  
\_F (GROUP\_NO='NO\_LEFT3',  
DX=0.0,)  
\_F (NOEUD='N1',  
DY=0.0,)  
\_F (GROUP\_NO= ("NO\_BAS3"),  
DY=0.0,)  
\_F (NOEUD='N8359',  
DX=0.0,)),  
PRES\_REP=\_F (GROUP\_MA='MA\_HAUT',  
PRES=5.0E6,));

#####  
# CALCULATION OF THE REACTIONS  
#####

RESU1=CALC\_NO (reuse =RESU1,  
RESULTAT=RESU1,  
INST=10.,  
OPTION='REAC\_NODA',  
MODELE=MO1,  
CHAM\_MATER=CHMAT,  
EXCIT=\_F (CHARGE=CH220,));

#####  
# RECOVERY OF THE NODAL REACTIONS  
#####

REANODA=CREA\_CHAMP (TYPE\_CHAM='NOEU\_DEPL\_R',  
OPERATION='EXTR',  
RESULTAT=RESU1,

NOM\_CHAM=' REAC\_NODA',  
INST=10.);

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#####  
# CONSTITUTION D A VECTOR LOADING OBTAINED CONSTITUTES REACTIONS  
#####

CH3=AFPE\_CHAR\_MECA (MODELE=MO1,  
VECT\_ASSE=REANODA,);

#####  
# SECOND STAT NOT LINE #  
#####  
# 3rd PHASE = RE-INJECTION OF the REACTION  
#####

RESU1=STAT\_NON\_LINE (reuse=RESU1,  
MODELE=MO1,  
CHAM\_MATER=CHMAT1,  
EXCIT= (\_F (CHARGE=CH3,  
FONC\_MULT=F0),  
\_F (CHARGE=CH220,)),  
COMP\_INCR= (\_F (RELATION=' ELAS',

```
GROUP_MA=' SOL_REST',),),  
ETAT_INIT=_F (EVOL_NOLI=RESU1),  
INCREMENT=_F (LIST_INST=LI,  
INST_INIT=10,  
INST_FIN=500,),  
NEWTON=_F (MATRICE=' TANGENTE',  
REAC_ITER=1,),  
CONVERGENCE=_F (RESI_GLOB_RELA=5.E-6,  
ITER_GLOB_MAXI=500,  
ITER_INTE_MAXI=100,  
ITER_INTE_PAS=-10,),  
PARM_THETA=0.57,);
```

```
#####  
# EXTRACTION OF THE FIELDS = DISPLACEMENTS, FORCED,  
# AND VARIABLES INTERNAL OBTAINED DURING PRECEDING CALCULATION  
#####
```

```
SIG1=CREA_CHAMP (TYPE_CHAM=' ELGA_SIEF_R',  
OPERATION=' EXTR',  
RESULTAT=RESU1,  
NOM_CHAM=' SIEF_ELGA',  
INST=500.);
```

```
DEP1=CREA_CHAMP (TYPE_CHAM=' NOEU_DEPL_R',  
OPERATION=' EXTR',  
RESULTAT=RESU1,  
NOM_CHAM=' DEPL',  
INST=500.);
```

```
CHBID = AFFE_CHAR_MECA (MODELE=MO1,  
DDL_IMPO= (_F (GROUP_NO=' NO_DROIT',  
DX=0.0),  
_F (GROUP_NO=' NO_LEFT2',  
DX=0.0),  
_F (GROUP_NO=' NO_BAS2',  
DY=0.0,)),),
```

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#####

# *THIRD STAT NOT LINE* #

#####

# *4th PHASE = LOADING CAN,*

# *CALCULATION CAN TO ALLOW:*

# *- AN INITIALIZATION OF FIELDS A 0 IN THE CONCRETE,*

# *- AND THEN ASSEMBLY*

#####

*BIDON=STAT\_NON\_LINE (MODELE=MO2,*

*CHAM\_MATER=CHMAT2,*

*EXCIT=\_F (CHARGE=CHBID),*

*COMP\_INCR= (\_F (RELATION=' ELAS',*

*GROUP\_MA=' SOL\_REST',),*

*\_F (RELATION=' ELAS',*

*GROUP\_MA=' BETON',),),*

*INCREMENT=\_F (LIST\_INST=LII,),*

*NEWTON=\_F (MATRICE=' TANGENTE',*

*REAC\_ITER=1,),*

*CONVERGENCE=\_F (RESI\_GLOB\_MAXI=1.,*

*ITER\_GLOB\_MAXI=1,*

*ITER\_INTE\_MAXI=10,*

*ITER\_INTE\_PAS=-10,),*

*PARM\_THETA=0.57,);*

*DEP2=CREA\_CHAMP (TYPE\_CHAM=' NOEU\_DEPL\_R',*

*OPERATION=' EXTR',*

RESULTAT=BIDON,  
NOM\_CHAM=' DEPL',  
INST=1.E6);

SIG2=CREA\_CHAMP (TYPE\_CHAM=' ELGA\_SIEF\_R',  
OPERATION=' EXTR',  
RESULTAT=BIDON,  
NOM\_CHAM=' SIEF\_ELGA',  
INST=1.E6);

#####  
# ASSEMBLY  
#####

DEPINI=CREA\_CHAMP (TYPE\_CHAM=' NOEU\_DEPL\_R',  
OPERATION=' ASSE',  
MAILLAGE=MAIL,  
ASSE= (\_F (CHAM\_GD=DEP2,  
GROUP\_MA=' BETON',  
CUMUL=' OUI',  
COEF\_R=0.),  
\_F (CHAM\_GD=DEP1,  
GROUP\_MA=' SOL\_REST',  
CUMUL=' OUI',),),);

SIGINI=CREA\_CHAMP (TYPE\_CHAM=' ELGA\_SIEF\_R',  
OPERATION=' ASSE',  
MODELE=MO2,  
ASSE= (\_F (CHAM\_GD=SIG2,  
GROUP\_MA=' BETON',  
CUMUL=' OUI',  
COEF\_R=0.),

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*\_F (CHAM\_GD=SIG1,  
GROUP\_MA=' SOL\_REST',  
CUMUL=' OUI',),),);*

*# VARINI=CREA\_CHAMP (TYPE\_CHAM=' ELGA\_VARI\_R',  
# OPERATION=' ASSE',  
# MAILLAGE=MAIL,  
# MODELE=MO2,  
# ASSE=\_F (CHAM\_GD=VAR2,  
# GROUP\_MA= (CONCRETE,),  
# CUMUL=' OUI',  
# COEF\_R=0.),  
# ASSE=\_F (CHAM\_GD=VAR1,  
# GROUP\_MA= (SOL\_REST,),  
# CUMUL=' OUI',),);*

*#####  
# QUATRIEMME STAT NOT LINE #  
#####  
# 5th PHASE = PRESENCE OF the VOUSOIRS,  
# DECONFINEMENT OF 50 A 100%  
#####*

*RESU1=STAT\_NON\_LINE (reuse=RESU1,  
MODELE=MO2,  
CHAM\_MATER=CHMAT2,  
EXCIT= (\_F (CHARGE=CH3,  
FONC\_MULT=F0),  
\_F (CHARGE=CH51,)),  
COMP\_INCR= (\_F (RELATION=' ELAS',  
GROUP\_MA=' SOL\_REST'),  
\_F (RELATION=' ELAS',  
GROUP\_MA=' BETON',)),  
ETAT\_INIT=\_F (DEPL=DEPINI,  
SIGM=SIGINI),*

*INCREMENT=\_F (LIST\_INST=LI,  
INST\_INIT=500.,  
INST\_FIN=1000.),  
NEWTON=\_F (MATRICE=' TANGENTE',  
REAC\_ITER=1,),  
CONVERGENCE=\_F (RESI\_GLOB\_RELA=5.E-6,  
ITER\_GLOB\_MAXI=500,  
ITER\_INTE\_MAXI=100,  
ITER\_INTE\_PAS=-10),  
PARM\_THETA=0.57,);*

*#####  
# CALCULATIONS AND POST TREATMENT  
#####*

*RESU1=CALC\_ELEM (reuse=RESU1,  
MODELE=MO2,  
CHAM\_MATER=CHMAT2,  
OPTION= ("SIEF\_ELNO\_ELGA"),  
RESULTAT=RESU1,);*

*RESU1=CALC\_NO (reuse=RESU1,  
CHAM\_MATER=CHMAT2,  
OPTION= ("SIEF\_NOEU\_ELGA"),  
RESULTAT=RESU1);*

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```

#####
# IMPRESSION OF THE RESULTS IN FORMAT CASTEM
# FOR VISUALIZATION OF THE ISOVALEURS
#####
# IMPR_RESU (MODELE=MO2,
# RESU=_F (FORMAT=' CASTEM',
# MAILLAGE=MAIL,
# RESULTAT=RESU1,));

#####
# TABLES OF POSTPROCESSING
#####

#-----
# DISPLACEMENTS NODE N1 FUNCTION OF the DECONFINEMENT
#-----

DEP_1=POST_RELEVE_T (ACTION=_F (INTITULE=' DEPL_FONC_DECONF_N1',
NOEUD=' N1',
RESULTAT=RESU1,
NOM_CHAM=' DEPL',
TOUT_ORDRE=' OUI',
TOUT_CMP=' OUI',
OPERATION=' EXTRACTION',));

IMPR_TABLE (TABLE=DEP_1,
FICHER=' RESULTAT',
FORMAT=' AGRAF',
NOM_PARA= ("INST", "DX", "DY",));

#-----
# FORCED NODE N1 FUNCTION OF the DECONFINEMENT
#-----

SIG_1=POST_RELEVE_T (ACTION=_F (INTITULE=' SIEF_FONC_DECONF_N1',
NOEUD=' N1',
RESULTAT=RESU1,
NOM_CHAM=' SIEF_ELNO_ELGA',
TOUT_ORDRE=' OUI',
NOM_CMP= ("SIXX", "SIYY"),
OPERATION=' EXTRACTION',));

IMPR_TABLE (TABLE=SIG_1,

```

FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("INST", "SIXX", "SIYY"),);

#-----  
# DISPLACEMENTS NODE N8359 FUNCTION OF the DECONFINEMENT  
#-----

DEP\_8359=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' DEPL\_FONC\_DECONF\_N8359',  
NOEUD=' N8359',  
RESULTAT=RESU1,  
NOM\_CHAM=' DEPL',  
TOUT\_ORDRE=' OUI',  
TOUT\_CMP=' OUI',  
OPERATION=' EXTRACTION',),);

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IMPR\_TABLE (TABLE=DEP\_8359,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("INST", "DX", "DY",),);

#-----  
# FORCED NODE N8359 FUNCTION OF the DECONFINEMENT  
#-----

```
SIG_8359=POST_RELEVE_T (ACTION=_F (INTITULE=' SIEF_FONC_DECONF_N8359',  
NOEUD=' N8359',  
RESULTAT=RESU1,  
NOM_CHAM=' SIEF_ELNO_ELGA',  
TOUT_ORDRE=' OUI',  
NOM_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',),);
```

```
IMPR_TABLE (TABLE=SIG_8359,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM_PARA= ("INST", "SIXX", "SIYY"),);
```

```
#-----  
# DISPLACEMENTS NO_LEFT2 == => 50%  
#-----
```

```
DEP_L50=POST_RELEVE_T (ACTION=_F (INTITULE=' DEPL_LEFT2_50%',  
GROUP_NO=' NO_LEFT2',  
RESULTAT=RESU1,  
NOM_CHAM=' DEPL',  
INST= (500),  
TOUT_CMP=' OUI',  
OPERATION=' EXTRACTION',),);
```

```
IMPR_TABLE (TABLE=DEP_L50,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM_PARA= ("NODE", "COOR_X", "COOR_Y", "DX", "DY"),);
```

```
#-----  
# DISPLACEMENTS NO_LEFT2 == => 100%  
#-----
```

```
DEP_L100=POST_RELEVE_T (ACTION=_F (INTITULE=' DEPL_LEFT2_100%',  
GROUP_NO=' NO_LEFT2',  
RESULTAT=RESU1,  
NOM_CHAM=' DEPL',  
INST= (1000),  
TOUT_CMP=' OUI',  
OPERATION=' EXTRACTION',),);
```

```
IMPR_TABLE (TABLE=DEP_L100,
```

FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM\_PARA= ("NODE", "COOR\_X", "COOR\_Y", "DX", "DY",),,);

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#-----

# FORCED NO\_LEFT2 URGENT ==> 50%

#-----

SIG\_L50=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' SIEF\_ELNO\_ELGA\_NO\_LEFT2\_50%',

GROUP\_NO=' NO\_LEFT2',

RESULTAT=RESU1,

NOM\_CHAM=' SIEF\_ELNO\_ELGA',

INST= (500),

NOM\_CMP= ("SIXX", "SIYY"),

OPERATION=' EXTRACTION',,);

IMPR\_TABLE (TABLE=SIG\_L50,

FICHER=' RESULTAT',

FORMAT=' AGRAF',

NOM\_PARA= ("NODE", "COOR\_X", "COOR\_Y", "SIXX", "SIYY",),,);

#-----

# FORCED NO\_LEFT2 URGENT ==> 100%

#-----

```
SIG_L100=POST_RELEVE_T (ACTION=_F (INTITULE=' SIEF_ELNO_ELGA_NO_LEFT2_100%',  
GROUP_NO=' NO_LEFT2',  
RESULTAT=RESU1,  
NOM_CHAM=' SIEF_ELNO_ELGA',  
INST= (1000),  
NOM_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',),);
```

```
IMPR_TABLE (TABLE=SIG_L100,  
FICHIER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM_PARA= ("NODE", "COORD_X", "COORD_Y", "SIXX", "SIYY"),);
```

```
#-----  
# DISPLACEMENTS NO_BAS2 ==> 50%  
#-----
```

```
DEP_B50=POST_RELEVE_T (ACTION=_F (INTITULE=' DEPL_NO_BAS2_50%',  
GROUP_NO=' NO_BAS2',  
RESULTAT=RESU1,  
NOM_CHAM=' DEPL',  
INST= (500),  
TOUT_CMP=' OUI',  
OPERATION=' EXTRACTION',),);
```

```
IMPR_TABLE (TABLE=DEP_B50,  
FICHIER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM_PARA= ("NODE", "COORD_X", "COORD_Y", "DX", "DY"),);
```

```
#-----  
# DISPLACEMENTS NO_BAS2 ==> 100%  
#-----
```

```
DEP_B100=POST_RELEVE_T (ACTION=_F (INTITULE=' DEPL_NO_BAS2_100%',  
GROUP_NO=' NO_BAS2',  
RESULTAT=RESU1,  
NOM_CHAM=' DEPL',  
INST= (1000),  
TOUT_CMP=' OUI',
```

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*OPERATION=' EXTRACTION',),);*

*IMPR\_TABLE (TABLE=DEP\_B100,*

*FICHIER=' RESULTAT',*

*FORMAT=' AGRAF',*

*NOM\_PARA= ("NODE", "COOR\_X", "COOR\_Y", "DX", "DY",),);*

*#-----*

*# FORCED NO\_BAS2 URGENT ==> 50%*

*#-----*

*SIG\_B50=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' SIEF\_ELNO\_ELGA\_NO\_BAS2\_50%',*

*GROUP\_NO=' NO\_BAS2',*

*RESULTAT=RESU1,*

*NOM\_CHAM=' SIEF\_ELNO\_ELGA',*

*INST= (500),*

*NOM\_CMP= ("SIXX", "SIYY"),*

*OPERATION=' EXTRACTION',),);*

*IMPR\_TABLE (TABLE=SIG\_B50,*

*FICHIER=' RESULTAT',*

*FORMAT=' AGRAF',*

*NOM\_PARA= ("NODE", "COOR\_X", "COOR\_Y", "SIXX", "SIYY",),);*

*#-----*

*# FORCED NO\_BAS2 URGENT ==> 100%*

*#-----*

```
SIG_B100=POST_RELEVE_T (ACTION=_F (INTITULE=' SIEF_ELNO_ELGA_NO_BAS2_100%',  
GROUP_NO=' NO_BAS2',  
RESULTAT=RESU1,  
NOM_CHAM=' SIEF_ELNO_ELGA',  
INST= (1000),  
NOM_CMP= ("SIXX", "SIYY"),  
OPERATION=' EXTRACTION',),);
```

```
IMPR_TABLE (TABLE=SIG_B100,  
FICHER=' RESULTAT',  
FORMAT=' AGRAF',  
NOM_PARA= ("NODE", "COOR_X", "COOR_Y", "SIXX", "SIYY"),);
```

```
END ();
```

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***Appendix 7 Comparison of the constraints obtained by calculation  
numerical and by the analytical solution***

***Case of the nonconstant tunnel***

***Evolution of the constraints according to the vertical axis***

***r/R***

***0***

***2***

***4***

***6***

***8***

***10***

***12***

***14***

***0***

***-2***



**-4**

**-6**

***Analytical solution radial Constraint***

**-8**

***Analytical solution Constraint orthoradiale***

***Constraint (MPa)***

**-10**

***Code\_Aster calculation Forced radial***

**-12**

***Code\_Aster calculation Forced orthoradiale***

***Case of the constant tunnel (from 50% of déconfinement)***

***Evolution of the constraints according to the vertical axis***

**0**

**2**

**4**

**6**

***r/R***

**8**

**10**

**12**

**14**

**0**

***Analytical solution radial Constraint***

***Analytical solution Constraint orthoradiale***

**-2**

***Code\_Aster calculation Forced radial***

**-4**

***Code\_Aster calculation Forced orthoradiale***

**-6**

**-8**

***Constraints (MPa)***

**-10**

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*Applicability of the operators of*  
*breaking process of Code\_Aster and councils*

*of use*

**Summary:**

*The characterization of the state of the fissured parts is based on the determination of the rate of refund of energy and stress intensity factors, bases of many criteria in fragile breaking process (starting in bottom of crack, propagation of defects, methods simplified). This document presents these*

*functionalities, available in Code\_Aster, indicates their field of validity and gives councils of use.*

*One also presents new formulations resulting from recent research tasks but not yet validated, like GTP and Gp.*

*The reading of this document can be done on two levels:*

- for a new user in breaking process, wanting to know the methods used and them orders of Code\_Aster necessary to the realization of its study,*
- for a user more informed, in the search of councils of use to solve certain points delicate and eager to take note of recent research tasks.*

*He is constantly referred to the Reference and Instruction manuals, whose reading remains essential. The bibliography must also make it possible to the reader to look further into the subject which interests it.*

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# ***1 Framework of use of the functionalities available in breaking process in Code\_Aster***

## ***1.1***

### ***Theoretical framework: principle of the method théta***

***One considers a fissured elastic solid occupying the field. Are:***

***U the field of displacement,***

***T the field of temperature,***

***F the field of voluminal forces applied to,***

***G the field of surface forces applied to a part S of,***

***U the field of displacements imposed on a part S of.***

***D***

***the tensor of the constraints,***

***the tensor of the deformations,***

***HT the tensor of the deformations of thermal origin,***

***(, T) density of free energy.***

***F***

***S***

***G***

***Sd***

***Let us consider the energy approach of the rupture of Griffith. The results are rigorous only in linear thermoelasticity but of the extensions are possible with the nonlinear problems.***

***For a fissured elastic solid, the criterion of propagation of Griffith results in:  $G > 2$  where is binding energy per unit of area. G, called rate of refund of energy, is defined by opposite of derived from the potential energy to balance  $W(U)$  compared to the field:***

***W***

***(U)***

***G = -***

***with:  $W(U) = ((U), T) D - F U D$***

***- G U D***

**S**

*The difficulty of the calculation of the rate of refund of energy comes from derivation compared to the field*

*of an integral depending on this same field. A rigorous method is the method théta, which is a Lagrangian method of derivation of the potential energy. It consists in introducing one field and to consider transformations  $F: MR. M + (M)$  of the area of reference in a field which corresponds to propagations of the crack. These transformations do not have to modify the edges of the field except the bottom of crack.*

*This method is detailed in [bib38] and the use of the field théta in Code\_Aster is described with [§2.2].*

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*In plane linear elasticity (assumption of the plane strains or plane stresses), the field of displacement  $U$  can break up into a singular part and a regular part. The part singular, also called singularity, contains the coefficients of intensity of constraints  $K$  and*

**I**

**K:**

**II**

**$U = U$**

**I**

**II**

**K**

**K**

**R +**

**U**

**I**  
**S +**  
**U**  
**II**  
**S**

*In plane linear elasticity, the coefficients of intensity of constraints are connected to the rate of refund of energy by the formula of IRWIN:*

**1**  
**2**  
**-**  
**G=**  
**(2 2**  
**K I + KII)**  
**déformatio**

*in*

**NS plane**  
**E**  
**1**  
**G= (2**  
**2**  
**K I + KII)**  
**constraint**

*in*

**S plane**  
**E**

**1.2**  
**Formulation of the functionalities of breaking process in**  
**Code\_Aster**

**1.2.1 Rate of refund of energy G**

*With the method théta, the rate of refund of energy G is solution of the variational equation:*

**G**  
**(S) (S) m (S) ds = G ( ),**  
**O**



where  $m$  is the unit normal at the bottom of crack located in the tangent plan at and returning in  $O$ , and where  $G()$  is defined by the opposite of derived from the potential energy  $W(U)$  with balance by report/ratio with the initial evolution of the bottom of crack:

$$D W(U) = -$$

$$D = 0$$

One notes the conditions to fill by the field (see [§2.2.1]).

In dimension 2, the bottom of crack is brought back to a point, and one can choose a field of such left that the variational equation is brought back to  $G = G()$ .

In dimension 3 dependence of  $G()$  with respect to the field on the bottom of crack is more complex. In Code\_Aster, one can calculate:

· the total rate of refund  $G$  corresponding to a uniform progression of the crack (order `CALC_G_THETA` [U4.82.03]). The user must choose a unit field  $\theta$  with vicinity of the bottom of crack checking  $(S) m(S) = 1, S$  and then:  $G L = G(S) ds = G()$

where  $L$  is the length of the bottom of crack,  
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**O**

*· the rate of refund of energy room G (S) solution of the preceding variational equation (order CALC\_G\_LOCAL [U4.82.04]). In this case, the user does not give a field  $\theta$ , fields I necessary to the resolution of the variational equation and the calculation of G S () are calculated automatically.*

*For a linear or non-linear thermoelastic problem the expression of G () is:*

$$G () = (U  
T  
D  
F U  
F  
U D  
ij  
I p p J  
K K  
K K  
I  
I K K  
I K  
,  
, -  
, -  
)  
,  
+ (  
,  
+  
)  
,  
K  
I$$

**T**

**+ (G  
U  
GU  
N  
D  
NU  
D  
IKK  
I  
I  
IKK  
K  
ij JIK**

**,  
+  
(, -  
))  
-  
,**

**K  
N  
S  
K  
Sd**

*If one places oneself on the assumption of the great transformations, the term should be replaced*

**U  
D by F S U D**

**with  
,  
,  
,  
,**

**ij  
I p p J**

*ik*  
*kj*  
*Ip*  
*pJ*

*S the tensor of the constraints of Piola-Lagrange called still second tensor of Piola-Kirchoff,*  
*F the gradient of the transformation which makes pass from the configuration of reference to the*  
*configuration*  
*current.*

*If one takes account of the initial strains 0 and the initial stresses 0*  
*, it is necessary to add it*

*ij*  
*ij*  
*term:*

*1 • •*

*HT*  
*1 • •*

,

,

*ij -*  
*ij ij K - ij -*  
*ij -*  
*ij*  
*ij K*  
*K*

*D*

*2*

*2*

*For a thermoelastoplastic problem the expression of  $G ()$  reserve in Code\_Aster is:*

~  
~  
 **$G ()$**   
~  
  
=  
  
 **$U$**   
 **$R$**   
,,  
,  
,  
,  
,,  
 **$ij$**   
 **$IK$**   
 **$KJ -$**   
 **$KK +$**   
  
-  
 **$TK + (+ y)$**   
  
 **$p K +$**   
 **$ij K -$**   
 **$p$**   
 **$ij$**   
 **$ij K$**   
 **$K$**   
  
 **$D$**   
  
  
  
 **$T$**   
  
 **$ij$**   
  
+  
(  
***traditional***

*terms*  
*F, G)*  
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*with:*

*~*  
*total mechanical energy,*  
*p the tensor of the plastic deformations,*  
*p the variable interns scalar isotropic work hardening (cumulated plastic deformation),*  
*one or more tensorial or scalar variables of kinematic work hardening,*  
*initial linear elastic limit,*

*y*  
*R the ray of the surface of load for isotropic work hardening.*

*~*  
*p*

*For a radial and monotonous loading:  $ij\ ij\ K = (R + y)\ p$*

*,*  
*, K +*

*ij, K and one find*

*ij*  
*the expression of  $G()$  in nonlinear thermoelasticity [R7.02.03].*

## 1.2.2 Coefficients of intensity of constraints K1 and K2 deduced from the calculation of G.

In linear thermoelasticity, the rate of refund of energy  $G$  is a symmetrical bilinear form of field of displacement  $U$ :  $G = G(U, U)$ . By using the method *théta*, the bilinear form  $G(,)$  associated  $G$  is defined by:

$1$   
 $B$

$B$

$G(U, v) =$

$(v$   
 $) +$   
 $(U$   
 $) - B(U, v) \text{ div } D$   
 $2 U$

$v$

while limiting themselves at the end traditional and while noting:

$($   
 $1$   
 $1$   
 $(U))$   
 $(U) = (U) : : (U) = B(U, U)$   
density of energy elastic:  
 $($

$2$

$2$

the tensor of elasticity,

$B$  the symmetrical bilinear form defined by:  $B(U, v) = (U) : : (v)$

In the method established in Code\_Aster (order `CALC_G_THETA [U4.63.03]`), for to uncouple the modes from rupture I and II and to calculate coefficients K1 and KII, one uses this form

bilinear symmetrical  $G$

$(,)$  and regular decomposition of the field of displacement  $U$  in parts  $U$  and singular  $U$ :

***I***

***II***

***u=u + K U + K U (I and II are known explicitly):***

***R***

***S***

***R***

***I***

***S***

***II***

***S***

***U***

***U***

***S***

***S***

***E***

***K***

***=***

***G***

***I***

***U, U***

***I***

***(S)***

***E***

***K***

***=***

***G***

***II***

***U, U***

***II***

***(S)***

***= 1-2 in plane deformations and = 1en forced plane.***

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### ***1.2.3 Coefficients of intensity of constraints K1, K2 and K3 obtained by extrapolation field of displacements.***

***For a plane crack in an elastic, homogeneous and isotropic material, one can also reach with the values of K1, K2 and K3 by extrapolation of the jumps of displacements on the lips of this fissure (order POST\_K1\_K2\_K3).***

***Contrary to the preceding approach (calculation of  $K_i$  by the bilinear form of the rate of refund of energy), one can thus calculate these coefficients in axisymmetric geometry and 3D and reach K3 coefficient. For each coefficient of intensity of constraint, method, less precise than method G\_THETA [R7.02.01], provides two values framing the solution. One can however be done an idea of the precision of the results by recomputing G by the formula of Irwin, starting from the values of K1, K2 and K3, and by comparing this value with that obtained with G\_THETA. Precision of results is clearly improved if elements touching the bottom of crack (quadratic elements) nodes mediums located at the quarter of the edges have.***

### ***1.2.4 Propagation***

#### ***Lagrangian***

***It is possible with Code\_Aster to calculate the rate of refund of energy for different lengths of crack (in 2D and 3D) by using only one grid representing a length of crack fix reference. These developments are available in linear elasticity, for the elements of continuous medium 2D and 3D, in the situations where the variations of geometry do not affect the edges charged.***

***Any calculation using this method requires, to ensure the passage of the real field studied area of reference, the preliminary creation of a field  $\theta$ , using order CALC\_THETA [U4.82.02]. The formulation developed in Code\_Aster does not take account of the terms***

*thermics, of the loadings on the lips of the crack nor of the forces of volume in general, except initial deformations which are taken into account in 2D only.*

*For more precise details on this option one will refer to the document [R7.02.04].*

### ***1.3 Field of validity of the functionalities of breaking process in Code\_Aster***

#### ***1.3.1 Model***

*The calculation of the rate of refund of energy  $G$  is valid for modelings of the continuous mediums 2D*

*plane strains or plane stresses (D\_PLAN, C\_PLAN), axisymmetric 2D (AXIS) and 3D (3D).*

*These modelings correspond for a two-dimensional medium to triangles to 3 or 6 nodes, quadrangles with 4, 8 or 9 nodes and of the segments with 2 or 3 nodes, for a three-dimensional medium with*

*hexahedrons with 8, 20 nodes or 27 nodes, of the pentahedrons with 6 or 15 nodes, of the tetrahedrons with 4 or 10*

*nodes, of the pyramids with 5 or 13 nodes, of the faces with 4, 8 or 9 nodes.*

*The calculation of the rate of refund of energy room  $G(S)$  has direction only for the modeling of the mediums*

*continuous 3D.*

*The calculation of the stress intensity factors  $K1, K2$  deduced from the bilinear form  $G(,)$  is valid only for modelings of the continuous mediums 2D plane deformations or*

*plane constraints (D\_PLAN, C\_PLAN). The calculation of the mode antiplan  $K3$  is not available.*

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*On the other hand, the method of extrapolation of displacements makes it possible to calculate  $K_i$  (of which  $K_3$ ) in axisymmetric and 3D when the crack is plane.*

*D\_PLAN C\_PLAN AXIS*

*3D*

*G*

*.*

*.*

*.*

*.*

*G (S) local*

*-*

*-*

*-*

*.*

*K1, K2*

*.*

*.*

*- -*

*calculation of G*

*K1, K2, K3*

*.*

*.*

*.*

*.*

*extrapolation of U*

*Modelings available*

### *1.3.2 Characteristics of material*

*For the calculation of the rate of refund of energy, the characteristics of the material (Young modulus,*

*, thermal and possibly limit dilation coefficient Poisson's ratio elastic, modulates*

*on work hardening) can depend on the temperature. Calculation is valid for a homogeneous material isotropic or for an isotropic bimatérial (crack with the interface of two materials to the characteristics different).*

*For the calculation of the coefficients of intensity of constraints at a given moment, the characteristics of*

***material must be independent of the temperature. Calculation is valid only for one isotropic homogeneous material (possibly for a bimatéériau if the point of crack is not located at the interface of two materials).***

***Modulate***

***Coefficient of***

***Coefficient of elastic Limit***

***Modulate***

***of Young  $E(T)$  Poisson  $(T)$***

***dilation***

***$\nu(T)$***

***of work hardening***

***thermics  $(T)$***

***$D\_SIGM\_EPSI$***

***G***

***.***

***.***

***.***

***.***

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***G(S) local***

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***.***

***K1, K2***

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***-***

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***-***

***Dependence of the characteristics at the temperature***

***Characteristics  $\nu(T)$  and  $D\_SIGM\_EPSI(T)$  are treated only for one elastic problem not linear with linear isotropic work hardening of Von Mises and the option of calculation of the rate of restitution of energy.***

***Material***

***homogeneous***

***Bimatériau (crack with the interface)***

***G***

•  
•  
***G (S) local***

•  
•  
***K1, K2***

•  
-

***Homogeneity of material***

***Material***  
***isotropic***  
***Orthotropic material***

***G***  
•  
-  
***G (S) local***

•  
-  
***K1, K2***  
•  
-

***Isotropy of material***  
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**1st case:** *There is a bimatériau but the point of crack is in only one material.*

*material 1*

*R*

*E*

*R*

*1, 1, 1*

*material 2*

*E2, 2, 2*

*If one is assured that the crown, definite enters the rays inferior R and higher R (*

*inf*

*sup*

*order CALC\_THETA [U4.82.02]), has like support of the elements of same material, calculation is valid some is the selected option. If not only the calculation of the rate of refund of energy is valid.*

**2nd case:** *There is a bimatériau where the point of crack is with the interface.*

*material 1*

*E1, 1, 1*

*R*

*R*

*material 2*

*E2, 2, 2*

*To date, only the option of calculation of the rate of refund of energy is valid. The calculation of coefficients*

*of intensity of constraints K1 and K2 is false in this case.*

### ***1.3.3 Relation of behavior used in postprocessing of mechanics of rupture***

*For the calculation of the rate of refund of energy, the possible relations of behavior are:*

- linear thermoelasticity,*
- nonlinear thermoelasticity (hyperelasticity),*
- thermo-elastoplasticity (criterion of Von Mises with isotropic or kinematic work hardening).*

*The calculation of the coefficients of intensity of constraints is possible only in thermoelasticity linear on the assumption of the small deformations.*

*The relation of behavior is selected in orders CALC\_G\_THETA [U4.82.03] and CALC\_G\_LOCAL [U4.82.04] via the key words factors COMP\_ELAS (thermoelasticity linear or not linear) or COMP\_INCR (thermo-elastoplasticity).*

*The relations treated under the key word factor COMP\_ELAS are:*

*ELAS: linear thermoelasticity,*

*ELAS\_VMIS\_LINE: Von Mises with linear isotropic work hardening,*

*ELAS\_VMIS\_TRAC: Von Mises with isotropic work hardening given by a traction diagram.*

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*The relations treated under the key word factor COMP\_INCR are:*

*VMIS\_ISOT\_LINE: Von Mises with linear isotropic work hardening,*

*VMIS\_ISOT\_TRAC: Von Mises with isotropic work hardening given by a traction diagram,*

*VMIS\_CINE\_LINE: Von Mises with linear kinematic work hardening.*

**RELATION***G or G (S) local**K1, K2**COMP\_ELAS "ELAS"*

.

.

*"ELAS\_VMIS\_LINE"*

.

-

*"ELAS\_VMIS\_TRAC"*

.

-

*COMP\_INCR "ELAS"*

.

.

*"VMIS\_ISOT\_TRAC"*

.

-

*"VMIS\_ISOT\_LINE"*

.

-

*"VMIS\_CINE\_LINE"*

-

-

***Relation of behavior used in breaking process***

*The relation of thermoelastic behavior nonlinear can be used with the large ones displacements and of great rotations (with the proviso of having only dead loads). This functionality is started by the key word DEFORMATION = "GREEN". The deformations are them deformations of Green-Lagrange [R7.02.03 §2.1]:*

$$\begin{aligned}
 &1 \\
 &\mathbf{U} = \\
 &\mathbf{U} + \mathbf{U} + \mathbf{U} \mathbf{U}
 \end{aligned}$$

$$\begin{aligned}
 &ij ( \\
 &) \\
 &(I J ji K I K J) \\
 &2
 \end{aligned}$$

,



,  
,  
,  
  
**1.3.4 Loading**

*Loadings currently supported by various modelings and for the calculation of functionalities of breaking process are as follows (see AFFE\_CHAR\_MECA (\_F) [U4.44.01] for more details):*

***C\_PLAN, D\_PLAN, AXIS  
3D***

***K1, K2  
G  
G and G (S) local  
TEMP\_CALCULEE***

.  
. .  
. .

***FORCE\_INTERNE***

.  
. .  
. .

***PRES\_REP***

.  
. .  
. .

***FORCE\_CONTOUR***

.  
. .

***///  
FORCE\_FACE***

***/// ///***

.

***FORCE\_NODALE***

- -  
-

***FORCE\_ARETE***

***/// ///***

-

***GRAVITY***

.  
. .  
*ROTATION*

.  
. .  
*EPSI\_INIT*

--  
-  
*DDL\_IMPO (on crack)*

--  
-  
*FACE\_IMPO (on crack)*

.  
*mean possible and available*

*/// means option without object*

-  
*mean option possible but nonavailable*

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*These loadings can depend on the geometry, the moment of calculation and possibly to apply to the lips of the crack.*

*The loadings not supported by an option are ignored.*

*It is important to note that the only loadings to be taken into account in a calculation of mechanics rupture with the method are those applied to the elements inside the crown (between  $R_{inf}$  and  $R_{sup}$  for a linear thermoelastic behavior or not linear [R7.02.01 §3.3], between the bottom of crack and  $R_{sup}$  for a thermoelastoplastic relation [R7.02.07]).*

*If one makes a calculation in great transformations (key word DEFORMATION = "GREEN" under the key word factor COMP\_ELAS) the supported loadings must be died loads, typically one force imposed and not a pressure [R7.02.03 §2.4].*

### **1.3.5 State initial**

*It is possible to take account of an initial state (either of the initial constraints, or of the deformations initial) for the calculation of the rate of refund of energy. Two possibilities are offered to the user:*

- to define initial deformations with key word EPSI\_INIT in the order AFFE\_CHAR\_MECA (\_F) [U4.44.01] and to recover them under the key word CHARGES in orders CALC\_G\_THETA [U4.82.03] or CALC\_G\_LOCAL [U4.82.04],*
- to recover a stress field or initial deformations resulting from a mechanical calculation (evol\_noli resulting from order STAT\_NON\_LINE [U4.51.03]) with the key word ETAT\_INIT.*

### **1.3.6 Contact**

*The calculation of the sizes of breaking process in Code\_Aster is not valid if there is contact with friction between the faces of the crack. Indeed the calculation of the rate of refund of energy*

*does not take into account the dissipative phenomena.*

*On the other hand if the elements of contact are beyond the crown defined between  $R_{inf}$  and  $R_{sup}$  them*

*calculations of  $G$ ,  $G(S)$ ,  $K1$  and  $K2$  are valid.*

*On the other hand, it is possible for the calculation of  $G$  and  $G(S)$  to only take into account conditions of contact without friction to avoid the interpenetration of the lips of the crack.*

### **1.4 Approach energy the elastoplastic rupture and formulation $G_p$ parameter**

*The traditional global solution presents important limits:*

- the loading must be monotonous,*
- more generally, the loading must be proportional and radial (see chapter [§2.5.2]),*

- *one cannot simulate great propagations,*
- *one cannot take into account a residual stress field (see chapter [§1.3.5]).*

*The application of the global solution apart from its field of validity led to problems of “transferability” of test-tubes with structures.*

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*Another approach was then considered with EDF-R & D: energy approach.*

*This new approach was developed, on the one hand, within the framework of the ductile tear [bib57], and,*

*in addition, within the framework of brittle fracture by cleavage.*

*In the case of brittle fracture by cleavage, one leaves the theory of Frankfurt Marigo in elasticity [bib56]. This theory is a generalization of the criterion of Griffith for fragile elastic materials.*

*One applies the principle of minimization of energy, to predict the initiation or the propagation of one fissure of surface  $S$  of a surface created  $dS$ . One defines, starting from elastic energy, a parameter Freezing, rate of refund of energy in elasticity [bib58] by the following formula:*

*Freezing = - [We (dS) - We (0)] /Surface (dS).*

*One extends then this approach to plasticity, by making the assumption that plastic dissipation and dissipation related to the rupture are independent.*

*One can then define a plastic parameter  $G$  [bib58], noted  $G_p$ , like a rate of refund of energy in plasticity incremental [bib58] by the following formula:*

*$G_p = - [W (dS) - W (0)] /Surface (dS)$*

*where  $W$  is total energy (free energy + energy of work hardening + plastically dissipated energy).*

***But one finds oneself then confronted with 2 paradoxes of the theory of Griffith [bib62]:***

- the paradox of Rice,***
- scale effects of the theory of Frankfurt-Marigo induced by the assumption of Griffith.***

***One makes the choice then model the defect in the form of notch and not of crack.  
 One defines a rate of refund of  $G_p$  energy applicable to a crack represented in notch, in being based on the formulation of Frankfurt-Marigo and mechanics damage continues, with the help of some additional assumptions.***

***Note:***

***Another alternative consists in being directed towards a theory of Frankfurt-Marigo based on one other models that that of Griffith, like that of Barenblatt.***

***It is supposed that this notch with the shape of a cigar, the bottom of notch ( ) being represented by a half-circle of ray  $R$ . the zone corresponding to the propagation of the notch is noted  $Z_e(L)$  (damaged Zone) and depends on  $L$ , outdistances propagated, in accordance with the figure below:***

***$Z_e(L)$***

***notch***

***$L$***

***( ): melts of notch***

***The  $G_p$  parameter is defined by the following formula:***

***$G_p =$   
we  $dS$***

***·  
[  
max (  
( . )) / ]***

***Notch ( )***

***$L$***

***$L$***

**L**

*where  $W_e$  is elastic energy.*

*This parameter makes it possible to predict:*

- *progressive propagation of the notch (when the maximum is obtained for  $L = 0$ )*
- *brutal propagation of the notch (when the maximum is obtained for  $L = 0$ ).*

*One evacuates in this case the 2 paradoxes of the theory of Griffith.*

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*One can use  $G_p$  to analyze situations of brittle fracture per cleavage, when the  $G_{theta}$  approach is not valid. They can be problems with:*

- *discharges [bib59],*
- *loadings nonproportional,*
- *residual stresses,*
- *effect small defect [bib60], [bib61].*

*One introduces the implementation of the calculation of  $G_p$  in Code\_Aster in the chapter [§ 2.5.2.3] and one*

*illustrate this approach on an example in the chapter [§3.4].*

**2**

**Methodology and recommendations of use**

**2.1**

**Grid of the fissured structure**

### **2.1.1 Tool for grid of fissured block**

*Maillor GIBI comprises a parameterized automatic procedure which makes it possible to conceive grids of blocks fissures in 3D. This procedure was developed by EDF-R & D and was validated to ensure the good quality of the grid. One obtains a grid with the format GIBI which can recognize Code\_Aster (order PRE\_GIBI). The user informs a certain number of parameters geometrical (dimensions of crack, cuts block,...) or topological (modeling of the basic torus of crack in crowns, sectors and sections, déraffinement, a number of elements,...) and software generate a block fissures, which can then be integrated in another structure. The user has indicators of quality of grid to adjust the parameters as well as possible.*

### **2.1.2 Methodology**

*Quality of the grid depends numerical quality on the results resulting from mechanical calculation (displacements and constraints) and by consequence of the quality of the sizes in mechanics of rupture. In the presence of a crack it is thus necessary to refine in the vicinity of the bottom of crack to collect with better singularities. But it is not necessary to refine exaggeratedly: interest of the method théta is to utilize the singular terms on elements between  $R_{inf}$  and  $R_{sup}$  and not on those with vicinity of the bottom of crack (except for a calculation in thermo-elastoplasticity, for this case private individual to refer to [§2.5.2]).*

*Calculations of the sizes of breaking process are valid for linear elements or quadratic, but it is strongly advised to use quadratic elements, in particular in 3D. The calculation of these sizes indeed requires to determine with a good approximation them deformation and stress fields which strongly vary in the vicinity of the bottom of crack. However, with an identical number of nodes, the quadratic elements give better results than linear elements, undoubtedly because they are ready to represent this type of variation. Let us add that in 3D, it is necessary to carry out a compromise between a sufficient refinement in bottom of crack on the one hand, and a reasonable size of problem on the other hand. The quadratic choice of elements contribute to carry out such a compromise.*

*A radiant grid in bottom of crack is not obligatory: the rays  $R_{inf}$  and  $R_{sup}$  are not dependent with the grid and the crown can be “with horse” on several elements. Nevertheless practice show that a radiant grid in bottom of crack gives good numerical results. The radiant grid has in particular the advantage of making it possible to impose a constant cutting according to the polar angle, around the bottom of crack, and in the immediate vicinity of this one, cutting well adapted to the asymptotic representation of the fields in bottom of crack. Indeed, this variation according to the polar angle does not depend on the distance from the point considered at the bottom from crack.*

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**In the case of the calculation of the coefficients of intensity of constraint by the method of extrapolation of jumps of displacements on the lips of this crack (order `POST_K1_K2_K3`), it is strongly advised to position the nodes mediums of the quadratic elements concerning the bottom of crack with quarter of the edges (grid of the type “`BARSOUM`”). Thus dependence in `R` of the field of displacement is represented better and the quality of the results is improved. Values of `Ki` coefficients obtained by this method tend towards those deduced from the calculation of `G` (`CALC_G_THETA_T` option `CALC_K_G`) with the refinement of the grid around the bottom of crack.**

### **2.1.3 Estimators**

**errors**

**To assess the quality of the grid it is advised to carry out an elastic design and to use them estimators of errors of discretization: estimators of errors of `ZHU-ZIENKIEWICZ` in elasticity 2D [`R4.10.01`] or the estimator of error by residue [`R4.10.02`].**

**These estimators are established in Code\_Aster in order `CALC_ELEM` [`U4.81.01`]. They are activated starting from the following options: `ERRE_ELEM_NOZ1` for `ZZ1`, `ERRE_ELEM_NOZ2` for `ZZ2` and `ERRE_ELGA_NORE` for the estimator in residue by element.**

## **2.2**

**Introduction of the field *thé*ta**

### **2.2.1 Definition of the field *thé*ta and conditions to respect**



The field  $\theta$  is a field of vectors, definite on the fissured solid, which represents the transformation field during a propagation of crack. It is pointed out that the rate of refund of energy  $G$  is solution of the variational equation:

$$\int_{(S)} \mathbf{m} \cdot d\mathbf{s} = G,$$

where  $\mathbf{m}$  is the unit normal at the bottom of crack located in the tangent plan at (i.e. tangent in the plan of cracking in 3D or the lips of the crack in 2D) and returning in. One notes conditions to fill by field  $C_i$  below:

$\mathbf{m}$

The transformation should modify only the position of the bottom of crack and not the edge of the field. field must thus be tangent with (in particular lips of the crack), i.e by noting  $\mathbf{N}$  normal with:  $\mathbf{N} = \mathbf{m}$

0

The field must be locally in the tangent plan with the lips of the crack and in normal 3D with the edge to which it belongs. This corresponds to the direction of propagation of the crack.

The field must also be continuous on.

Quantity.  $\mathbf{m}$  represents the normal speed of the bottom of crack.

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### **2.2.2 Choice of the field $\theta$ in Code\_Aster**

**Because of the singularity of the field of displacement, one uses fields.  $m$  constant with vicinity of the bottom of crack, thus cancelling in this vicinity the singular terms**

-  
**in  $G$  ( $\cdot$ ).  
 $\mu_i, p, K$   
 $K, K$**

**The field  $\theta$  is defined in the following way: in each node of the bottom of crack, one is given 2 rays  $R$  ( $S$  and  $R$  ( $S$ . In on this side  $R$  ( $S$  the module of the field  $\theta$  is constant, with beyond it is**

**inf  
)  
sup  
)  
inf  
)**

**no one and it are linear between the two.**

**$R$  sup  
 $0$   
 $R$   
 $N$   
inf  
  
 $0$   
 $0$   
 $R$ inf  
 $R$  sup**

**The construction of the field  $\theta$  is described precisely in [R7.02.01]. It is established in order  $CALC\_THETA$  in 2D and 3D for the calculation of the total rate of refund  $G$ , and in order  $CALC\_G\_LOCAL$  for the calculation of the local rate of refund  $G$  ( $S$ ).**

**In 2D and axisymmetric the bottom of crack limits itself to a point. The user defines:**

**O**· *the rays  $R$  and  $R$ ,**inf**sup*· *the module in bottom of crack,***O**· *direction of propagation of the crack  $Mr$ .***In 3D the user defines:**· *the rays  $R$  ( $S$  and  $R$  ( $S$ ,**sup*

)

*inf*

)

· *directions of propagation of the crack only at the ends of the bottom of crack**(key words  $DTAN\_ORIG$  and  $DTAN\_EXTR$  in order  $DEFI\_FOND\_FISS$  [U4.82.01]),*· *the topology of the bottom of crack: opened or closed according to if the crack is emerging or not,*· *the module in bottom of crack (only for the calculation of  $G$  total if not  $P$* **O***fields  $I$  necessary to the resolution of the variational equation and the calculation of  $G$   $S$* *( ) are**calculated automatically according to the family of functions of selected interpolation: Lagrange or Legendre, to see [§2.4]).**The directions of the field  $\theta$  except ends are calculated automatically starting from the lips of fissure, but the user can possibly define them itself by using key word  $DIRE\_THETA$ , to see [§2.2.3].***The field is then built so that:** $(R(S)) = 0$ if  $R(S) R(S)$ *sup* $(R(S)) = m$ if  $R(S) R(S)$ **O***inf* $R - R$  $(R(S))$ *sup*

=

 $m$  if  $R(S) R(S) R(S)$  $R - R$ **O**

*inf*  
*sup*  
*sup*  
*inf*  
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### ***2.2.3 Problem of the discretization in 3D***

***Problem of the emerging crack in a nonperpendicular way: at the end emerging of melts of crack, the field cannot simultaneously be normal with the edge to which it belongs (in the tangent plan of the lips of the crack) and to check the condition  $N = 0$  on.***

***Advised solution: To define the direction of the field  $O$  on all the nodes of the bottom of crack with key word `DIRE_THETA` in orders `CALC_THETA [U4.82.02]` or `CALC_G_LOCAL [U4.82.04]`.***

***In the vicinity of the emerging end to choose like direction for the field  $O$  the average enters direction checking***

***1  $N = 0$  on and normal direction with the edge.***

***2***

***1***

***N***

***2***

***Problem of the choice of  $R$  and  $R$***

***: The calculation of the sizes of breaking process is***

*inf*

*sup*

*independent of the choice of the crown of integration, i.e. choice of  $R$  and  $R$ . Nevertheless it*

*inf*

*sup*

*is preferable to comply with some rules:*

*· never not to take  $R$*

*= 0 or too small compared to dimensions of the problem because them*

*inf*

*singular displacements are badly calculated in the vicinity of the bottom of crack (valid also in 2D),*

*· in 3D it is necessary to find a compromise between  $R$  not too small and  $R$  not too large. Indeed if*

*inf*

*sup*

*one analyzes the algorithm of construction of the field  $\theta$  (see [R7.02.01]), one notes that to know the direction of the field  $\theta$  in an unspecified point of the solid, it is necessary to project this point on the bottom of crack (i.e. to determine the X-coordinate of the basic point fissures it nearer) and to associate the same direction to him. If one considers a point too far away from the bottom*

*of crack, it may be that the algorithm of research of the basic point of crack nearest give an “erroneous” point: the direction of the field  $\theta$  is badly calculated, with the direction where it*

*does not correspond to the propagation of awaited crack.*

*Solutions:*

*· to check by visualizing the grid that, for the  $R$  chosen, one is not likely to have points*

*sup*

*“badly” projected,*

*· to take several crowns to check the invariance of  $G$ , preferably which are followed*

*[R1, R2], [R2, R3], [R3, R4],...*

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## **2.3**

**Standardization of the total rate of refund  $G$  in Code\_Aster**

### **2.3.1 2D forced plane and plane deformations**

**In dimension 2 (plane constraints and plane deformations), the bottom of crack is tiny room to a point and**

**the value  $G$  () resulting from order CALC\_G\_THETA is independent of the choice of the field:**

$$G = G (),$$

### **2.3.2 Axisymetry**

**Into axisymmetric it is necessary to standardize the value  $G$  () obtained with Aster:**

**$l$**

$$G =$$

$$G ()$$

**$R$**

**where  $R$  is the distance from the bottom of crack to the axis of symmetry [R7.02.01, §2.3.3].**

### **2.3.3 3D**

**In dimension 3, the value of  $G$  () for a field given by the user is such as:**

$$G () = G (S) (S) m (S) ds$$

**$O$**

**In order CALC\_THETA [U4.82.02], the user defines the direction of the field in bottom of fissure. By defect, it is the normal at the bottom of crack in the plan of the lips. By choosing one unit field in the vicinity of the bottom of crack, one  $a$ :**

$$(S) m (S) = 1$$

**and:**

$$G () = G (S) D$$

**$O$**

*Either  $G$  the total rate of refund of energy, to have the value of  $G$  per unit of length, it is necessary to divide the value obtained by the length of the crack  $L$ :*

$G () = G L$   
*in 3D*

### *2.3.4 Symmetry of the model*

*Not to forget to multiply by 2, values of the rate of refund of energy  $G$  or  $G (S)$  if one model that half of the solid compared to the crack (or to specify the key word SYME\_CHAR = "SYME" or "ANTI" in the orders concerned).*

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*Version*

*6.4*

*Titrate:*

*Applicability of the operators of breaking process*

*Date:*

*03/04/03*

*Author (S):*

*I. DEBOST, G. DEBRUYNE, Y. WADIER, E. SCREWS Key*

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*2.4*

*Method of interpolation in 3D*

### *2.4.1 Tally*

*general*

*The rate of refund of energy room  $G (S)$  is solution of the variational equation*

$G$

$(S) (S) m (S) ds = G ()$ .

$O$

*To solve this equation, the scalar field  $G (S)$  is discretized on a basis which we note*

$(p (S$

•  
**J**  
**))IjN**  
**NR**  
*That is to say G components of G (S) in this base:  $G(S) = G p$*

**J (S**  
**J**  
**)**  
**J**  
**j=1**  
**0**  
**S**  
**O**

*It is also necessary to define P independent fields I discretized on a noted basis (Q (S*

:  
**K**  
**))IkM**  
**M**  
**I (S) = I Q S**  
**K**  
**K ()**  
**K =1**

*G are given by solving the linear system with P unknown equations and NR:*

**J**  
  
**NR**

**G has**  
**= B, I = 1, P**  
**ij**  
**J**  
**I**  
**j=**  
**1**  
**M**

*with A*  
**I**  
**=**  
**p**



*m*

*ij*

*K*

*J (S) qk (S)*

*(S) ds*

*K*

*=I*

*O*

*B*

*I*

*=*

*G*

*I*

*( )*

*This system has a solution if one chooses P independent fields I such as: P NR and if MR. NR. It can comprise more equations than unknown factors, in which case it is solved within the meaning of least squares.*

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## **2.4.2 Methods of smoothing of G and Théta: polynomials of Legendre, functions of form nodes**

*In Code\_Aster, one chose two families of bases (cf [§2.2]):*

· *polynomials of LEGENDRE S of degree J (0*

*J ()*

*J 7),*

· *functions of form of the node K of: S (1*

*)*

*K ()*

*O*

*K NNO = a number of nodes of O*

*(of degree 1 for the linear elements and of degree 2 for the quadratic elements).*

*G S*

*() is broken up:*

· *is according to the polynomials of LEGENDRE:*

*LISSAGE\_G = "LEGENDRE"*

· *is according to the functions of forms of the nodes of the bottom of crack:*

*LISSAGE\_G = "LAGRANGE"*

· *is according to the functions of forms of the nodes of the bottom of crack with simplification of stamp to reverse:*

*LISSAGE\_G = "LAGRANGE\_NO\_NO"*

*I (S) are broken up:*

· *is according to the polynomials of LEGENDRE:*

*LISSAGE\_THETA = "LEGENDRE"*

· is according to the functions of forms of the nodes of the bottom of crack:

LISSAGE\_THETA = "LAGRANGE"

Attention, all the combinations between the families of functions of smoothing for G and THETA are not authorized:

G S

() LEGENDRE G S () LAGRANGE G S () LAGRANGE\_NO\_NO

I (S) LEGENDRE

·

not not

I (S) LAGRANGE

·

·

·

**Théta method: Legendre/G: Legendre:** the resolution of the linear system gives:

NDEG

G (S) = G (J

)

J (S)

j=0

**Théta method: Lagrange/G: Legendre:** one is reduced to the resolution of the linear system to NNO equations and with NDEG +1 unknown factors:

NDEG

I

S

S dS G

G

, I I, NNO

J () I ()

=

=

J

()

j=0

O

In this case, one must have  $NDEG \leq NNO$ , that is to say  $NDEG \leq \min(7, NNO)$  where  $NNO$  is the number of nodes of the bottom of crack.

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**Thétha method: Lagrange/G: Lagrange:** one is reduced to the resolution of the square linear system

$NNO$

$I$

$S$

$S dS G$

$G$

,  $I = 1, NNO$

$J() I()$

$J$

=

$()$

$j=0$

O

*Simplified method known as LAGRANGE\_NO\_NO for smoothing of  $G$  consists with diagonaliser the matrix thus obtained by summation of the horizontal terms.*

### **Remarks and councils of use:**

- *The user does not give a field  $\theta$ , fields  $I$  necessary to the calculation of  $G(S)$  are calculated automatically according to the method specified in order CALC\_G\_LOCAL [U4.82.04].*
- **Choix of the maximum degree of the polynomials of Legendre:** *this choice depends on the number of nodes in bottom of crack. If one has a low number of nodes (ten) it is useless of to take a degree higher than 3 (one conceives easily that the results are poor if one try to find a polynomial of degree 7 passer by by 10 points). Beyond a score of nodes in bottom of crack one can use degrees going up to 7. The experiment shows that the choice of a degree equal to 5 gives good results in the majority of the cases.*
- **Choix of the method:** *it is difficult to give a preference to one or the other method. In principle both give equivalent numerical results. Nevertheless method  $\theta$ : Lagrange is a little more expensive in time CPU than the  $\theta$  method: Legendre. For the first calculation, the use of the two methods and the comparison of the results, allows to consolidate the validity of the model. If the bottom of crack is a closed curve, problems of continuity of the solution at the arbitrarily selected point like X-coordinate curvilinear origin prohibit the use of the polynomials of Legendre. If the bottom of crack were declared "closed" in DEFI\_FOND\_FISS [U4.82.01], one must use the functions of form (Lagrange) to describe the functions  $G$  and  $\theta$ .*
- **Problème of nonthe respect of symmetry:** *if one models only half of the solid by report/ratio with the crack, one must in theory have a curve  $G(S)$  whose slope of the tangent is null with the interface of symmetry. This is not respected by the two methods. Values  $G(S)$  obtained at the ends of the bottom of crack must always be interpreted with prudence, especially if the crack is emerging in a nonperpendicular way (see [§2.2.3]).*
- **Problème of the oscillations** *of the solution with smoothing of  $G$  by the polynomials of Legendre, in particular if  $G(S) = 0$  or constant. If one tries to interpolate a constant function by one polynomial of raised degree, one expects this problem.*

## 2.5 Calculation of $G$ for a non-linear problem

*The essential problem in the nonlinear situations comes from the difficulty in separating them various energy contributions. It is necessary to consider two very distinct classes of problems:*

- that where, in spite of nonthe geometrical linearities or of behavior, one can exhiber one potential for the interior and external actions (nonlinear elasticity or hyperelasticity),
- that where such a potential does not exist (thermo-elastoplasticity).

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*For the first class, one can extend the criterion of Griffith by using the potential energy to balance, and to calculate the rate of refund of energy as in linear thermoelasticity.*

*For the second class of problem, the essential difficulty comes owing to the fact that dissipation is not only due to the propagation of the crack itself. One cannot distinguish which share any more restored energy is used for the propagation and which share is directly used by another dissipative phenomenon (plasticity in fact).*

### **2.5.1 Nonlinear thermoelasticity [R7.02.03]**

#### **2.5.1.1 Not linearity of behavior**

*The relation of nonlinear elastic behavior is described in [R5.03.20]. It should be noted that the law elastoplastic of Hencky-Von Put (isotropic work hardening) in the case of a radial loading and monotonous is equivalent to the non-linear elastic law. Material hyperelastic A a behavior reversible mechanics, i.e. any cycle of loading does not generate any dissipation. The EC fact the relation of behavior of material derives from the free potential energy and one can give one feel at the rate of refund of energy within the framework of the energy approach of Griffith.*

#### **Geometrical 2.5.1.2 Not linearity**

*One extends the relation of behavior to great deformations, insofar as it derives from one potential (hyperelastic law). This functionality is started by the key word DEFORMATION =*

**“GREEN” in orders  $CALC\_G\_THETA$  [U4.82.03] and  $CALC\_G\_LOCAL$  [U4.82.04].**

*The behavior of the solid is supposed to be hyperelastic, namely that the tensor of deformations of Green-Lagrange  $E$  is connected to the field of displacement  $U$  measured compared to the configuration of reference by:*

$$O$$

$$I$$

$$E(\mathbf{U}) =$$

$$(U + u + u U$$

$ij$   
 $I J$   
 $J I$   
 $I K$   
 $K J$ )

2

,

,

,

,

*and that the relation of behavior derives from the free potential energy ( $E$ ):*

$S$

=

$ij$

$E$

$ij$

*$S$  being the tensor of the constraints of Piola-Lagrange called still second tensor of Piola-Kirchoff*

*Such a relation of behavior makes it possible in any rigour to take into account the large ones deformations. However, one confines oneself with great displacements and great rotations, but one remain in small deformations. That to ensure the existence of a solution and to be identical to one elastoplastic behavior under a monotonous radial loading [R5.03.20 §2.1].*

### **2.5.2 Thermo-elastoplasticity [R7.02.07]**

*The field of validity of the calculation of the rate of refund of energy is limited to the thermoelastic framework*

*linear or non-linear. To deal with the elastoplastic problem, two solutions are possible:*

- to bring back itself to a non-linear thermoelastic problem with restrictive assumptions,*

· *to use another formulation, like that of the energy approach.*

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*2.5.2.1 Equivalence enters a nonlinear thermoelastic problem and a thermo problem elastoplastic*

*The relation of nonlinear elastic behavior makes it possible to deal with the problems of breaking process by approaching the thermoelastoplastic behavior. In the case of one monotonous radial loading, it makes it possible to obtain strains and stresses of structure similar to those which one would obtain if the material presented an isotropic work hardening.*

*The use of the indicators of discharge and loss of radiality makes it possible to be ensured of equivalence laws of behavior.*

*But conditions of loadings proportional and monotonous, essential to ensure coherence of the model with actual material, lead to important restrictions of the field of capable problems being dealt with by this method (thermal in particular can lead it to local discharges).*

*2.5.2.2 Formulation of parameter GTP*

*Caution:*

*This formulation results from recent research tasks and parameter GTP does not have yet experimental validity.*

*Within the thermoelastoplastic framework, dissipated energy is distributed on the one hand in rupture*



*and of other*

*leaves in plasticity without it being possible to separately quantify a priori these two types of dissipation. The choice suggested in Code\_Aster consists in deriving total mechanical energy for to obtain a rate of refund of energy, which we will call parameter of rupture GTP. It parameter makes it possible to analyze the nonmonotonous situations of loadings of the defect, for irreversible material behaviors. The relations of thermoelastoplastic behavior are described in detail in the document [R5.03.02].*

*How to make a calculation of GTP in thermoplasticity?*

*· The presence of the key word factor COMP\_INCR, and the key word factor RELATION = "VMIS\_ISOT\_LINE" (or "VMIS\_ISOT\_TRAC") in the orders CALC\_G\_THETA and CALC\_G\_LOCAL indicate that it is necessary to recover the field of displacements U, constraints, and characteristics of elastoplastic material. It is also necessary to recover the fields of the tensors of plastic deformation by operator CALC\_ELEM [U4.81.01].*

*· Modélisation by a notch: The defect must be modelled by a notch and not by a crack.*

*Indeed the formulation of G for a thermoelastoplastic relation is valid only for a notched solid and not for a fissured solid: the principal difficulty in the establishment of this formulation is impossibility of showing the existence of derived from total mechanical energy for a field comprising a crack, and this mainly by the absence of knowledge of the singularities of the fields in plasticity. It is important to note that the terms taken into account in a calculation thermoelastoplastic with the method *théta* are those supported by the elements between the point of crack and Rsup (in opposition to calculation in thermoelasticity not linear where only the terms between Rinf and Rsup are nonnull).*

*Form of possible notch:*

OK  
OK  
NOT

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*Within the framework of the method théta one considers that the notch is propagated while keeping even form (even if that does not have physical significance for a notch of the type pelletizes).*

*The type of the notch and the ray in bottom of notch do not have an influence on the values of GTP provided that the thickness of the notch is low compared to dimensions of structure. If one models by a pointed notch (traditional crack) the results must to be regarded as forgery (the terms of gradient of the plastic deformations are badly calculated numerically).*

*It is necessary to use a fine grid with quadratic elements in the vicinity bottom of the notch to have reliable results in the cases of discharge.*

***· Difficultés:***

*The smoothness of the grid can lead to important computing times.*

*The modeling of a crack by a notch is delicate in 3D.*

*Which interpretation to make results obtained with this parameter of rupture GTP? With run of the discharge the values of GTP are initially decreasing then then increasing: this is in conformity with the definition of GTP which integrates all accumulation plastic in bottom of defect. If one places oneself on the assumption of Griffith, one could thus to have propagation of the crack in discharge, which is problematic. Like one the problem sees remains open and still requires the validation of a criterion of rupture by experimental tests.*

***2.5.2.3 Approaches energy the elastoplastic rupture and fomulation of the Gp parameter***

***This formulation results from recent research tasks [bib62].***

***One defines a rate of refund of energy in plasticity called Gp applicable to a crack represented in notch, while being based on the formulation of Frankfurt-Marigo for the fragile mediums and on mechanics continues damage (see the chapter [§1.4]).***

***The Gp parameter is defined by the following fomule:***

**$G_p =$   
 $w_e dS$**

**.  
[(  
max  
(. )) /] L**

**L  
Notch (L  
)**

*where  $w_e$  is elastic energy.*

*How to make a calculation of  $G_p$  in thermoplasticity?*

**Grid:**

*The user must carry out a grid of the structure with a defect modelled in the form of a notch and not in the form of a crack. The notch with the shape of a cigar or even the shape of a crack prolonged of a circle in its end.*

**OK  
OK**

**Two types of authorized notches**

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*The bottom of notch ( ) is represented by a half-circle of ray R. the zone corresponding to propagation of the notch is noted Ze (L) (damaged Zone) and depends on L, outdistances propagated, in accordance with the figure below:*

*Ze (L)*

*notch*

*L*

*( ): melts of notch*

*Notch with chips*

*The potential damaged zone is modelled by a stacking of a hundred chips which will allow to make the calculation of energy.*

*The refinement of the grid close to the bottom of the notch must be extremely fine. Indeed, one advises*

*to choose the following geometrical data:*

- the ray of the circle in bottom of notch must be about  $R = 50$  microns, according to material considered,*
- each chip must have a thickness equal to  $1/5 R$  is  $\delta = 10$  microns.*

*One varies the propagated distance L while varying the number of chips considered:  $L = K \delta$ . Only one grid is enough.*

*Note:*

*The Gp parameter does not depend pathologically on the grid.*

*Difficulties:*

*The grid must be parameterized of kind to being able to carry out postprocessings automatically with loops on the kth chip considered.*

*Because of smoothness of the grid, calculations can be rather long and require place memory.*

*The grid of a notch in 3D is rather delicate to realize.*

*Calculation:*

*One makes a calculation with STAT\_NON\_LINE (). The calculation of energy in Code\_Aster is done simply thanks to order POST\_ELEM () with option ENER\_ELAS.*

*It is necessary then for each moment of nonlinear calculation, to calculate  $G_p(K)$ , for each value  $L$  corresponding to  $K$  chips by the formula:*

$$G_p(K) = E_{elas}(K)/(K \text{ delta}l)$$

*One determines then for each moment of calculation, the ligament where the maximum of  $G_p$  is obtained and in particular at the moment corresponding to the rupture.*

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### *2.5.3 Indicators of discharge and loss of radiality*

*These indicators make it possible to locate the local discharges and the loss of radiality. Attention with the interpretation of the indicators of discharge and loss of radiality: the value given to time  $T_i$  corresponds to the diagnosis from what occurs between  $T_i$  and  $t_{i+1}$ . Thus, the computed value with the last step of*

*time does not have a direction. The indicator of discharge is negative to indicate a local discharge, and*

*the indicator of radiality is worth 0 for a radial way.*

### *2.5.4 The Councils of use of the law of behavior*

*Calculation in linear thermoelasticity:*

*Before carrying out a calculation into non-linear it is advised to carry out the first thermo calculation linear rubber band and post-to treat the results to have a first idea of about size results.*

### ***Calculation into non-linear:***

***Insofar as it is possible it is preferable to make a thermoelastoplastic calculation and of to compare the results obtained with those of a nonlinear thermoelastic calculation. That allows to make sure that the loading is radial and monotonous, with possibly a certain approximation (use of the indicators of discharge and loss of radiality). If such is not the case, the problem remain open, and one can then be directed worms of postprocessings of the type “approaches local”.***

***Even if nothing prohibits in Code\_Aster to carry out a calculation with a law of behavior and of post-to treat with another law, the results are generally to question and the user must thus to be very attentive on this point.***

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***3***

***Implementation of a calculation in breaking process in***

***Code\_Aster***

***3.1 Methodology***

***3.1.1 Orders***

***Code\_Aster***

***One presents the principal orders here to be implemented in Code\_Aster Version 6. for to carry out a postprocessing in fragile breaking process. For more precise details on orders concerned, one will be able to refer to the documentation of use.***

**Acquisition of the data of the file of grid: LIRE\_MAILLAGE [U4.21.01]**

*For a grid 3D it is necessary to think as of the generation of the grid of naming the nodes of the bottom of fissure and the meshes of the lips of the crack. The nodes of the bottom of crack must be ordered for to define the direction of course of the curvilinear X-coordinate of the bottom of crack. One can order the nodes of melts of crack with order DEFI\_FOND\_FISS [U4.82.01].*

**The Council:**

*Obligatorily to use quadratic elements (for an elastoplastic problem and strongly advised for a 3D problem).*

*For more details to consult [§2.1].*

**Definition of the model: AFFE\_MODELE [U4.41.01]**

*The modelled physical phenomenon is mechanical (PHENOMENE=' MECANIQUE'). Modeling is chosen among modelings of the continuous mediums 2D plane deformations or plane constraints, axisymmetric 2D and 3D (D\_PLAN, C\_PLAN, AXIS, 3D).*

**Characteristics of material: DEFI\_MATERIAU [U4.43.01] and AFFE\_MATERIAU [U4.43.03]**

*The behavior is either elastic linear (key word factor ELAS or ELAS\_FO) or nonlinear (word key factor ECRO\_LINE or ECRO\_LINE\_FO or TRACTION). Characteristics of materials to define are the modulus Young, the Poisson's ratio, possibly the dilation coefficient thermics and in the nonlinear case elastic limit and the module of work hardening or the curve of traction. These characteristics can depend on the temperature for the calculation of the rate of refund of energy.*

*For the calculation of the stress intensity factors the characteristics must be defined on all materials, including on the elements of edge, because of method of calculation [R7.02.05]. For to ensure itself so it is advised to make a AFFE=\_F (TOUT=' OUI') in the order AFFE\_MATERIAU [U4.43.03], even if it means to use the rule of overload then.*

**Assignment of the mechanical loadings: AFFE\_CHAR\_MECA (\_F) [U4.44.01]**

*The mechanical loadings are those of the continuous mediums. One will take care that the loadings used either supported well by the operators of breaking process (voir§1.3.4) if not they are been unaware of.*

*For a problem where thermics intervenes, one recovers the thermal loading of origin by the word key TEMP\_CALCULEE in order AFFE\_CHAR\_MECA [U4.44.01]. For the possible resolution thermal problem, it is necessary to define the thermal model with AFFE\_MODELE [U4.41.01] ( selected modeling is the same one as that of the mechanical model). The thermal loadings are those of the continuous mediums and are defined with AFFE\_CHAR\_THER (\_F) [U4.44.02]. The resolution is made with THER\_LINEAIRE [U4.54.01] or THER\_NON\_LINE [U4.54.02].*

**Resolution of the mechanical problem: MECA\_STATIQUE [U4.51.01] or STAT\_NON\_LINE [U4.51.03]**

*If the problem is elastic linear, the total operator MECA\_STATIQUE is used who calculates them displacements starting from the model, of the material field, the boundary conditions and the loading. The concept produced by this operator is of evol\_elas type.*

*If the problem is non-linear, the total operator STAT\_NON\_LINE is used who produces a concept of evol\_noli type.*

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*It is possible to use order CREA\_CHAMP (OPERATION='EXTR') [U4.72.04] to recover the field of displacements to the nodes (necessary for the postprocessing of mechanics of rupture). But one can also directly use the concept evol\_elas and evol\_noli in orders of breaking process, by specifying the desired sequence numbers.*

*The Council: For an expensive non-linear calculation in memory and time CPU, it is advised of to constitute a base and to continue the study for postprocessings (in particular in mechanics of rupture). For more details to consult the documents BEGINNING [U4.11.01], CONTINUATION [U4.11.03] and END [U4.11.02]. It is then necessary to be vigilant on the compatibility of the versions of Code\_Aster between two connected executions.*

*Postprocessing in breaking process*

*Definition of the characteristics of the bottom of crack: DEFI\_FOND\_FISS [U4.82.01]*

*This order makes it possible to define:*

- in 2D the node of the bottom of crack and the normal with the crack,*
- in 3D nodes of the bottom of crack and meshes of the lips of the crack.*



*In 2D this order is obligatory only for the calculation of the coefficients of intensity of constraints. In the case of a symmetrical structure where half of the crack is represented, the single one lip must be defined by LEVRE\_SUP. If the crack does not emerge, it is not then of course necessary to define the directions of  $\theta$  at the ends by DTAN\_ORIG and DTAN\_EXTR.*

*Assignment of the field  $\theta$ : CALC\_THETA [U4.82.02]*

*This order makes it possible to affect the field  $\theta$  necessary to the calculation of the rate of refund of energy or of the stress intensity factors. The field  $\theta$  is a field with the nodes defined on all it grid.*

*The user must define the characteristics of the field  $\theta$ :*

- the module (equal to 1. a priori),*
- direction of propagation: equalize with that of the bottom of crack in 2D, calculated automatically in 3D starting from the directions of propagation of the nodes in bottom of crack (these directions are recovered by the concept of the fond\_fiss type produces by the operator DEFI\_FOND\_FISS or by key word DIRE\_THETA),*
- the Rinf rays and Rsup of the crowns surrounding the bottom of crack and used in method  $\theta$ : in 2D the bottom of crack is tiny room to a node and the crowns are circulars. In 3D the rays can be variable with the curvilinear X-coordinate of the bottom of fissure and Rinf, Rsup define two deformed and variable cylinders then surrounding the bottom of crack.*

*This order is not necessary if one carries out a calculation of the rate of refund of energy room: field  $\theta$  is calculated automatically starting from the bottom of crack resulting from DEFI\_FOND\_FISS, of rays Rinf and Rsup and of the method of interpolation defined in order CALC\_G\_LOCAL.*

*Choice of the rays Rinf and Rsup:*

- The choice of the rays Rinf and Rsup is independent of the topology of the grid (even if it is preferable, one is not obliged to have a radiant grid at a peak of crack).*
- Never not to use a definite field  $\theta$  with a ray lower null Rinf. Indeed fields displacements are singular in bottom of crack and introduce results vague in postprocessing of breaking process.*
- In thermo-elastoplasticity, one uses a crack as notch. One will make sure that the ray Rinf inferior is quite higher than the ray of the notch.*
- In 2D the ray higher Rsup can be as large as one wants in condition of course that crown thus defined either contained in the solid.*
- In 3D the problem is more delicate: it is necessary to find a compromise between Rinf not too small (results vague because of the fields of singular displacements evil calculated in bottom of*

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*fissure) and  $R_{sup}$  not too large (direction of the field  $\theta$  can be badly calculated). To see it [§2.2.3] for more details.*

*· Not to forget that the loadings applied beyond  $R_{sup}$  have a null contribution in postprocessings of breaking process. This can be useful if one is applied loading not supported like `FORCE_NODALE`, `DDL_IMPO` (in 2D) or `FACE_IMPO` (in 3D) to see [§1.3.4].*

*· Prendre several consecutive crowns to check  $[R1, R2]$ ,  $[R2, R3]$ ,  $[R3, R4]$ ,...*

**Calculation of the rate of refund of energy in 2D or 3D: `CALC_G_THETA` (`_T`) [U4.82.03]**

**Order `CALC_G_THETA` makes it possible to calculate the rate of refund of energy  $G$  in 2D or 3D by the method  $\theta$  in the case of a linear thermoelastic problem or not linear.**

**For this calculation the user must specify obligatorily:**

- the model,*
- the material field,*
- the field of displacements (starting from a field with the nodes or of a result),*
- the field  $\theta$ ,*

**and possibly:**

- loading (if the voluminal, surface loading on the lips of the crack or origin thermics),*
- the relation of behavior (by linear defect thermoelasticity),*
- plastic deformations (if the behavior is thermoelastoplastic).*

**Order `CALC_G_THETA` also allows the calculation of the rate of refund of energy with Lagrangian propagation (i.e. for an extension of the crack by using the same grid) in 2D or 3D in the case of a linear thermoelastic problem (option `CALC_G_LAGR`). For more**

*precise details one will refer to the document [R7.02.04].*

***Calculation of the coefficients of intensity of constraints in 2D: CALC\_G\_THETA (\_T) [U4.82.03]***  
***Order CALC\_G\_THETA makes it possible to calculate the coefficients of intensity of constraints in 2D***

***(plane constraints or plane deformations) by the method  $\theta$  in the case of a problem thermoelastic linear. It is necessary to specify option CALC\_K\_G under the key word OPTION. For this calculation the user must specify obligatorily:***

- the model,***
- the material field,***
- the field of displacements (starting from a field with the nodes or of a result),***
- the field  $\theta$ ,***
- bottom of crack,***

***and possibly loading (if the voluminal, surface loading on the lips of the crack or of thermal origin).***

***Calculation of the coefficients of intensity of constraints by extrapolation of the field of displacements: POST\_K1\_K2\_K3.***

***Order POST\_K1\_K2\_K3 makes it possible to calculate the coefficients of intensity of constraints (y included/understood K3) in 2D (forced plane or plane deformations), 3D and axisymmetric the case of one***

***crack planes in a homogeneous and isotropic elastic material.***

***For this calculation the user must obligatorily specify the fields of displacement on each lip, provided in the form of tables extracted the concept evol\_elas result by the order POST\_RELEVE\_T.***

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**Calculation of the rate of refund of energy room in 3D: CALC\_G\_LOCAL (\_T) [U4.82.04]**

*Order CALC\_G\_LOCAL makes it possible to calculate the rate of refund of energy G in 2D or 3D by the method  $\theta$  in the case of a linear thermoelastic problem or not linear.*

*For this calculation the user must specify obligatorily:*

- the model,*
- the material field,*
- the field of displacements (starting from a field with the nodes or of a result),*
- bottom of crack,*
- the rays Rinf and Rsup defining the crowns surrounding the bottom of crack,*

*and possibly:*

- loading (if the voluminal, surface loading on the lips of the crack or origin thermics),*
- the relation of behavior (by linear defect thermoelasticity),*
- method of discretization of the field  $\theta$  in bottom of crack (per defect method of Legendre, degree 5),*
- plastic deformations (if the behavior is thermoelastoplastic).*

*It will be noted that the field  $\theta$  is calculated starting from the bottom of crack and the rays Rinf and Rsup (useless*

*to use safe order CALC\_THETA for the particular case of the Lagrangian propagation).*

*Order CALC\_G\_THETA also allows the calculation of the rate of refund of energy room with Lagrangian propagation in 3D (option CALC\_G\_LGLO) in the case of a thermoelastic problem linear [R7.02.04].*

**Calculation of energy for the calculation of the rate of refund of energy in Gp plasticity:**

*One uses order POST\_ELEM (), with option ENER\_ELAS. One obtains the calculation of Gp by one*

*post\_traitement manual (see chapter [§1.4] and chapter [§ 2.5.2.3]).*

### **3.1.2 Traps to be avoided**

#### **Grid:**

*In 3D the nodes of the bottom of crack must be ordered.*

*For a thermoelastoplastic problem (parameter GTP and Gp) it is necessary to model the crack by one notch and to use quadratic elements.*

#### **Loading:**

*During a thermal calculation, one should not forget to introduce into the operand CHARGES of CALC\_G\_THETA or CALC\_G\_LOCAL the thermal load of origin.*

*The not supported loadings are ignored. No message of alarm is transmitted, one will refer thus with [§1.3.4] to make sure that the loadings used have a direction in breaking process and are well treated.*

*If the list of the loads comprises more than one load, a loading of comparable nature cannot appear that in only one load. In the contrary case, only the last load is taken into account.*

*If the field of displacement were calculated by a load with a multiplying coefficient different from 1. , one will have, to obtain G corresponding to the good loading, to introduce into the operand CHARGES*

*CALC\_G\_THETA or CALC\_G\_LOCAL the load in question multiplied by this coefficient (see COMB\_CHAM\_NO [U4.72.02] for this problem).*

*If one makes a calculation in great transformations (key word DEFORMATION = “GREEN” under the key word*

*factor COMP\_ELAS) the supported loadings must be died loads, typically one force imposed and not a pressure [R7.02.03 §2.4].*

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**Law of behavior:**

**Nothing prohibits in practice to solve the mechanical problem with a law of behavior (in MECA\_STATIQUE or STAT\_NON\_LINE) and to carry out postprocessing with another law of behavior: to avoid.**

**Symmetry of the loading and standardization:**

**In orders CALC\_G\_THETA and CALC\_G\_LOCAL key word SYME\_CHAR makes it possible to indicate if**

**the loading is symmetrical or antisymmetric in the case or one only half of the solid models compared to the crack.**

**This key word is essential if one uses option "CALC\_K\_G" to calculate the factors of intensity of constraints: it makes it possible to assign K2 to 0 if the loading is symmetrical compared to the crack or K1 with**

**0 if it is antisymmetric.**

**It also makes it possible to multiply by 2, the values of the rate of refund of energy G if one does not model**

**that half of the solid compared to the crack.**

**"WITHOUT" "ANTI" "SYME"**

**G GASTER 2.\***

**GASTER 2.\***

**GASTER**

**K1 K1ASTER K1ASTER 0.**

**K2 K2ASTER 0. K2ASTER**

**Caution:**

**Not to forget that in certain configurations, a manual postprocessing is necessary to obtain the standardization of the value of the rate of refund of energy. In particular in axisymmetric, it is necessary to divide GASTER by the distance from the bottom of crack to the axis of symmetry and into**

**3D by the length of the bottom of crack [§2.3].**

**Definition of the bottom of crack and the Rinf rays and Rsup in 3D:**

**When the crack is emerging, to define the directions of the field  $\theta$  well at the ends of the bottom of fissure using key words DTAN\_ORIG and DTAN\_EXTR in order DEFI\_FOND\_FISS [U4.82.01]. See 2.2.2.**

**Attention with the choice of the Rinf rays and Rsup of the crown. See [§2.2.3].**

***Calculation of energy for the calculation of the rate of refund of energy in  $G_p$  plasticity:  
It should be taken care that energy is calculated with sufficient precision because one carries out for  
calculation of  $G_p$  a difference between very small quantities.***

### ***3.1.3 Checks concerning postprocessings of breaking process***

***It is important to have an idea of about size of the results before beginning any calculation  
numerical (simplified model, test of reference, bibliography,...).***

***It is advised to use successively orders  $CALC\_G\_THETA$  or  $CALC\_G\_LOCAL$  with with  
less 3 fields  $\theta$  of different crowns to ensure itself of the stability of the results. In the event of  
important variation (higher than 5-10%) it is necessary to wonder about the good taking into account  
of all  
modeling. This stability is a condition necessary (but not sufficient) for the validity of  
results.***

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### ***3.2 Example 1: Calculation of $G$ , $K1$ and $K2$ for an elastic problem linear in 2D***

***It is about a test of breaking process for a linear elastic problem in plane constraints  
SSLP101 [V3.02.101]. One calculates the rate of refund of energy and the coefficients of intensity of  
constraints for a linear elastic problem in plane constraints.***

#### ***3.2.1 Geometry***

***Rectangular plate with emerging crack OC.***

***For reasons of symmetry, the model is tiny room to the half-structure  $Y 0$ .***

***Y***  
***I***  
***v***  
***H***  
***U***  
***With***  
***O***  
***C***  
***X***  
***has***

***Height plates:  $H = 250$  mm***

***C = N668***

***Width plates:  $I = 100$  mm***

***Depth fissures:  $have = 37.5$  mm (OC)***

### ***3.2.2 Material properties***

***E = 200000 NAKED MPa = 0.3***

***Assumption of the plane constraints.***

### ***3.2.3 Boundary conditions and loadings***

***Constraint imposed in  $Y = H$ :***

***= 1 MPa***

***Displacement for the edge ( $X I$  has,  $Y = 0$ ):***

***$v = 0$ .***

***Not fixes a:***

***U = v = 0.***

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### **3.2.4 Command file**

**BEGINNING ()**

**MA=LIRE\_MAILLAGE ()**

**MO=AFFE\_MODELE (MAILLAGE=MA,**

**AFFE=\_F (ALL = "YES",**

**PHENOMENON = "MECHANICAL",**

**MODELING = "C\_PLAN"))**

**MAT=DEFI\_MATERIAU (ELAS=\_F (E = 200000. , NAKED = 0.3, RHO = 1.))**

**CHMAT=AFFE\_MATERIAU (MAILLAGE=MA,**

**AFFE=\_F (ALL = "YES", MATER = CHECHMATE))**

**CH=AFFE\_CHAR\_MECA (MODELE=MO, DDL\_IMPO= (**

**\_F (GROUP\_NO = "GRNM5", DY = 0.),**

**\_F (NODE = "N451", DX = 0.)),**

**FORCE\_CONTOUR=\_F (GROUP\_MA = "GRMA1", FY = 1.))**

**FCONT = FORMULA (REEL= """" (REAL: X, REALITY: Y) =1. """")**

**CHFONC=AFFE\_CHAR\_MECA\_F (MODELE=MO,**

**FORCE\_CONTOUR=\_F (GROUP\_MA = "GRMA1",**

**FY = FCONT))**

**CHAMDEPL=MECA\_STATIQUE (MODELE=MO, CHAM\_MATER=CHMAT,**

**EXCIT=\_F (LOAD = CH))**

**DEP=CREA\_CHAMP (OPERATION=' EXTR', TYPE\_CHAM=' NOEU\_DEPL\_R',**

**NOM\_CHAM=' DEPL', RESULTAT=CHAMDEPL,  
NUME\_ORDRE=1)**

**THETA1=CALC\_THETA (MODELE=MO,  
THETA\_2D=\_F (NODE = "N668", MODULE = 1. ,  
R\_INF = 22.04078,  
R\_SUP = 30.),  
DIRECTION= (1. , 0. , 0. ,))**

**FOND=DEFI\_FOND\_FISS (MAILLAGE=MA,  
FOND=\_F (NODE = "N668"),  
NORMALE= (0. , 1. , 0. ,))**

**G1=CALC\_G\_THETA\_T (MODELE=MO,  
DEPL=DEP,  
THETA=THETA1,  
CHARGE=CHFONC,  
SYME\_CHAR=' SYME',  
COMP\_ELAS=\_F (RELATION = "ELAS",  
DEFORMATION = "SMALL"),  
CHAM\_MATER=CHMAT)**

**GK1=CALC\_G\_THETA\_T (MODELE=MO,  
DEPL=DEP,  
THETA=THETA1,  
FOND\_FISS=FOND,  
SYME\_CHAR=' SYME',  
CHARGE=CHFONC,  
CHAM\_MATER=CHMAT,  
OPTION=' CALC\_K\_G')  
PRECISION=1.E-4)**

**END ()**

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### **3.3 Example 2: Calculation of $G$ and $G(S)$ local for a thermo problem rubber band in 3D**

**It is about a test of breaking process into thermomechanical for a three-dimensional problem HPLV103 [V7.03.103]. One considers a circular crack plunged in a thermoelastic medium. One imposes a uniform temperature on the lips of the crack. This test makes it possible to calculate the rate of restitution of energy total  $G$  and the rate of refund  $G$  local in various points of the bottom of crack.**

#### **3.3.1 Geometry**

**One considers a circular crack plunged in a thermoelastic medium:**

**Z**

**E**

**H**

**F**

**G**

**O**

**C**

**D**

**y**

**With**

**B**

**C**

**I**

**X**

**The ray of the crack is:  $OA = OB = 1.0$**

**The medium is modelled by a parallelepiped of dimensions:  $OE = OD = OC = 30.0$**

#### **3.3.2 Material properties**

**Thermal conductivity:**

**= 1.**

**Thermal dilation coefficient: =  $10^{-6}/^{\circ}C$**

*Young modulus:*

$E = 2.105 \text{ MPa}$

*Poisson's ratio:*

$= 0.3$

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### ***3.3.3 Boundary conditions and loadings***

**Z**

***T0 = constant = - 1***

**Y**

**O**

***has***

**X**

### ***3.3.4 Command file***

**BEGINNING ()**

**M=LIRE\_MAILLAGE ()**

**M=DEFI\_GROUP (reuse=M, MAILLAGE=M, CREA\_GROUP\_NO= (**

**\_F (GROUP\_MA = "LEVREINF"),**

**\_F (GROUP\_MA = "SSUP\_S"),**

**\_F (GROUP\_MA = "SAV\_S"),**

```
_F (GROUP_MA = "SLAT_S"),  
_F (GROUP_MA = "SINF"),  
_F (GROUP_MA = "SAR"),  
_F (GROUP_MA = "SLAT"),  
_F (NAME = "INFINITE",  
UNION = ("SINF", "SAR", "SLAT",))  
)
```

```
#-----  
# BEGINNING OF THERMICS #  
#-----
```

```
MOTH=AFFE_MODELE (MAILLAGE=M,  
AFFE=_F (ALL = "YES",  
PHENOMENON = "THERMAL",  
MODELING = "3D")  
)
```

```
MATH=DEFI_MATERIAU (THER=_F (RHO_CP = 0. , LAMBDA = 1.))
```

```
CMTH=AFFE_MATERIAU (MAILLAGE=M,  
AFFE=_F (ALL = "YES",  
MATER = MATHS)  
)
```

```
CHTH=AFFE_CHAR_THER (MODELE=MOTH, TEMP_IMPO= (  
_F (GROUP_NO = "INFINITE",  
TEMP = 0.0),  
_F (GROUP_NO = "LEVREINF",  
TEMP = 1.))  
)
```

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**THLI=Ther\_Lineaire (MODELE=MOTH,  
CHAM\_MATER=CMTH,  
EXCIT=\_F (LOAD = CHTH)  
)**

**TEMP=CREA\_CHAMP (OPERATION=' EXTR', TYPE\_CHAM=' NOEU\_TEMP\_R',  
NOM\_CHAM=' TEMP', RESULTAT=THLI,  
INST=0.0  
)**

**#-----  
# END OF THERMICS #  
#-----**

**MO=AFFE\_MODELE (MAILLAGE=M,  
AFFE=\_F (ALL = "YES",  
PHENOMENON = "MECHANICAL",  
MODELING = "3D")  
)**

**MA=DEFI\_MATERIAU (ELAS=\_F (E = 200000. ,  
NAKED = 0.3,  
ALPHA = 0.000001)  
)**

**#**

**CM=AFFE\_MATERIAU (MAILLAGE=M,  
AFFE=\_F (ALL = "YES",  
MATER = MA,  
TEMP\_REF = 0.)  
)**

**#**

**CH=AFFE\_CHAR\_MECA (MODELE=MO,  
TEMP\_CALCULEE=TEMP, DDL\_IMPO= (  
\_F (GROUP\_NO = "SSUP\_S", DZ = 0.),  
\_F (GROUP\_NO = "SLAT\_S", DX = 0.),**

*\_F (GROUP\_NO = "SAV\_S", DY = 0.)*  
)

#

*MEST=MECA\_STATIQUE (MODELE=MO,  
CHAM\_MATER=CM,  
EXCIT=\_F (LOAD = CH)*  
)

#

*DEPLA=CREA\_CHAMP (OPERATION=' EXTR', TYPE\_CHAM=' NOEU\_DEPL\_R',  
NOM\_CHAM=' DEPL', RESULTAT=MEST,  
INST=0.0*  
)

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#-----

# **CALCULATION OF G**

#-----

*FF=DEFI\_FOND\_FISS (MAILLAGE=M,*

*FOND=\_F (GROUP\_NO = "LFF"),*

*NORMALE= (0. , 0. , 1. ),*

*DTAN\_ORIG= (1. , 0. , 0. ),*

*DTAN\_EXTR= (0. , 1. , 0. )*

)

```

#
#
THETA1=CALC_THETA (MODELE=MO,
FOND_FISS=FF,
THETA_3D=_F (ALL = “YES”,
MODULATE = 1.0,
R_INF = 0.07,
R_SUP = 0.2)
)

```

```

#
G1=CALC_G_THETA_T (MODELE=MO,
DEPL=DEPLA,
CHAM_MATER=CM,
THETA=THETA1,
CHARGE=CH,
COMP_ELAS=_F (RELATION = “ELAS”,
DEFORMATION = “SMALL”)
)

```

```

#-----
# CALCULATION OF GLOCAL #
#-----

```

```

GLOC1=CALC_G_LOCAL_T (MODELE=MO,
DEPL=DEPLA,
CHAM_MATER=CM,
FOND_FISS=FF,
CHARGE=CH,
DEGRE=6,
R_INF=0.07,
R_SUP=0.2,
LISSAGE_THETA=' LAGRANGE',
LISSAGE_G=' LEGENDRE',
COMP_ELAS=_F (RELATION = “ELAS”,
DEFORMATION = “SMALL”)
)

```

**END ()**

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**3.4**

***Example 3: calculation of  $G_p$  for an elastoplastic problem in 2D***

***One carries out a calculation in breaking process for an elastoplastic problem in 2D deformations plane.***

***One implements the calculation of the  $G_p$  parameter resulting from recent research tasks (see chapter [§ 2.5.2.3]) to highlight “the effect small defect”.***

***Context and objective:***

***Tenacity is a parameter determined in experiments on a test-tube CT fissured in traction, who is supposed to represent the breaking strength of material. But on the test-tubes, the cracks are big sizes compared to the real cases. The effects of triaxiality are important and plasticity weak.***

***On the contrary on real cases, the cracks are smaller sizes, the effects of triaxiality are more weak, and plasticity is stronger. Measured tenacity would be then larger, from where a profit of margins potential. The size of the crack thus has an effect on the measured value of tenacity. It is this effect which is called “effect small defect”.***

***One applies here the energy approach based on the calculation of  $G_p$  parameter to the interpretation of the effect small defect.***

***One considers on the one hand a test-tube SENB with a great defect (SENB1) and on the other hand one test-tube SENB with a small defect (SENB2).***

**3.4.1 Geometry**

***Rectangular plate with small or great defect. One represents only half of the structure.***

**Height plates  $H = 50$  mm**

**Width plates  $L = 420$  mm**

**Spacing between two supports  $S = 370$  mm**

**Cut defect  $a_f = 25$  mm (SEN B1) or 3.8 mm (SEN B2).**

**$L/2$**

**$L_{pilot}$**

**$L_{igr}$**

**$H$**

**$a_f$**

**$L_{appui}$**

**$S/2$**

### **3.4.2 Properties of materials**

**Young modulus:  $E = 208510$**

**Poisson's ratio:  $\nu = 0.3$**

**Traction diagram with nonlinear work hardening (behavior VMIS\_ISOT\_TRAC)**

### **3.4.3 Boundary conditions and loadings**

**One applies the condition of support to  $L_{appui}$   $D_y = 0$ .**

**One applies the condition of symmetry  $dx = 0$  to the ligament of defect LIGR.**

**One charges in displacement out of  $D_y$  on edge LPILOT.**

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### ***3.4.4 2 command files for each of the 2 cases***

***TEST-TUBE SENB1 GREAT DEFECT af/H = 0.5 IS af = 25 MM***

***BEGINNING ()***

***PRE\_GIBI ()***

***MA=LIRE\_MAILLAGE ()***

***MA=DEFI\_GROUP (reuse =MA,***

***MAILLAGE=MA,***

***CREA\_GROUP\_NO=\_F (TOUT\_GROUP\_MA=' OUI',),)***

***#***

***# MODELING OF THE GRID***

***#***

***MOD=AFFE\_MODELE (MAILLAGE=MA,***

***AFFE=\_F (TOUT=' OUI',***

***PHENOMENE=' MECANIQUE',***

***MODELISATION=' D\_PLAN',),)***

***#***

***# DEFINITION OF MATERIAL***

***#***

***SIGM\_F = DEFI\_FONCTION (NOM\_PARA = "EPSI",***

***VALE= (***

***2.74E-03, 571.32,***

***1.29E-02, 609.42,***

***2.31E-02, 647.52,***

***3.33E-02, 685.62,***

***4.34E-02, 715,***

***5.36E-02, 746,***

***6.37E-02, 775,***

***7.38E-02, 797,***

***8.39E-02, 814,***

***9.40E-02, 831.66,***

***0.10405 , 844.47,***

***0.11411 , 856.22,***

0.12416 , 867.1 ,  
0.14425 , 886.7 ,  
0.16434 , 904.04,  
0.18441 , 919.62,  
0.20448 , 933.78, ),

**PROL\_DROITE = "CONSTANT",**  
**PROL\_GAUCHE = "CONSTANT",**

)

**ACIER=DEFI\_MATERIAU (ELAS=\_F (E=208510.,**

**NU=0.3,**

**ALPHA=0.0),**

**TRACTION=\_F (SIGM = SIGM\_F),**

)

**CH\_MAT=AFFE\_MATERIAU (MAILLAGE=MA,**

**AFFE=\_F (GROUP\_MA=' SENB',**

**MATER=ACIER,**

**TEMP\_REF=0.0),)**

#

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**# DEFINITION Of a LIST Of MOMENTS AND a SLOPE**

**#**

**LIST=DEFI\_LIST\_REEL (DEBUT=0.0,**

**INTERVALLE= (\_F (JUSQU\_A=22.0,**

**NOMBRE=22,)**

**\_F (JUSQU\_A=27.0,**

**NOMBRE=5,)**

**\_F (JUSQU\_A=32.0,**

**NOMBRE=5,)**

**\_F (JUSQU\_A=37.0,**

**NOMBRE=5,)**

**\_F (JUSQU\_A=42.0,**

**NOMBRE=5,)**

**\_F (JUSQU\_A=47.0,**

**NOMBRE=5,)**

**\_F (JUSQU\_A=52.0,**

**NOMBRE=5,)**

**\_F (JUSQU\_A=57.0,**

**NOMBRE=5,)**

**\_F (JUSQU\_A=61.0,**

**NOMBRE=4,)**

**\_F (JUSQU\_A=65.0,**

**NOMBRE=4,)**

**\_F (JUSQU\_A=70.0,**

**NOMBRE=5,)**

**\_F (JUSQU\_A=76.0,**

**NOMBRE=6,)**

**\_F (JUSQU\_A=82.0,**

**NOMBRE=6,)**

*\_F (JUSQU\_A=88.0,  
NOMBRE=6,)  
\_F (JUSQU\_A=94.0,  
NOMBRE=6,)  
\_F (JUSQU\_A=100.0,  
NOMBRE=6,)),)*

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***RAMPE=DEFI\_FONCTION (NOM\_PARA=' INST',  
VALE= (0.0, 0.0, 100.0, 100.0),  
PROL\_DROITE=' LINEAIRE',  
PROL\_GAUCHE=' LINEAIRE',)***

#

***# LOADING AND CONDITIONS LIMITING***

#

***CHAR=AFFE\_CHAR\_MECA (MODELE=MOD,  
DDL\_IMPO= (\_F (GROUP\_NO=' LIGR',  
DX=0.0,)  
\_F (GROUP\_NO=' LAPPUI',  
DY=0.0,)  
\_F (GROUP\_NO=' LPILOT',  
DY=-0.04,)),)***

#

***# APPLICATION OF THE LOAD & CALCULATION OF THE CONSTRAINTS***

#

**RESU=STAT\_NON\_LINE (MODELE=MOD,  
CHAM\_MATER=CH\_MAT,  
EXCIT=\_F (CHARGE=CHAR,  
FONC\_MULT=RAMPE,)  
COMP\_INCR=\_F (RELATION=' VMIS\_ISOT\_TRAC',  
DEFORMATION=' PETIT',  
GROUP\_MA=' SENB'),  
INCREMENT=\_F (LIST\_INST=LIST,  
NUME\_INST\_FIN=30,)  
NEWTON=\_F (PREDICTION=' TANGENTE',  
MATRICE=' TANGENTE',  
REAC\_ITER=4,)  
RECH\_LINEAIRE=\_F (RESI\_LINE\_RELA=1.E-3,  
ITER\_LINE\_MAXI=3,)  
CONVERGENCE=\_F (RESI\_GLOB\_MAXI=1.E-08,  
RESI\_GLOB\_RELA=1.E-08,  
ITER\_GLOB\_MAXI=20,)  
SOLVEUR=\_F (METHODE=' MULT\_FRONT',  
RENUM=' METIS'),)**

**#  
# CALCULATION OF G  
#**

**THETA1=CALC\_THETA (MODELE=MOD,  
DIRECTION= (0.0, 1.0, 0.0),  
THETA\_2D=\_F (GROUP\_NO=' O',  
MODULE=1.0,  
R\_INF=0.25,  
R\_SUP=0.5,))**

**G1=CALC\_G\_THETA\_T (MODELE=MOD,  
CHAM\_MATER=CH\_MAT,  
THETA=THETA1,  
RESULTAT=RESU,  
TOUT\_ORDRE=' OUI',  
SYME\_CHAR=' SYME',  
COMP\_ELAS=\_F (RELATION=' ELAS\_VMIS\_TRAC',  
DEFORMATION=' PETIT'),)**

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**IMPR\_TABLE (TABLE=G1, FORMAT = "AGRAF")**

**THETA2=CALC\_THETA (MODELE=MOD,  
DIRECTION= (0.0, 1.0, 0.0),  
THETA\_2D=\_F (GROUP\_NO=' O',  
MODULE=1.0,  
R\_INF=0.50,  
R\_SUP=1.0,))  
G2=CALC\_G\_THETA\_T (MODELE=MOD,  
CHAM\_MATER=CH\_MAT,  
THETA=THETA2,  
RESULTAT=RESU,  
TOUT\_ORDRE=' OUI',  
SYME\_CHAR=' SYME',  
COMP\_ELAS=\_F (RELATION=' ELAS\_VMIS\_TRAC',  
DEFORMATION=' PETIT',))**

**IMPR\_TABLE (TABLE=G2, FORMAT = "AGRAF")**

**THETA3=CALC\_THETA (MODELE=MOD,  
DIRECTION= (0.0, 1.0, 0.0),  
THETA\_2D=\_F (GROUP\_NO=' O',  
MODULE=1.0,  
R\_INF=1.0,  
R\_SUP=2.0,))**

**G3=CALC\_G\_THETA\_T (MODELE=MOD,  
CHAM\_MATER=CH\_MAT,  
THETA=THETA3,  
RESULTAT=RESU,**



**TOUT\_ORDRE=' OUI',  
SYME\_CHAR=' SYME',  
COMP\_ELAS=\_F (RELATION=' ELAS\_VMIS\_TRAC',  
DEFORMATION=' PETIT',),)**

**IMPR\_TABLE (TABLE=G3, FORMAT = "AGRAF")**

**END ()**

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**CONTINUATION (PAR\_LOT=' NON')**

**ENEE= [None] \*200**

**ENET= [None] \*200**

**#**

**deltal = 0.01**

**#**

**importation bone**

**f2=open ("fort.44", "W")**

**f3=open ("fort.45", "W")**

**f2.write ("brutal Propagation - Test-tube SENB1 - Grid M1 | N")**

**f2.write ("Work hardening diagram traction ECA | N")**

**f2.write ("Propagation - elastic Energy - G plastic (dW/dl) | N")**

**for K in arranges (1,101):**

**LIG = "COPS\_%i" % (K)**

**print "ligament number: ", K**

*print “cumulated propagation: ”, k\*deltal, “millimetres”*

```
ENEE [K] = POST_ELEM (MODELE=MOD,
RESULTAT=RESU,
CHAM_MATER=CH_MAT,
TOUT_ORDRE = ' OUI',
ENER_ELAS=_F (GROUP_MA=LIG),
TITRE=' Energy élastique',
)
IMPR_TABLE (TABLE=ENEE [K],
FORMAT_R='IPE18.11')
```

*# End of the iterations*

```
for J in arranges (1,31):
f2.write (“Urgent: %f \ N” % (J))
gpmax = 0.
for K in arranges (1,101):
ETOT=ENEE [K] [“TOTAL”, J]
GP = 2.0* (ETOT)/(k*deltal)
yew GP > gpmax:
gpmax = GP
kmax = k*deltal
f2.write (“%f %0.11f %3f \ N” % ((k*deltal), ETOT, GP))
f3.write (“%f %3f %3f \ N” % (J, kmax, gpmax))

f2.close ()
f3.close ()
```

*END ()*

*TEST-TUBE SENB2 SMALL DEFECT  $a_f/H = 0.076$  IS  $a_f = 3.8$  MM*

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**BEGINNING ()**

**PRE\_GIBI ()**

**MA=LIRE\_MAILLAGE ()**

**MA=DEFI\_GROUP (reuse =MA,  
MAILLAGE=MA,  
CREA\_GROUP\_NO=\_F (TOUT\_GROUP\_MA=' OUI',),)**

**#  
# MODELING OF THE GRID**

**#  
MOD=AFFE\_MODELE (MAILLAGE=MA,  
AFFE=\_F (TOUT=' OUI',  
PHENOMENE=' MECANIQUE',  
MODELISATION=' D\_PLAN',),)**

**#  
# DEFINITION OF MATERIAL**

**#  
SIGM\_F = DEFI\_FONCTION (NOM\_PARA = "EPSI",  
VALE= (**

**2.74E-03, 571.32,  
1.29E-02, 609.42,  
2.31E-02, 647.52,  
3.33E-02, 685.62,  
4.34E-02, 715,  
5.36E-02, 746,  
6.37E-02, 775,  
7.38E-02, 797,  
8.39E-02, 814,  
9.40E-02, 831.66,  
0.10405 , 844.47,  
0.11411 , 856.22,  
0.12416 , 867.1 ,**

0.14425 , 886.7 ,  
0.16434 , 904.04,  
0.18441 , 919.62,  
0.20448 , 933.78,

),  
**PROL\_DROITE** = "CONSTANT",  
**PROL\_GAUCHE** = "CONSTANT",  
)

**ACIER=DEFI\_MATERIAU (ELAS=\_F (E=208510.,**  
**NU=0.3,**  
**ALPHA=0.0),)**  
**TRACTION=\_F (SIGM = SIGM\_F),**  
)

**CH\_MAT=AFFE\_MATERIAU (MAILLAGE=MA,**  
**AFFE=\_F (GROUP\_MA=' SENB',**  
**MATER=ACIER,**  
**TEMP\_REF=0.0),)**

#

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***Author (S):***

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***:***

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***# DEFINITION Of a LIST Of MOMENTS AND a SLOPE***

***#***

***LIST=DEFI\_LIST\_REEL (DEBUT=0.0,***  
***INTERVALLE= (\_F (JUSQU\_A=22.0,***  
***NOMBRE=22),)***

***\_F (JUSQU\_A=27.0,  
NOMBRE=5,)  
\_F (JUSQU\_A=32.0,  
NOMBRE=5,)  
\_F (JUSQU\_A=37.0,  
NOMBRE=5,)  
\_F (JUSQU\_A=42.0,  
NOMBRE=5,)  
\_F (JUSQU\_A=47.0,  
NOMBRE=5,)  
\_F (JUSQU\_A=52.0,  
NOMBRE=5,)  
\_F (JUSQU\_A=57.0,  
NOMBRE=5,)  
\_F (JUSQU\_A=61.0,  
NOMBRE=4,)  
\_F (JUSQU\_A=65.0,  
NOMBRE=4,)  
\_F (JUSQU\_A=70.0,  
NOMBRE=5,)  
\_F (JUSQU\_A=76.0,  
NOMBRE=6,)  
\_F (JUSQU\_A=82.0,  
NOMBRE=6,)  
\_F (JUSQU\_A=88.0,  
NOMBRE=6,)  
\_F (JUSQU\_A=94.0,  
NOMBRE=6,)  
\_F (JUSQU\_A=100.0,  
NOMBRE=6,)),)***

***RAMPE=DEFI\_FONCTION (NOM\_PARA=' INST',  
VALE= (0.0, 0.0, 100.0, 100.0),  
PROL\_DROITE=' LINEAIRE',  
PROL\_GAUCHE=' LINEAIRE',)***

***#  
# LOADING AND CONDITIONS LIMITING  
# -----  
#***

***CHAR=AFFE\_CHAR\_MECA (MODELE=MOD,  
DDL\_IMPO= (\_F (GROUP\_NO=' LIGR',  
DX=0.0,)***

*\_F (GROUP\_NO=' LAPPUI',  
DY=0.0,),  
\_F (GROUP\_NO=' LPILOT',  
DY=-0.04,),),  
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*#  
# APPLICATION OF THE LOAD & CALCULATION OF THE CONSTRAINTS  
#  
RESU=STAT\_NON\_LINE (MODELE=MOD,  
CHAM\_MATER=CH\_MAT,  
EXCIT=\_F (CHARGE=CHAR,  
FONC\_MULT=RAMPE,),  
COMP\_INCR=\_F (RELATION=' VMIS\_ISOT\_TRAC',  
DEFORMATION=' PETIT',  
GROUP\_MA=' SENB',),  
INCREMENT=\_F (LIST\_INST=LIST,  
NUME\_INST\_FIN=95,),  
NEWTON=\_F (PREDICTION=' TANGENTE',  
MATRICE=' TANGENTE',  
REAC\_ITER=4,),  
RECH\_LINEAIRE=\_F (RESI\_LINE\_RELA=1.E-3,  
ITER\_LINE\_MAXI=3,),  
CONVERGENCE=\_F (RESI\_GLOB\_MAXI=1.E-08,  
RESI\_GLOB\_RELA=1.E-08,  
ITER\_GLOB\_MAXI=20,),  
SOLVEUR=\_F (METHODE=' MULT\_FRONT',*

**RENUM=' METIS',),)**

**#**

**# CALCULATION OF G**

**#**

**THETA1=CALC\_THETA (MODELE=MOD,  
DIRECTION= (0.0, 1.0, 0.0),  
THETA\_2D=\_F (GROUP\_NO=' O',  
MODULE=1.0,  
R\_INF=0.25,  
R\_SUP=0.5),),)**

**G1=CALC\_G\_THETA\_T (MODELE=MOD,  
CHAM\_MATER=CH\_MAT,  
THETA=THETA1,  
RESULTAT=RESU,  
TOUT\_ORDRE=' OUI',  
SYME\_CHAR=' SYME',  
COMP\_ELAS=\_F (RELATION=' ELAS\_VMIS\_TRAC',  
DEFORMATION=' PETIT',),)**

**IMPR\_TABLE (TABLE=G1, FORMAT = "AGRAF")**

**THETA2=CALC\_THETA (MODELE=MOD,  
DIRECTION= (0.0, 1.0, 0.0),  
THETA\_2D=\_F (GROUP\_NO=' O',  
MODULE=1.0,  
R\_INF=0.50,  
R\_SUP=1.0),),)**

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**G2=**CALC\_G\_THETA\_T (MODELE=MOD,  
CHAM\_MATER=CH\_MAT,  
THETA=THETA2,  
RESULTAT=RESU,  
TOUT\_ORDRE=' OUI',  
SYME\_CHAR=' SYME',  
COMP\_ELAS=\_F (RELATION=' ELAS\_VMIS\_TRAC',  
DEFORMATION=' PETIT',),)

**IMPR\_TABLE (TABLE=G2, FORMAT = “AGRAF”)**

**THETA3=**CALC\_THETA (MODELE=MOD,  
DIRECTION= (0.0, 1.0, 0.0),  
THETA\_2D=\_F (GROUP\_NO=' O',  
MODULE=1.0,  
R\_INF=1.0,  
R\_SUP=2.0,),)

**G3=**CALC\_G\_THETA\_T (MODELE=MOD,  
CHAM\_MATER=CH\_MAT,  
THETA=THETA3,  
RESULTAT=RESU,  
TOUT\_ORDRE=' OUI',  
SYME\_CHAR=' SYME',  
COMP\_ELAS=\_F (RELATION=' ELAS\_VMIS\_TRAC',  
DEFORMATION=' PETIT',),)

**IMPR\_TABLE (TABLE=G3, FORMAT = “AGRAF”)**

**#**

**END ()**

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**CONTINUATION (PAR\_LOT=' NON')**

**ENE= [None] \*200;**

**ENET= [None] \*200;**

**#**

**deltal = 0.01**

**#**

**#**

**importation bone**

**f2=open ("fort.44", "W")**

**f3=open ("fort.45", "W")**

**f2.write ("brutal Propagation - Test-tube SENB2 - Grid M1 \ N")**

**f2.write ("Work hardening diagram traction ECA \ N")**

**f2.write ("Propagation - elastic Energy - G plastic (dW/dl) \ N")**

**for K in arranges (1,101):**

**LIG = "COPS\_%i" % (K)**

**print "ligament number: ", K**

**print "cumulated propagation: ", k\*deltal, "millimetres"**

**ENE [K] = POST\_ELEM (MODELE=MOD,**

**RESULTAT=RESU,**

**CHAM\_MATER=CH\_MAT,**

**TOUT\_ORDRE = ' OUI',**

**ENER\_ELAS=\_F (GROUP\_MA=LIG),**

**TITRE=' Energy élastique',**

**)**

**IMPR\_TABLE (TABLE=ENE [K],**

**FORMAT\_R='IPE18.11')**

**# End of the iterations**

**for J in arranges (1,96):**

**f2.write (“Urgent: %f \ N” % (J))**

**gpmax = 0.**

**for K in arranges (1,101):**

**#f2.write (“Deltal: %f \ N” % (k\*deltal))**

**#f2.write (“Nb chips: %i \ N” % (K))**

**ETOT=ENEE [K] [’, J]**

**GP = 2.0\* (ETOT)/(k\*deltal)**

**yew GP > gpmax:**

**gpmax = GP**

**kmax = k\*deltal**

**f2.write (“%f %0.11f %3f \ N” % ((k\*deltal), ETOT, GP))**

**f3.write (“%f %3f %3f \ N” % (J, kmax, gpmax))**

**f2.close ()**

**f3.close ()**

**END ()**

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**Titrate:**

**Applicability of the operators of breaking process**

**Date:**

**03/04/03**

**Author (S):**

**I. DEBOST, G. DEBRUYNE, Y. WADIER, E. SCREWS Key**

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**3.4.5 Interpretation**

**For large crack (SENBI)**

*This case corresponds to calculation on test-tube CT.*

*One identifies the moment  $T1 = 30$  S corresponding to the arrow with the experimental rupture of 1.21 Misters One*

*determine at this moment  $G$  theta which is stable for various crowns:*

*$G_{theta\ SENB1} = 47.86$*

*One then determines for every moment the ligament where  $G_p$  is maximum and in particular at moment  $T1$ :  $G_p = 0.606$  on ligament 26 for  $dl = 0.26$  Misters.*

*For small crack (SENB2)*

*One determines in this case the moment when  $G_{pmax}$  is worth also 0.606.*

*It is about  $t2 = 80$  S on ligament 16 for  $dl = 0.16$  Misters.*

*One calculates at the moment  $t2$  the value of  $G_{theta\ SENB2} = 153.79$ .*

*One thus deduces an effect from it small defect which is expressed in the form:*

*$(epd)^2 = G_{theta\ SENB2}/G_{theta\ SENB1} = 3.21$  is  $epd = K_{SENB2}/K_{SENB1} = 1.79$*

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*Applicability of the operators of breaking process*

*Date:*

03/04/03

*Author (S):*

**I. DEBOST, G. DEBRUYNE, Y. WADIER, E. SCREWS Key**

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## **4 Documentation**

***Code\_Aster relating to the mechanics of brittle fracture***

**Key**

***Titrate document***

*Reference documents:*

[R7.02.01]

*Rate of refund of energy in linear thermoelasticity*

[R7.02.03]

*Rate of refund of energy in nonlinear thermoelasticity*

[R7.02.04] *Representation*

*Lagrangian of variation of field*

[R7.02.05]

*Calculation of the coefficients of intensity of constraints in plane linear thermoelasticity*

[R7.02.07]

*Rate of refund of energy in thermo-élasto-plasticity*

[R7.02.08]

*Calculation of the coefficients of intensity of constraints by extrapolation of the field of displacements*

*Documents of Use:*

[U4.82.01] *Operator*

**DEFI\_FOND\_FISS**

[U4.82.02] *Operator*

**CALC\_THETA**

[U4.82.03] Operator  
CALC\_G\_THETA\_T  
[U4.82.04] Operator  
CALC\_G\_LOCAL\_T  
[U4.82.05] Operator  
POST\_K1\_K2\_K3  
[U4.81.22] Operator  
POST\_ELEM

*Documents of Validation:*

*SSLP101*

*Rate of refund of energy in plane constraints*

*SSLP102*

*Rate of refund of energy with initial deformations (Lagrangian propagation)*

*SSLP103*

*Calculations of the stress intensity factors KI and KII for a fissured circular plate in linear elasticity*

*SSLP310*

*Biblio\_18 Fissures pressurized in an unlimited plane field*

*SSLP311*

*Biblio\_65 fissures central oblique in a finished rectangular plate, with two materials, subjected to uniform traction*

*SSLP313*

*Crack inclined in an unlimited plate, subjected to a uniform traction ad infinitum*

*SSLV110*

*Rate of refund of energy for a semi-elliptic crack in an infinite medium*

*SSLV112*

*Calculation of G by the Lagrangian method for a circular crack*

*SSLV134*

*Fissure circular in infinite medium*

*SSNP102*

*Rate of refund of energy for a plate notched in elastoplasticity*

*SSNP311*

*Biblio\_131 Cracking in mode II of an elastoplastic test-tube*

*SSNP312*

*DMT94.132 Fissures parallel with the interface in a bimetallic test-tube CT*

*HPLA310*

*Biblio\_49 Fissures radial external in a circular bar subjected to a thermal shock*

*HPLA311*

*Murakami 11.39 Fissures circular in the center of a sphere subjected to a temperature uniform on the lips*

## **HPLP100**

*Calculation of the rate of refund of the energy of a plate fissured in thermoelasticity*

## **HPLP101**

*Plate fissured in thermoelasticity (forced plane)*

## **HPLP310**

*Biblio\_35 Fissures radial intern in a thick cylinder under pressure and loading thermics*

## **HPLP311**

*Murakami 11.17: Fissure in the center of a rectangular thin section making obstacle with one uniform heat flow in isotropic medium*

## **HPLV102**

*Rate of refund of energy in thermoelasticity for a circular crack in infinite medium*

## **HPLV103**

*Thermoelastic calculation of  $G$  3D for a circular crack*

*\* These tests result from the validation independent of version 3 in breaking process and are diffused in electronic documentation.*

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*6.4*

*Titrate:*

*Applicability of the operators of breaking process*

*Date:*

*03/04/03*

*Author (S):*

**I. DEBOST, G. DEBRUYNE, Y. WADIER, E. SCREWS** *Key*

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**Note of modeling of damping mechanics**

## **Summary**

***Linear and non-linear dynamic analyses, for the study of the vibratory response with an excitation in force or moving imposed or for the modal analysis complexes, require to add characteristics of mechanical cushioning to the characteristics of rigidity and mass.***

***One has several traditional modelings, applicable to all the types of finite elements available:***

- the model of viscous damping,***
- the model of damping hysteretic (known as also “structural damping”) for the analysis harmonic of viscoelastic materials.***

***For the analyses using a modal base of real clean modes, it is possible to introduce coefficients of damping modal.***

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***1***

***Model of viscous damping***

***The model of viscous damping is most usually used. It corresponds to modeling of a dissipated energy proportional to the vibratory speed:***

***1***

$$1$$
$$ED = vT Cv = C Cu$$

*éq 1-1*

2  
2

*where C is the matrix of viscous damping, with real coefficients.*

*It leads to the traditional equations of the dynamics of the structures:*

$$Driven + Cu + Ku = F (T)$$

*éq 1-2*

*with K stamps rigidity and M stamps of mass.*

*1.1*  
*Viscous damping proportional “total”*

*This modeling, easy to implement, corresponds to:*

$$C = K + M$$

*éq 1.1-1*

*It is currently available, by using operator COMB\_MATR\_ASSE [U4.72.01], after having assembled the matrices of rigidity and mass with real coefficients, but it is of a low utility:*

*• validation of algorithms of resolution,*

· *useless for the industrial studies, because it does not make it possible to represent the heterogeneity of the structure compared to damping (dissipation with the supports or the assemblies). Of more the total identification of the coefficients and is not possible, in modal analysis experimental, that for two Eigen frequencies [f1 f2] distinct; it gives, for Eigen frequencies fi [F, F*

*I  
2] with I = 2 F  
I, a law of evolution of damping  
tiny room of the form:*

*I = I +*

*I*

*1.2  
Viscous damping proportional of the elements of the model*

*1.2.1 Characteristics  
of damping*

*It is possible to build a matrix of damping starting from each element of the model, as for rigidity and the mass.*

*Two functionalities are usable:*

- *the assignment of discrete elements, on meshes POI1 or SEG2, by operator AFFE\_CARA\_ELEM [U4.42.01]. This one makes it possible to define, with several possible modes of description, a matrix of damping for each degree of freedom.*
- *the definition of a characteristic of damping for any elastic material by the operator DEF1\_MATERIAU [U4.43.01] by:*

*AMOR\_ALPHA*

*:*

*[R]*

*AMOR\_BETA*

*:*

*this material being then affected with the meshes concerned.*

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### **1.2.2 Calculation of the matrices of damping**

**For all the types of finite elements (of continuous, structural or discrete mediums), it is possible of to calculate the real elementary matrices corresponding to the option of calculation**

**“AMOR\_MECA”, afterwards**

**to have calculated the elementary matrices corresponding to the options of calculation**

**“RIGI\_MECA” and**

**“MASS\_MECA” or “MASS\_MECA\_DIAG”. Each elementary matrix is then of the form:**

**· when material I, of characteristics of viscous damping proportional (I I), is affected with the element elem**

$$celem = I kelem + I melem$$

**· for a discrete element**

$$celem = adiscret$$

**This operation is possible with:**

**mel**

**[matr\_elem\_DEPL\_R] = CALC\_MATR\_ELEM**

**(**

**/**

**OPTION:**

**“AMOR\_MECA”**



**MODEL:**

*Mo*

*[model]*

**CHAM\_MATER:**

*chmat*

*[cham\_mater]*

**CARA\_ELEM:**

*will cara*

*[cara\_elem]*

*);*

*The assembly of all the elementary matrices of damping is obtained with the operator Usual ASSE\_MATRICE [U4.61.22]. It will be noted that one must use same classifications and it even mode of storage that for the matrices of rigidity and mass (operator NUME\_DDL [U4.61.11]).*

*It is noticed that the matrix of damping obtained is, in general, nonproportional:*

$$C \bullet = K + M$$

### *1.2.3 Use of the matrix of viscous damping*

*The matrix C is usable for the direct linear dynamic analysis (key word MATR\_AMOR) with operators of linear dynamic response:*

*• transitory*

*DYNA\_LINE\_TRAN*

*[U4.53.02]*

*• harmonic*

*DYNA\_LINE\_HARM*

*[U4.53.11]*

*It is essential for the modal analysis complexes with the operators of research of the values clean:*

*• by iterations opposite*

*MODE\_ITER\_INV*

*[U4.52.04]*

*• by simultaneous iterations*

**MODE\_ITER\_SIMULT**  
**[U4.52.03]**

*For the analyses in modal base, one must project this matrix in the subspace defined by one together of real clean modes. This operation is possible with the operator PROJ\_MATR\_BASE [U4.63.12]. Let us note that in the case general (C nonproportional), the matrix projected is not diagonal. It remains nevertheless usable (key word AMOR\_GENE) for the calculation of dynamic response in force or imposed in modal space, with the operator of linear dynamic response:*

*· transitory*  
**DYNA\_TRAN\_MODAL**  
**[U4.53.21]**  
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### **1.2.4 Use of viscous modal damping**

*For the analyses in modal base of real clean modes, the dynamic differential equation in generalized co-ordinates:*

$$\mathbf{T} \mathbf{2} \mathbf{q}'' + 2 \mathbf{q}' + \mathbf{Q} \mathbf{I} =$$

***F***  
***I***  
***I***  
***I***  
***I***  
***I***  
***I***  
***I***  
***(T)***  
***éq***  
***1.2.4-1***  
***μi***

***fact of appearing a modal damping coefficient I expressed like a fraction of critical damping and generalized mass of the μi mode, which depends on the mode of standardization clean mode.***

***In the case of a matrix of damping C strictly proportional, coefficients I from the diagonal terms of the matrix of damping generalized T C deduce by:***

***T***  
***I C I***  
***2 I I =***

***T***  
***I M I***

***and, in the case of clean modes normalized with the unit modal mass,***

***T***  
***2 I I = I C I***

***One can use this relation in the case of a matrix of damping C nonproportional, in applying the assumption of BASILE, who is acceptable for weak depreciation (in particular if it does not have there damping localised dominating) and of the real clean modes sufficiently uncoupled.***

***The modal damping coefficients can be provided by order (key word AMOR\_REDUIT) with two operators for:***

***· transitory analysis in modal space***

***DYNA\_TRAN\_MODAL***

***[U4.53.21]***

***· seismic analysis by spectrum of oscillator***

***COMB\_SISM\_MODAL***

***[U4.84.01]***

*Let us note that there is not any tool for automatic extraction of these coefficients, starting from the matrix of damping generalized T C), concept produced by operator PROJ\_MATR\_BASE [U4.63.12].*

**2**  
*Model of damping hysteretic*

*The model of damping hysteretic is usable to treat the harmonic answers of structures with viscoelastic materials. The damping coefficient hysteretic is determined starting from a test under harmonic cyclic loading with the pulsation for which one a relation stress-strain obtains which makes it possible to define:*

*· the energy dissipated by cycle in the form:*

$$E = D$$

*cycle*

*· the YOUNG modulus complexes  $E^*$  starting from the relation stress-strains:*

$$J(T) = \frac{E}{\omega}$$

*and  $\theta = \arctan(\frac{D}{E})$  with  $\theta$  and amplitudes*

*,  $\theta$  phase*

$$E^* = E - jD$$

=  
 $0$   
( $\cos + J \sin$ )

$0$   
 $0$   
where  $E^* = E1 + J E2 = E1 (1+ J)$

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*with*  
 $0$   
 $0$   
 $1$   
 $E =$   
( $\cos$ )

= *real part and*  $E2 =$   
( $\sin$ )

= *imaginary part*

0  
0  
E  
= 1 = tg = *factor of dissipation*  
E2

*This led to the equations of the dynamics of the structures:*

$$M \ddot{u} + K * (1 + J) U = F ()$$

*éq 2-1*

*with K stamps real elastic rigidity, M stamps of mass and the coefficient damping hysteretic. Let us note that one often speaks about complex matrix of rigidity.*

2.1  
*“Total” damping hysteretic*

*This modeling, easy to implement, corresponds to:*

$$(- M \ddot{2} + J K + K) U = F ()$$

*éq  
2.1-1*

*It is currently available, by using operator COMB\_MATR\_ASSE [U4.72.01], after having assembled the matrix of rigidity to real coefficients, but it is of a low utility:*

- *validation of algorithms of resolution,*
- *useless for the industrial studies, because it does not make it possible to represent the heterogeneity of the structure compared to damping (dissipation located in particular zones structure treated with viscoelastic materials).*

2.2  
*Damping hysteretic of the elements of the model*

2.2.1 *Characteristics of damping*

*It is possible to build a complex matrix of rigidity starting from each element of the model, as for real rigidity and the mass.*

*Two functionalities are usable:*

*· the assignment of discrete elements, on meshes PO11 or SEG2, by the operator AFFE\_CARA\_ELEM [U4.42.01]. This one makes it possible to define, with several modes of description possible, a matrix of real rigidity for each degree of freedom and one damping coefficient hysteretic to apply to this matrix.*

**AMOR\_HYST:**

*éta*

**[R]**

*· the definition of a characteristic of damping for any elastic material by the operator DEF1\_MATERIAU [U4.43.01] by the key word:*

**AMOR\_HYST:**

*éta*

**[R]**

*this material being then affected with the meshes concerned.*

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**2.2.2 Calculation of the matrices of damping**

*For all the types of finite elements (of continuous, structural or discrete mediums), it is possible of to calculate the complex elementary matrices corresponding to the option of calculation*

*“RIGI\_MECA\_HYST”,*

*after having calculated the elementary matrices corresponding to the options of calculation*

*“RIGI\_MECA”.*

*Each elementary matrix is then of the form:*

*· when material I, of characteristics of damping hysteretic I, is affected with the element elem*

$$k^*elem = kelem (1 + J I)$$

*· for a discrete element defined by a matrix of rigidity kdiscret and a coefficient of damping hysteretic*

$$k^*elem = kdiscret (1 + J)$$

*This operation is possible with:*

*mel*

*[matr\_elem\_DEPL\_C] = CALC\_MATR\_ELEM*

*(*

*/*

**OPTION:**

**“RIGI\_MECA\_HYST”**

**MODEL:**

*Mo*

*[model]*

**CHAM\_MATER:**

*chmat*

*[cham\_mater]*

**CARA\_ELEM:**

*will cara*

*[cara\_elem]*



**RIGI\_MECA:**  
*rigi*  
*[matr\_elem\_\*]*

**CHARGE**  
:  
*l\_char*  
*[l\_char\_meca]*  
);

*The assembly of the matrix of rigidity complexes  $K^*$ , starting from the elementary matrices is obtained with usual operator ASSE\_MATRICE [U4.61.22]. It will be noted that one must use the same one classification and same mode of storage as for the matrix of mass (operator NUME\_DDL [U4.61.11]).*

*The loading used for the calculation of the matrix of real rigidity (OPTION "RIGI\_MECA") must be informed by the key word "CHARGES" for calculation of the matrix of complex elementary rigidity.*

### *2.2.3 Use of the complex matrix of rigidity*

*The matrix of rigidity complexes  $K^*$  is usable for the direct linear dynamic analysis (key word MATR\_RIGI) with the operator of dynamic response linear:*

*· harmonic*  
**DYNA\_LINE\_HARM**  
*[U4.53.11]*

*For the search for eigenvalues, no functionality is currently available for the use of the model of hysterical damping.*

*For the analyses in modal base, no functionality is currently available for the use model of damping hysteretic.*

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**G. DEVESA, V. GUYONVARH** *Key*

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*Organization (S): EDF-R & D /AMA*

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***U2.06 booklet: Dynamics***

***Document: U2.06.07***

***Interaction ground-structure (ISS) in seismic analysis  
with the Code\_Aster interface - PROMISS3D***

***Summary:***

***This document is a note of description of use of the Code\_Aster interface - PROMISS3D to treat them***

*problems of interaction ground-structure (ISS) in dynamic analysis: vibrations, seism... One presents to it like*

*case of application the standard case of a building on erasing common subjected to a seismic excitation treaty with*

*various representations of the foundation: rigid or flexible with in this last case the taking into account*

*total or reduced of the modes of deformation of the foundation raft.*

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## *1 Introduction*

*Treatment in seismic analysis of the problem of the behaviour of buildings posed on flexible foundation*

*require the taking into account of the interaction between the ground and the structure. However, traditional tools for*

*to treat this interaction (PARASOL and CLASSI) authorize only rigid foundations, or even take into account only exclusively homogeneous grounds and foundation rafts of form not unspecified (case of PARASOL). This is why code PROMISS3D, developed at the Central School of Paris, was chained by a procedure established in Code\_Aster to make it possible to model with time of the flexible foundations, the heterogeneous grounds - with an extension particular to the laminated grounds -*

*and of the foundation rafts of an unspecified form, and thus to allow calculations of dynamic interaction with one or several unspecified structures.*

*On the one hand, the modeling of the structure of the building as well as the loadings which are to him*

*applied, is realized with Code\_Aster, and in addition, it is necessary to carry out the analysis constraints*

*dynamic obtained starting from the characteristics of the elements of the structure modelled using this code. It is thus then necessary to constitute an interface between PROMISS3D and Code\_Aster to connect the two preceding operations with the calculation of the linear dynamic evolution of the ground-buildings unit carried out by PROMISS3D.*

*This document has thus as a matter to describe this interface consisted modules of calculation developed around PROMISS3D and by new specific orders of Code\_Aster. One y fact as a preliminary a simplified description of software PROMISS3D, complete and detailed description*

*of its principle being made in the user's manual of PROMISS3D - MISS2D [bib1]. One presents to it the case of standard application of a nuclear small island subjected to a seismic excitation treaty with different*

*case of foundation: rigid or flexible with or without reduction of modes of deformation of the foundation raft.*

2

## *Description and principle of software PROMISS3D*

*Software PROMISS3D makes it possible to deal with the problems of propagation of wave in fields rubber bands or fluids.*

*It uses the geometrical assumption of linearity and behavior: that is to say the equation of Navier (conservation of the momentum) with the law of Hooke in the springy media and the equation of the waves in the fluid environments.*

*This assumption makes it possible to apply a transformation of Fourier compared to the temporal variable*

*for the whole of the fields to be calculated and thus, to operate the resolution in the field of frequencies. The return in the temporal field is carried out in postprocessing by the transformation of Opposite Fourier.*

*Lastly, software PROMISS3D rests on a method of under-structuring: the field of study is broken up into under-fields coupled between them by interfaces. One applies a method to it of resolution multi-fields and only the interfaces between fields require to be with a grid by finite elements of border.*

*The resolution is carried out then on the borders of the under-fields and is founded on knowledge elementary solutions, functions of Green, fields generated in an infinite field by one specific request. One can thus treat the case of the not limited fields, by avoiding any reflexion parasite on fictitious borders truncating the field of study. Moreover, one original extension and economic was brought to the method by the introduction treatment of laminated fields implicitly taking into account various homogeneous layers of a field without having recourse to a grid of their interfaces.*

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**3**

### ***Principle of the Code\_Aster interface - PROMISS3D***

**3.1**

#### ***Case of the external field in PROMISS3D***

*In the case of one or several buildings subjected to a seismic excitation which one wants to study the interaction ground-structure (ISS), one separates by an interface the field from the “structure” including/understanding the buildings (but also possibly parts of ground not laminated like fill) of the field “ground” (either laminated, or homogeneous or comprising even fluid parts (e.g.: reserve of stopping)) modelled directly by PROMISS3D [Figure 3.1-a].*

***Interface***

***Structure***

***small island***

***Ground layer 1***

***Ground layer 2***

#### ***Appear 3.1-a: Model of interface ground - structure***

*The structure modelled by Code\_Aster is regarded as an external field for PROMISS3D. In this case, one breaks up a displacement in this field on modes which, reduced to the interface, can be null i.e. the dynamic clean modes of the structure on base fixes, or not null, i.e. the static modes:*

***U = has +***

***I***

***B***

***I***

***J***

***I***

The coefficients **have** and **bj** is respectively the factors of participation of the dynamic modes and statics. **M** and **K** are respectively the assembled matrices of mass and rigidity. Then, the writing balance of the field “structure” within the meaning of virtual work provides the following system:

**K**

2

**has**

**dd**

**Kds**

**Mdd Mds**

**F D**

-

=

**K**

**B**

+

**ds**

**Kss**

**Mds Mss**

**F S F**

The matrices **Kdd** and **Kss** are the assembled rigidities projected respectively on the modes dynamic and static: **TK** and **TK**.

The matrices **Mdd**, **Mss** are the assembled masses projected respectively on the modes dynamic and static: **TM** and **TM**.

**Kds** and **Mds** are the link-words or products cross: **TK** and **TM**.

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**$f_d$**  and  **$f_s$**  are respective projections on the dynamic and static modes of the vector forces applied  $F$  to the field “structure”:  **$TF$**  and  **$TF$** .

$F$  represents the action with the sign close to the field “structure” on the interface and can thus be expressed with

to leave the preceding system, by eliminating the factor has, by:  **$F = feq + K^* B$**

with  **$feq$**  the vector of equivalent forces and  **$K^*$**  the matrix of impedance of the field given by:

$$feq = -fs + (Kds - 2 Mds) T (Kdd - 2 Mdd) - 1 fd$$

$$K^* = (Kss - 2 Mss) - (Kds - 2 Mds) T (Kdd - 2 Mdd) - 1 (Kds - 2 Mds)$$

It is shown simply that one can be reduced to the resolution of 2 local problems to obtain  **$feq$**  and  **$K^*$** . Indeed  **$feq$** , solution of the 1st local problem, is the effort applied to the blocked interface when one

apply the forces to the field “structure”. And when, in the 2nd local problem, one imposes displacements of unit static modes  $B$  on the interface without forces applied to the field “structure”, one obtains  **$K^* B$**  like effort applied to the interface.

The resolution is carried out on (S) the interface (S) which must (or must) be with a grid (S) with elements surface directed towards the interior of the field “ground” and on this (or these) interface (S) it must y have between 6 and 10 nodes per wavelength. In the field of the seism one is interested in a beach of frequency going of 0.1 Hz to 30 Hz.

### 3.2 Contents of the interface

The Code\_Aster chaining - PROMISS3D requires the transfer of following information.

**In the Code\_Aster direction towards PROMISS3D, one transfers successively:**

- information concerning the grid of the interface ground-structure (nodes and elements surface) as well as the static modes of interface and the dynamic modes of the structure

reduced to the nodes of this interface and ordered according to its local classification, information on the basis of static and modal dynamic mode independent of local classification: modal masses and rigidities, modal factors of participation and other terms of coupling between the dynamic modes and the static modes and, for each load interns with the structure, projections of the assembled vector corresponding, on static and dynamic modes as well as the multiplicative function of time associated.

**In direction PROMISS3D towards Code\_Aster, one recovers:**

· Of the evolutions of results of displacements, speeds and accelerations generalized (standard "TRAN\_GENE") (T), "(T), " (T) on the one hand, and (T), " (T), " (T) on the other hand, projected respectively

starting from the dynamic modes and static modes. One will be able to then project, then to combine these results on the physical basis:  $U(T) = .(T) + .(T)$ .

In the case of a harmonic calculation one recovers complex evolutions by frequency () and () (of type "HARM\_GENE") before projecting them to produce an evolution of it harmonic on the physical basis:  $U() = .() + .()$ . () and () are always complexes because of the form complexes impedance of ground: K.

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### 3.3

#### **Procedure of sequence of the programs**

An automatic procedure was made up in order to encapsulate the programs necessary to Code\_Aster chaining - PROMISS3D.

The user must first of all constitute the data of Code\_Aster for the preprocessing like those to describe the stratifications of the ground in module DOS2M of PROMISS3D in order to calculate



*functions of Green.*

*A first program, **gtaster**, starting from the file result of Code\_Aster, generates the data of PROMISS3D including/understanding: grid of the interface (suffix .mail), calculation data (.in), them impedances of the structure (.ext), loadings on the structure (.cext), data of postprocessing (.post).*

*A second program, **ptaster**, recover the movements of the interface calculated by PROMISS3D in displacements, speeds and accelerations generalized and transmits them to Code\_Aster for post-to treat.*

*It is possible in the same tender successively to launch the programs gtaster, PROMISS3D, ptaster on the central machine of treatment by successive calls to EXEC\_LOGICIEL contained in an macro-order of Code\_Aster called MACRO\_MISS\_3D [U7.03.11].*

## **4**

### ***Use of the Code\_Aster interface - PROMISS3D***

*The Code\_Aster-PROMISS3D interface follows the following diagram [Figure 4-a]:*

#### ***1st Stage***

*Data of ground  
Representation*

*Parameters of calculations  
small island + foundation  
Nom\_étude.raster*

*Nom\_étude.optmiss*

#### ***Code\_Aster***

*IMPR\_MACR\_ELEM*

*Nom\_étude.sol*

*- Calculation of the modes*

*dynamic in base*

*- M, K, C projected on the basis  
embedded.*

#### ***Code PROMISS3D***

*modal: and*

*- Calculation of the modes*

*- Grid of the interface.*

*statics*

#### ***2nd Stage***

*Signals of seismic excitation*

*Response of the structure,*

*determination of the factors*

*MACRO\_MISS\_3D*

*of participation modal*

*IMPR\_MISS\_3D*

*Accélérogrammes*

*With and B*

*compatible with*

*spectrum of ground*

*LIRE\_MISS\_3D*

**3rd Stage**

*RECU\_FONCTION*

*CALC\_FONCTION*

**Code\_Aster**

*Recombination*

*SRO and functions*

*Evolution in displacement, speed*

*modal*

*of transfer*

*and/or acceleration of the answers*

*Order of Code\_Aster*

*Data file PROMISS3D*

**Appear 4-a: Principal stages of calculations of ISS**

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## 4.1 Orders

### *Code\_Aster for the preprocessing*

*Before using the orders of Code\_Aster specific to the coupling, it is necessary to pass by the following stages of modeling of the structure:*

- *calculation of the clean modes by order `MODE_ITER_SIMULT` [U4.52.03],*
- *definition of the dynamic interface, producing type (`CRAIGB` (recommended) or `MC-NEAL`) and its grid of the interface ground-structure, by order `DEFI_INTERF_DYNA` [U4.64.01],*
- *definition of a modal base supplements by order `DEFI_BASE_MODAL` [U4.64.02]: it calculates the static modes of the dynamic interface previously definite and complete the base of the clean modes if base is of the `TRADITIONAL` type. It is also possible of to calculate unspecified static modes directly without dynamic interface (in its case one does not use order `DEFI_INTERF_DYNA`) by order `MODE_STATIQUE` [U4.52.14] and to define a modal base then supplements of type `RITZ` by the order `DEFI_BASE_MODAL`. The interest of the modal bases of `RITZ` is to be able to assemble modes calculated with boundary conditions different. For example, modes dynamic calculated in base embedded with all ddls of the interface blocked and their static modes of interface calculated in various ways:*

- *maybe with a solid condition of connection which confers on the interface a movement of body rigid,*

- *maybe with modes of unspecified interface of pace calculated like clean modes (via order `MODE_ITER_SIMULT`) of the structure on carpet of springs of ground;*
- *assembly of the dynamic macronutrient by order `MACR_ELEM_DYNA` [U4.65.01], with to leave the modal base previously definite.*

*The data to be transferred from Code\_Aster towards PROMISS3D are obtained by the use of 2 specific orders:*

- *first order `IMPR_MACR_ELEM` [U7.04.33] makes it possible to produce the grid of the interface ground-structure and modes static and dynamic reduced to this interface. These terms are used to establish the contribution of the structure on the impedance.*
- *evolution in time or frequency whose user will provide the moments or the frequencies of restitution.*

*If the evolution is frequential, the frequencies of calculation, defined in PROMISS3D, must*

*to be coherent with that defined in IMPR\_MISS\_3D (generally one uses the beach of frequency of study between 0 and 30 Hz at the time D`studies seismic).*

*If the evolution is temporal, the beach of restitution in time defined in IMPR\_MISS\_3D must be included/understood in the duration of the seismic excitation.*

*One can, for the calculation of this evolution, to define at the same time loadings in the structure by the key word factor EXCIT, including/understanding the vector assembled correspondent with each one of*

*these loads, and of the loadings coming from the ground (signals of seismic excitation) by key word factor EXCIT\_SOL, including/understanding the type of excitation and the direction of each one of these*

*loads. In each one of these key words factors, one also gives the signal in frequency or in time associated with the definite load. Loadings given by EXCIT or EXCIT\_SOL in the same call to IMPR\_MISS\_3D are combined in only one evolution calculated by PROMISS3D. IMPR\_MISS\_3D is thus réépétable to obtain several calculated evolutions.*

*One initially encloses the data file of Code\_Aster by the FINE word then one carries out. One creates thus concepts results (modes and dynamic macronutrient in particular) on a basis of data stored on the central machine of treatment.*

*One thus gives the hand to PROMISS3D in order to calculate by a resolution in the field frequencies each evolution previously definite. According to the strategy of restitution (in time or frequency) of this evolution, one will apply or not one opposite transformation of Fourier.*

*It is possible to treat in the same tender without writing on a basis of data orders of preprocessing, the launching of PROMISS3D by MACRO\_MISS\_3D [U7.03.11] and orders of postprocessing. But except for the problems of small cut, it is strongly advised, for reasons of size memory and control of parameter time in the classes of tender, to continue to split the study into 3 time and to work with a data base Aster.*

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## 4.2 Orders

### **Code\_Aster** for postprocessing

*Order LIRE\_MISS\_3D [U7.02.31] makes it possible to recover an evolution of its choice among those calculated by PROMISS3D, the choice being done by the data of a logical unit. It is necessary to point out the type of the evolution, transient or harmonic. In this last case, one recover at the same time the real part and the imaginary part data for each frequency of calculation of displacements, speeds and accelerations generalized. By the data of the modal base supplements projection, via the dynamic macronutrient, one then obtains the transitory or harmonic evolution on the physical base of the structure modelled by Code\_Aster.*

*One can then carry out the traditional postprocessing of a seismic study:*

- *Extraction of the temporal evolutions of fields of acceleration or displacement to various levels of ground or structure by order RECU\_FONCTION [U4.32.03].*
- *Calcul of the spectra of response in these same levels of ground or structure by order CALC\_FONCTION [U4.32.04] and operand SPEC\_OSCI.*

## 4.3

### **Orders specific to MISS3D**

#### 4.3.1 Orders

*It is possible, except standard use of the Code\_AsterPROMISS3D interface, to use tools of calculations specific to MISS3D and to recover the useable results or not by Code\_Aster.*

*Thus, while acting on the files of preprocessing PROMISS3D (cf [§3.3] and [Figure 4-a]) related to optimization of calculations (extension .optimis) and/or with the calculation data (extension .in), one can to profit from the following options (cf [§ 5.1.4] to have examples of use):*

- *Calcul with variable step of frequency. The resolution of the equation of the waves (cf [§ 2]) is done then in the field of the frequencies with a more or less coarse step according to bands' frequencies. That makes it possible to refine around the interesting frequencies and to be less precis elsewhere [§ 5.1.4.1].*
- *Définition of points of control. The points of control make it possible to recover information, in particular on the incidental fields and the fields diffracted by (S) interface (S) (cf [Figure 3-a]), anywhere in the ground. For that one must write a file of instructions MISS3D (his name and its extension is completely free) which will make it possible to extract towards an output file from the evolutions from fields incidental or diffracted for each point of control and in each direction of space [§ 5.1.4.2].*
- *In the case of buried foundation (cf [§ 5.1.3.2]) of fictitious resonances appear in certain configurations: soft grounds, wide foundation raft. They are due to the resonance of*

*started from ground excavated and are located at a frequency close to  $F$*

*$= V 4H$*

*fictitious*

*$P$*

*where  $V$  is*

*the speed of the wave of compression and  $H$  depth of the excavation.*

*An option makes it possible to be freed some by using order RFIC in the file related to the optimization of calculations (extension .optmis) [§ 5.1.4.3].*

*· Simultaneous Calcul of the impedances of ground and a transitory and/or harmonic answer of structure.*

*For that one must use a file of instructions MISS3D which will make it possible to write in one output file values of the impedances of ground or the seismic forces according to frequency for all ddls of the interface [§ 5.1.4.4].*

### **4.3.2 Files MISS3D**

*Two files of MISS3D, located in the repertory associated with the study on the waiter dedicated to Code\_Aster and with software PROMISS3D, are interesting to check or control which types of calculations are carried out at the time of the study and time associated with each orders MISS3D.*

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#### **4.3.2.1 the data file principal**

*It has necessarily the suffix .in (nom\_étude.in for example) and contains all the orders used by MISS3D at the time of the study. It can call upon auxiliary data files. It break up schematically into three parts:*

*· definition of the data,*

- *stages of calculation,*
- *postprocessing,*

*these various phases being able to be connected and repeated by respecting the logic of the program. The execution can be carried out in several phases with resumptions of the various stages of calculation*

#### **4.3.2.2 auxiliary data files**

*The whole of the data necessary to the definition of a complex problem led to a file of order big size in which the hierarchy of information tends to disappear. Of more, often of similar calculations data files have which different only from some lines, common parts being able to be consigned in the same file. In order to allow of such cuttings, it is possible in certain menus to disconnect the reading of the data on a file auxiliary by means of key word FICP.*

#### **4.3.2.3 the output file**

*It has necessarily the suffix .out (nom\_étude.out for example) and gives an indication of the unit orders read by the program, as well as the times CPU spent in each phase of calculation. The information printed during the various phases of the program is detailed for each key word.*

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**5**

***Case of application of taking into account of the ISS by the interface***

## ***Code\_Aster - PROMISS3D***

*To take into account the ISS that amounts representing the ground by a mechanical system are equivalent. Two methods are currently used:*

- lawful method within the competences of ground for which stiffnesses of the system of springs of ground independent of the frequency and are adjusted on the first mode of swinging and first mode of pumping of the system coupled ground-building (S),*
- frequential method of coupling where the impedance of the ground evolves/moves according to frequency.*

*It is the frequential method of coupling which is implemented in PROMISS3D [bib1] for to model the ISS. However, this method makes it possible to determine the stiffnesses of the system of springs of ground of the lawful method thanks to a specific option of the chaining Code\_Aster/PROMISS3D (option MISS\_IMPE of order MACRO\_MISS\_3D). In this case, it calculation follows the following diagram:*

### ***Grid***

***LIRE\_MAILLAGE***

***DEFI\_MATERIAU***

***Definition of the model***

***AFFE\_MATERIAU***

***AFFE\_MODELE***

***AFFE\_CARA\_ELEM***

***Calculation of the dynamic modes***

***structure in embedded base***

***AFFE\_CHAR\_MECA***

***(Dx=Dy=Dz=Drx=Dry=Drz=0)***

***MACRO\_MATR\_ASSE***

***POST\_ELEM***

***Calculation of the 6 static modes***

***MACRO\_MODE\_MECA***

***structure in rigid foundation***

***(LIAISON\_SOLIDE) and PO blocking***

***(Dx=Dy=Dz=Drx=Dry=Drz=0)***

***AFFE\_CHAR\_MECA***

***MACRO\_MATR\_ASSE***

***MODE\_STATIQUE***

***Definition bases modal and***

***Projection of M, K, C on the basis***

***DEFI\_BASE\_MODAL***

***MACR\_ELEM\_DYNA***



*Impression of the data for  
the calculation of ISS by MISS3D  
IMPR\_MACR\_ELEM  
IMPR\_MISS\_3D  
Launching of MISS3D  
Order of Code\_Aster  
MACRO\_MISS\_3D  
(OPTION: MISS\_IMPE)  
End*

*Appear 5-a: Synoptic of the calculation of the stiffnesses within the competence of ground are equivalent*

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*Method of adjustment stiffnesses of the system of springs of ground on the first mode of swinging and the first mode of pumping of the system coupled ground-building (S) is described in document [bib3].*

*As case of application of the Code\_Aster/PROMISS3D chaining, one takes as example one complex structure [Figure 5-b], [Figure 5-c] resting on a cruciform foundation raft [bib4].*

*The interest of this case is that it makes it possible to consider the various modes of representation of the interface*

*ground structure. Thus, the foundation can be considered either rigid, or flexible with the totality of the modes*

*statics, is flexible with some modes of foundation chosen according to a method of reduction modal [bib2].*

***Enclosures***

***Structures***

***Interns***

***Section E-W***

***Section NS***

***Appear 5-b: Grid of the structure***

***Appear 5-c: Grid of the foundation of the structure***

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## **5.1**

### **chaining**

**Code\_Aster - PROMISS3D: Stages and parameters**

*Calculations are carried out by implementing the Code\_Aster chaining - PROMISS3D. The different ones parameters and stages necessary to the calculation of ISS are described below:*

#### **5.1.1 Data transmitted by Code\_Aster (cf [Figure 4-a])**

**Code\_Aster transmits to PROMISS3D: the grid of the interface enters the ground and the structure (face lower of the foundation raft), the modal base combining the dynamic modes of the structure and the modes statics as well as projection on this basis of the matrices  $M$ ,  $K$  and  $C$ . This operation is carried out via operator `IMPR_MACR_ELEM` of Code\_Aster.**

**Code\_Aster transmits also the data relating to the seismic excitation : they are them accélérogrammes  $acc1$ ,  $acc2$  and  $acc3$ . That is done thanks to order `IMPR_MISS_3D` of Code\_Aster.**

**The whole of the data transmitted via operators `IMPR_MACR_ELEM` and `IMPR_MISS_3D` are printed in the file `nom_étude raster` result of the type: `libr` on unit 26 per defect.**

#### **5.1.2 Data specific to PROMISS3D for its calculation in the field frequential**

**PROMISS3D is based on the assumption of linearity as well from the geometrical point of view as of the point of**

*sight of the behavior of the materials [bib1]. This assumption of linearity makes it possible to solve them problems in the frequential field. It is in the file: nom\_étude.optmiss, which is in the repertory associated with the Aster study, which one defines the parameters necessary to calculations in field of the frequencies. One finds there in particular the beach of frequency [Fmin, Fmax] in which will be carried out the calculation and the step of sampling dF. The file nom\_étude.optmiss is given in appendix 1 of the document.*

*The rules of adjustment of the parameters are recalled in the document [bib1]. For our part us took the following parameters for the study of a nuclear small island:*

### **Fmax**

*The beach of frequency depends on the nature of the ground. The maximum frequency reserve is 20 Hz (ground means-slackness).*

$$dF = 0.1 \text{ Hz}$$

*The sampling rate retained is identical to that of accélérogrammes acc1.c2, acc2.c2 and acc3.c2 used for the seismic excitation.*

$$F_{min} = 0.1 \text{ Hz}$$

*This parameter is a function of the two precedents. It is necessary that the report/ratio*

*F*

*- F*

*Max*

*min is an entirety.*

*dF*

$$Z0 = -11.60 \text{ m}$$

*One must return the dimension of the base of the foundation. For our study the foundation is surface. Axis OZ of the model must always be vertical and the normals with plans of the grid of the foundation are obligatorily directed towards the interior of field of the ground.*

### **5.1.3 Data relating to the ground**

*It is in the file nom\_étude.sol, which is in the repertory associated with the Aster study, that one described the data relating to the ground. The constitution of the ground laminated there is indicated like*

*the site of the hearth of the seismic excitation and parameters of sampling of the functions of Green. The file nom\_étude.sol is given in Appendix 1 of the document.*

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### 5.1.3.1 Given of ground

*They are given layer by layer. One described the mechanical characteristics there (Young modulus, Poisson's ratio, density, reduced damping) of materials constitutive of layers and their thicknesses.*

**Recalls:**

· *The propagation velocity of the waves of compression is given by*

**:**

**2(1-**

**G**

**p =**

**·**

**1-**

**2**

· *The propagation velocity of the waves of shearing is given by:*

**G**

**S =**

**·**

· *The modulus of rigidity G, the modulus of elasticity E (Young) and the coefficient of*

**E**

*Poisson are connected by the relation: G =*

**·**

**2 (1+ )**

### 5.1.3.2 space Discretization of the ground and Geometry of the stratification

*The discretization in voluminal finite elements of the half space infinite ground is not accessible. It is traditional for fields not limited of  $R^3$  to have recourse to a formulation by equation integral based on the knowledge of a fundamental solution which for (S) the medium (X) considered (S) in ISS is called: functions of Green. This solution is then discretized by finite elements of border what makes it possible to limit the space discretization of the field and thus to net only it (or ) the interface (S) (cf [§ 5.1.3.3]).*

#### **Recalls:**

*The functions of Green give the “impulse” response of the medium to a source specific, in the absence of any reflective surface. The solution makes it possible to reproduce the signal source with a shift corresponding to the time of way source-receiver, and a decrease of the level proportional to the distance source-receiver. Adapted, the functions of Green can take into account all or some boundary conditions on obstacles. The use of these functions is particularly useful for the integral formulations of the problems of radiation by the structures and of diffraction by obstacles.*

*The finite elements of border built and used by PROMISS3D are generated from “connector industry” of the grid of the foundation belonging to the external field (Code\_Aster). It grid must be carried out to leave D`linear or quadratic surface elements to the normals imperatively directed towards the interior of the ground. However, it is to be announced that the presence of elements quadratic on the interface nothing brings. Indeed, for PROMISS3D, the fields being used for calculation functions of Green are constant by side of element (the presence of node S intermediaries does not have no interest for PROMISS3D). Moreover, it should be noted that PROMISS3D has a method of calculation original which avoids netting the interface between the various layers of the ground. Two cases of figure can arise:*

- *The foundation is surface: In this case, it is enough to only one level source and receiver located on the free face (at the higher level of the soil horizon in contact with the air). Concretely, in the file nom\_étude.sol one specifies that only one source is necessary, thanks to the key word SOURCE, by indicating if one solves a problem in geometry 2D or 3D. The key word RECEP, which announces the position of the receiver for calculation functions of Green, must appear on the description of the 1st layer. constraints being null on the free face, it is useless to calculate them what leads to to use option ALGO\_DEPL for the calculation algorithm of the functions of Green.*

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*One gives below an example of file **nom\_étude.sol** commented on:*

**TITR**

**GROUND ONGBABY**

*\* Name which one gives to the characteristics ground used*

**MATERIAL 2**

*\* A number of Materials associated with the stratification with the ground*

**RO E**

**NAKED BETA**

**ETA**

**2150 4400.E06**

**0.45**

**0.08 0.**

**2070 1421.E06**

**0.45**

**0.114 0.**

*\* Description of the soil mechanics characteristics*

**2 SLEEP**

*\* Numbers stratification taken into account during calculation*

**25.0 SUBDUE 1**

*\* Thickness and material associated with the soil horizon.*

**RECEP**

*\* receiving is placed at the top of the 1st layer*

**25.0 2 SUBDUE**

*\* Layer 2 is not in contact with the foundation. One does not place there*

*\* of receiver*

*SUBS SUBDUE 2*

*\* The substratum is located, in the example, under the 2nd layer*

*SOURCE 1 3D*

*\* Shallow foundation of structure => Only one source*

*FORCE HORIZ*

*\* The source is applied to the top of the 1st layer*

*POSI 1*

*ALGO DEPL*

*\* Because shallow foundation*

*SPEC CAR*

*\* Automatic management of the sampling of the functions of Green*

*OFFSETS 110/440 \* Parameter of horizontal sampling of the functions of Green*

***Interface:***

***Elements***

***surface***

***linear.***

***Normals***

***are directed***

***towards the interior***

***ground medium***

***Layer 1***

***Layer 2***

***Appear 5.1.3.2 - has: Representation of the ground with shallow foundation***

*· The **foundation is buried**: It previously was seen, the finite elements of border built and used by PROMISS3D are generated starting from the grid of the foundation belonging to the external field (Code\_Aster). In the case of a grid cutting it volume of laminated space, it is appropriate to have several levels sources and receivers to cover the whole of the grid. Thus, on the side part of the buried foundation, one place:*

*-*

*a source in the centre of gravity of each element, as on the level of the base of foundation (cf [5.1.3.2 Figure - B]),*

*- a receiver on points of Gauss of each element. The rule stated in PROMISS3D is to lay out with more the 6 receivers on each element but it is recommended to use only 4 of them placed at the top of the element like all them quarters length of the element (cf [5.1.3.2 Figure - B]).*

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*The provision of the receivers and the sources in the file **nom\_étude.sol** is generic it is appropriate thus to use for the side part of the foundation in contact with the ground a regulated grid where all the elements have even height (cf [5.1.3.2 Figure - B]).*

*Concretely, in the file **nom\_étude.sol** one specifies the number of sources necessary, thanks to key word **SOURCE**, by indicating if one solves a problem in geometry 2D or 3D. The word is applied key **RECEP** to announce the position of the receivers, necessary to the calculation of the functions of Green, on ad hoc soil horizons. At the time of the taking into account of the burial of a foundation, **PROMISS3D** implements formulations regularized to improve the precision of calculations and to limit the effort of integration. In the case of a buried foundation it is thus imperative to use option **ALGO\_REGU** for the calculation algorithm of the functions of Green.*

*One gives below an example of file **nom\_étude.sol** commented on. One supposes, for the example considered, that the foundation is buried of 20m and that one has two elements on the height of foundation (cf [5.1.3.2 Figure - B]):*

*TITR**GROUND OTU \* Nom which one gives to the characteristics ground used**MATERIAL 2 \* a Number of materials associated with the stratification with the ground**RO**E**NAKED**BETA**ETA**2150**4400.E06**0.45 0.08 0.*

\*  
*Description of the characteristics*  
2070 1421.E06

0.45 0.114 0. \* soil mechanics

10 SLEEP \* *Nombre of stratification taken into account during calculation*  
2.5 1 RECEP SUBDUE \* *the 1st layer of the ground is divided into 9 underlayers.*  
2.5 1 RECEP SUBDUE \* *a receiver is placed at the top of each underlayer.*  
2.5 1 RECEP SUBDUE \* *the first 8 underlayers are in opposite with the foundation.*  
2.5 1 RECEP SUBDUE \*  
2.5 1 RECEP SUBDUE \*  
2.5 1 RECEP SUBDUE \*  
2.5 1 RECEP SUBDUE \*  
2.5 1 RECEP SUBDUE \*  
5.0 SUBDUE 1 RECEP \* *Reliquat of 1st horizon soil located in lower part of the foundation*  
25.0 2 SUBDUE \* *layer 2 is not in contact with the foundation. One does not place there*  
\* *of receiver*  
SUBS SUBDUE 2 \* *the substratum is located, in the example, under the 2nd layer*  
SOURCE 3 3D \* 3 (2+1) *Sources placed at the centre of gravity of each element*  
\* (2) *and on the level of the base of the foundation (1)*  
FORCE HORIZ POSI 3 \* *the source is applied to the top of the 3rd underlayer*  
FORCE HORIZ POSI 7 \* *the source is applied to the top of the 7th underlayer*  
FORCE HORIZ POSI 9 \* *the source is applied to the top of the 9th underlayer*  
  
ALGO REGU \* *Bus buried foundation*  
SPEC automatic CAR \* *Management of the sampling of the functions of Green*  
OFFSETS 110/440 \* *Parameter of horizontal sampling of the functions of Green*

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**Interface:**  
**Elements**  
**surface**  
**linear.**  
**Normals**  
**Receiver**  
**are directed**  
**Receiver and**  
**towards the interior**  
**Source**  
**ground medium**  
**Layer 1**  
**Layer 2**

**Appear 5.1.3.2 - B: Representation of the ground with buried foundation**

**Note:**

*If on part of the burial, there is no rigid connection between the wall of the building buried and the ground, then it is necessary to define the surface elements of this wall without connection rigid ground-building by key word GROUP\_MA\_SOL\_SOL of operator IMPR\_MACR\_ELEM. Moreover, it is necessary to direct these surface elements towards the outside of the ground medium.*

**5.1.3.3 Parameters of sampling of the functions of Green**

**The calculation of the functions of Green follows the following stages:**

- decomposition of the solution in plane or cylindrical waves elementary,**
- resolution of the problem of the elementary waves by the methods of the coefficients of reflexion transmission,**
- synthesis of the solution in Cartesian space (space field) by transform of Fourier opposite.**

**The functions of Green are thus sampled.**

**The parameter of horizontal sampling: OFFSET**

**OFFSET =  $X_{max}/NR$**

**With  $X_{max}$  length wraps with the biggest length of the foundation. For the small island the length of to erase is 110 m =>  $X_{max} = 110 Mr.$**

**With NR, a number of points of sampling. It is given starting from the average size of**

*elements of the foundation. This length to erase it nuclear small island is approximately 3 Mr. One chooses*

*12 points of sampling per element.*

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*The distance between 2 samples is then given by:  $D = 3.00/12 = 0.25m$ .*

*The number of samples is thus equal to:  $NR = 110/0.25 = 440$ .*

*The parameter of spectral sampling: SPEC*

*SPEC = CAR PROMISS3D manages the parameters of sampling.*

#### *5.1.4 The parameter setting of postprocessing specific to MISS3D*

*It is possible, except standard use of the Code\_AsterPROMISS3D interface, to use tools of calculations specific to MISS3D and to recover the useable results or not by Code\_Aster (cf [§4.3]).*

##### *5.1.4.1 calculation MISS3D with variable step of frequency*

*To increase the precision of a calculation of ISS, one can return a list of frequencies to the hand. It is in the file: nom\_étude.optmis (cf [§ 5.1.2]) that one defines the number and the list of frequencies on which will carry calculation.*

*Order MISS3D for the list of frequency is: LFREQ to which one must associate a continuation of values corresponding to the frequencies for which one will carry out calculation.*

*LFREQ = nf*

*with nf a number of frequencies retained for calculation*

*f1 f2 f3.... fi.... fn*

*with fi frequency for which one wishes to carry out calculation*

*One gives below an example of file nom\_étude.optmis commented on. In the example considered, the foundation surface, is excavated 11.60m and one looks at the answer on 6 precise frequencies:*

*\*  
\* File nom\_etude.21 (.optmiss)*

*\*  
\**

*LFREQ 6*

*\* One carries out a calculation on 6 frequencies.*

*7.1.7.2.7.3 12.3 15.7 18.9*

*\* List frequencies of calculation*

*Z0  
-11.6*

*\**

*Foundation  
excavated  
with*

*11.60m  
SURFING \*  
Foundation  
surface*

*Foot-note:*

*In the file nom\_étude.optmis one must choose the option either Liste of Frequency LFREQ or that is to say sampling of the Frequency: FREQ. Options LFREQ and FREQ are not compatible.*

#### *5.1.4.2 calculation MISS3D on points of control.*

*The points of control make it possible to recover information on the incidental fields, diffracted or radiated by (S) the interface (S), anywhere in the ground.*

*To carry out calculations on points of control, one indicates, in the file: nom\_étude.optmis (cf [§ 5.1.2]), their number (instruction CONT) like their geometrical co-ordinates (X, y, Z) in ground.*

*The calculation of the fields starting from the points of control is post-treaty as well in time in frequency by MISS3D because it does not intervene in the resolution of the problem coupled between the different ones*

*under-fields. One must thus define, in the nom\_étude.optmis (cf [§ 5.1.2]), a data file auxiliaries (cf [§ 4.3.2.2]) (instruction FICP) which must preferably (that is strongly to advise) to reside in the repertory associated with the study on the waiter dedicated to Code\_Aster and the software*

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*In this file of postprocessing one must, in the order:*

1)

*To stipulate if one wishes to carry out a calculation in the temporal field (TIME instruction) rather than into frequential (default option).*

**Foot-note:**

*It is necessary to specify the end of calculations in time (return in the frequential field) by the FINTime instruction.*

2)

*To see (instruction LIRA) the file with the extension .sign which contains the transform of Fourier of the signal used as excitation in far fields during coupled calculation Code\_Aster PROMISS3D. This file is in the repertory associated with the study on waiter dedicated to Code\_Aster and software PROMISS3D,*

**Foot-note:**

*During postprocessing, for calculations in time or frequency, in order to recover a coherent temporal signal with the excitation, the FFT of the signal of excitation in far fields must be filtered (instruction FILTERS). In the frequential field MISS3D multiplies the FFT of the signal of excitation by a window of amplitude 1 on all the frequency band. At the time of the passage in the temporal field that amounts carrying out the product of convolution according to*

*:*  
*signal D excitation T*

*( ) =*  
*-1 (signal sign*

*.*  
*) \* T*

*(-) D*  
*FFT*

*who allows*  
*T*

*to completely describe the signal of excitation in the temporal field.*

*3)*

*To give the name of a file temporal result (or frequential) which will contain them displacements, speeds or accelerations calculated at the point of control (instruction FICH).*

*4)*

*To define which type of field (incidental, radiated or diffracted) will be used for calculation. table below points out the whole of the results which can be obtained in postprocessing starting from point of control by MISS3D:*

*Instruction MISS3D*

*Results*

*Field associé\**

*CUI*

*Displacements, speeds, accelerations*

*Incidental field*

*UCTR*

*Displacements, speeds, accelerations*

*Radiated field*

*CTOT \*\**

*Displacements, speeds, accelerations*

*Diffracted field*

*CSOL \*\**

*Displacements, speeds, accelerations*

*Fields incident+diffracté*

*\* Incidental field, radiated or diffracted by the interfaces of the field*  
*\*\* Attention: For fields diffracted CTOT and CSOL before defining thanks to instruction FICP the file of post treatment it is imperatively necessary to insert in the file nom\_étude.optmis the word key CHMI (Field with the Interface). One gives below an example of file nom\_étude.optmis commented on:*

*\* File Nom\_étude.21 (.optmis)*

**FREQ .01 35.01 .25**

*\* Calculation between 0.1 Hz and 35.01Hz by step of 0.25 Hz*  
**ZO 0.**

*\* Not excavated foundation*

**SURFING**

*\* Shallow foundation*

**CONT 2**

*\* 2 points of control will be used for the post-treatment*

**0. 100. 0.**

*\* Co-ordinates (X, y, Z) of the 1st point of control*

**0. 100. -5.4**

*\* Co-ordinates (X, y, Z) of the 2nd not of control*

**CHMI**

*\* Taking into account of the field diffracted by the interface*

**FICP /home/gubonva/uaster/BR/fichier.post**

*\* File of postprocessing of the points of control*

*\* described and commented on hereafter*

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*One can refer to the example of postprocessing of points of control with accompanying notes page following to obtain an example of file of post treatment (fichier.post) by taking guard however to replace order CUI (incidental field) by CTOT or CSOL.*

*Foot-note:*

*By defect the instructions of the table above deliver results in displacement. To obtain the results of speed or in acceleration it is necessary to use the operand CAPTIONS followed key word QUICKLY or ACCE. For example: CUI CAPTIONS ACCE in this case MISS3D calculates the response in acceleration to the point of control.*

*Caution:*

*It is imperative to be coherent on the type of calculation to realize compared to the file .sign (cf .2) exploited for postprocessing. If this file comes, for example, of one signal in acceleration it is appropriate to seek a result in acceleration.*

5)  
*As MISS3D works in the frequential field, one must specify, among all them sampled frequencies, on which numbers of frequency one wishes to carry it out postprocessing (instruction FREQ).*

*Foot-note:*

*In the case of a postprocessing in time cf 1. , it is advisable to select all the frequencies (instructions FREQ ALL), if not a filtering will be automatically applied.*

6)  
*To specify starting from which type of fields of excitation one will carry out postprocessing (instruction FIELD). One can thus use one, two or the three fields relating to the waves of pressure and shearing in the ground of the incidental far field.*

7)  
*To indicate on which degrees of freedom one wishes post-to treat (instruction DDL).*

*Foot-note:*

*in 3D:*  
*DDL 1 corresponds to direction X*  
*DDL 2 corresponds to the direction y*  
*DDL 3 corresponds to direction Z*

8)

*To define the check-point on which one carries out postprocessing (instruction NOT).*

*One gives below an example of file nom\_étude.optmis commented on. For the example considered, the foundation surface, is not excavated and one carries out postprocessings on two points of control:*

*\* File Nom\_etude.21 (.optmis)*

*FREQ .01 35.01 .25*

*\* Calculation between 0.1 Hz and 35.01Hz by step of 0.25 Hz*

*ZO 0.*

*\* Not excavated foundation*

*SURFING*

*\* Shallow foundation*

*CONT 2*

*\* 2 points of control will be used for the post-*

*\* treatment*

*0. 100. 0.*

*\* Co-ordinates (X, y, Z) of the 1st point decontrôle*

*0. 100. -5.4*

*\* Co-ordinates (X, y, Z) of the 2nd not decontrôle*

*FICP /home/gubonva/uaster/BR/fichier.post*

*\* File of postprocessing of the points of control*

*\* described and commented on hereafter*

*One gives below an example of file of postprocessing of points of control with accompanying notes. For the example considered, one seeks, accelerations in the temporal field caused by incidental fields in two points of control located at a distance of 100 m of the foundation and at respective depths of 0.m and 5.40m (cf [5.1.4.2 Figure - has]).*

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**100m**

**Z**

**Not control 1**

**y**

**5.40m**

**X**

**Layer 1**

**Not control 2**

**Layer 2**

**Appear 5.1.4.2 - has: Example of points of control**

**\* /home/gubonva/uaster/BR/fichier.post file**

**\* The file must be placed on the Aster waiter.**

**TIME NT=1024 TMAX=10.24**

**\* One carries out a return in time to carry it out**

**\* calculation. NT=nombre of step of time.**

**\* TMAX=longuor of the window of time.**

**FILTER LIRA réponse.01.sign**

**\* The incidental FFT of the fields is recovered**

**\* calculated by MISS3D starting from accéléro.**

**FICH réponse.01.p1.t**

**\* results obtained starting from the 1st point of**

**\* control will be recorded in the file**

**\* réponse.01.p1.t**

**CUI CAPTIONS ACCE**

**\* Calculations of accelerations associated with the field**

**\* incidental.**

**FREQ ALL**

**\* One calculates displacements from all**

**\* sampled frequencies.**

**FIELD ALL**

**\* horizontal components and vertical of**

**\* incidental field will intervene during calculation of**

**\* displacements.**

**DDL 1**

**\* One calculates here only the component in X of**

**\* displacement.**

**POINT 1**

**\* Calculations previously described will be done on**

**\* the 1st point of control.**

***FICH réponse.01.p2.t***

***\* results obtained starting from the 2nd not of***

***\* control will be recorded in the file***

***\* réponse.01.p2; T***

***CUI CAPTIONS ACCE***

***\* Calculations of displacements associated with the field***

***\* incidental.***

***FREQ ALL***

***\* One calculates displacements from all***

***\* sampled frequencies.***

***FIELD ALL***

***\* horizontal components and vertical of***

***\* incidental field will intervene during calculation of***

***\* displacements.***

***DDL 1***

***\* One calculates here only the component in X of***

***\* displacement.***

***POINT 2***

***\* Calculations previously described will be done***

***\* with the 2nd not of control.***

***FINT***

***\* End of calculations in time***

***EOF***

***\* End of file***

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***5.1.4.3 calculation MISS3D in foundation buried with suppression of fictitious resonances***

*The formulation of the elements of borders applied to the dynamic problem of the interaction ground structure can reveal frequencies of fictitious resonances which correspond to frequencies of excitation of the finished field hidden (foundation) in a semi-infinite field (ground).*

*These fictitious resonances appear in certain configurations: soft grounds, large foundation raft (cf [§ 4.3.1]).*

*To free itself some one uses order RFIC in the file: nom\_étude.optmis (cf [§ 5.1.2]).*

*Calculation with the elimination of fictitious resonances can be is carried out directly during the 1st calculation*

*MISS3D is post-treaty by MISS3D after having realized of the phenomenon in comparison with results.*

*Foot-note:*

*Order RFIC is very greedy in computing times. To use can go until doubling computing times for MISS3D. It is thus advised to use order RFIC rather in postprocessing.*

*The syntax of order RFIC of MISS3D is as follows:*

*RFIC telemfd with telemfd size in meter of the smallest element of the grid of the foundation One gives below an example of file nom\_étude.optmis (cf [§ 5.1.2]) commented on. In the example considered, the foundation is buried a depth of 6.05m. Size of smallest element of the foundation is 3 Mr. One looks at the answer on 6 precise frequencies in being been free from the problem of fictitious resonances:*

*\*  
\* File nom\_étude.21 (.optmiss)*

*\**

*\**

*LFREQ 6*

*\* One carries out a calculation on 6 frequencies.*

*7.1.7.2.7.3 12.3 15.7 18.9*

*\* List frequencies of calculation*

*Z0*

*-6.05*

*\**

*Foundation*

*buried*

*with*

## **6.05m**

### **RFIC 3**

*\* Elimination of fictitious resonances*

#### **5.1.4.4 calculation MISS3D with simultaneous research of the impedances of ground**

*The impedances of ground express the dynamic rigidity of the field. They are expressed in the form of square matrix depending on the frequency. Each line and each column of this matrix corresponds to a particular mode, a term of the matrix being the virtual work exerted by one of these modes on another mode.*

**Foot-note:**

*During a calculation in time (TIME instruction) no impedance of ground can be calculated. MISS3D makes it possible to calculate the impedances of ground (instruction IMPDC) at the same time as response of the foundation to the seism. For this calculation of the impedances of ground, MISS3D carries them out same calculations as a postprocessing with operand MISS\_IMPE of the order MACRO\_MISS3D of Code\_Aster.*

*The result of the calculation of the impedances (matrices) is stored in a file result (instruction IMPE) who must imperatively reside in the repertory associated with the study on the waiter dedicated to Code\_Aster and with software PROMISS3D.*

*One gives below an example of file nom\_étude.optmis (cf [§ 5.1.2]) commented on. In the example considered, the foundation surface is excavated a depth of 11.60m.*

*\* File Nom\_étude.21 (.optmis)*

**FREQ .01 20. 0.1**

*\* Calculation between 0.1 Hz and 20Hz by step of 0.1 Hz*

**ZO 11.60**

*\* Excavated foundation with 11.60m*

**SURFING**

*\* Shallow foundation*

**IMPE /home/gubonva/uaster/BR/r\_éponse.01.impe**

*\* the calculated impedances will be recorded in*

*\* file réponse.01.impe*

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**5.1.5 Output data of PROMISS3D**

*Following calculation by PROMISS3D, Code\_Aster recovers the modal factors of participation for to obtain displacement, speed and the acceleration in any point of the structure by recombination modal. This recombination can be written in the form:*

$$U(X, T) = \sum A(T) A(X) + \sum B(T) B(X)$$

With

**B**

*with  $U(X, T)$ : field of displacement of the structure*

*With,  $b$ : dynamic and static modes*

*With,  $b$ : modal factors of participation*

*For calculations of the spectra of answer, the file result which contains the factors of participations modal names  $nom\_étude.nn.t$  (where  $nn$  corresponds to the sequence number of the coming loading of Code\_Aster is the occurrence of the call to order **IMPR\_MISS\_3D**). It is created automatically under the central machine of treatment in the repertory indicated in the order **MACRO\_MISS\_3D**.*

*For the calculation of the transfer functions one applies like loading a harmonic excitation of*

*modulate 1. That is carried out in Code\_Aster thanks to order **IMPR\_MISS\_3D**. The file in left PROMISS3D comprising the dynamic response structure complexes is named then*

***nom\_étude.nn.h** (where  $nn$  corresponds to the sequence number of the loading coming from Code\_Aster is*

*occurrence of the call to order **IMPR\_MISS\_3D**). It is created automatically under the machine of treatment in the repertory indicated in macro-order **MACRO\_MISS\_3D**.*

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**5.2*****Method of calculation on rigid foundation***

*The rigid condition of foundation is obtained by imposing on the foundation raft of the building a movement of*

*solid body (the number of static modes associated is then tiny room to 6). For that one uses them linear relations of type LIAISON\_SOLIDE in order AFFE\_CHAR\_MECA [U4.44.01] enters the whole of the node S of the foundation (gathered in the group of node: SRADIER).*

*The whole of the node S of the foundation is then connected to the central node: PO. The unfolding of calculation is done in the following way [Figure 5.2-a]:*

***Grid small island*****LIRE\_MAILLAGE****DEFI\_MATERIAU*****Definition of the model*****AFFE\_MATERIAU****AFFE\_MODELE****AFFE\_CARA\_ELEM*****Calculation of the dynamic modes******structure in embedded base*****AFFE\_CHAR\_MECA****(Dx=Dy=Dz=Drx=Dry=Drz=0)****MACRO\_MATR\_ASSE****POST\_ELEM*****Calculation of the 6 static modes*****MACRO\_MODE\_MECA*****structure in rigid foundation***



***(LIAISON\_SOLIDE) and PO blocking***

***(Dx=Dy=Dz=Drx=Dry=Drz=0)***

***AFFE\_CHAR\_MECA***

***MACRO\_MATR\_ASSE***

***MODE\_STATIQUE***

***Definition bases modal and***

***Projection of M, K, C on the basis***

***DEFI\_BASE\_MODAL***

***1st Stage***

***MACR\_ELEM\_DYNA***

***Impression of the data for***

***the calculation of ISS by MISS3D***

***IMPR\_MACR\_ELEM***

***IMPR\_MISS\_3D***

***Launching of MISS3D***

***2nd Stage***

***MACRO\_MISS\_3D***

***Restitution on the basis of physical***

***transitory answer resulting from MISS3D***

***LIRE\_MISS\_3D***

***3rd Stage***

***Calculation of the spectra***

***and of the transfer transfer functions***

***RECU\_FONCTION***

***Order of Code\_Aster***

***CALC\_FONCTION***

***End***

***Appear 5.2-a: Synoptic of calculation on rigid foundation***

*The associated command files are given in Appendix 2.*

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### ***5.3 Method of calculation on flexible foundation with totality of static modes***

*The interface between the foundation and the ground is in the case of the building already studied represented by group nodes SRADIER on which only the translations are blocked ( $D_x=D_y=D_z=0$ ) the number static modes to calculate amounts to 1731 which corresponds to the number of node S on the foundation (577 nodes) multiplied by the number of associated degrees of freedom. The method implemented is as follows [Figure 5.3-a]:*

#### ***Grid small island***

***LIRE\_MAILLAGE***

***DEFI\_MATERIAU***

#### ***Definition of the model***

***AFFE\_MATERIAU***

#### ***Boundary condition***

***AFFE\_MODELE***

***AFFE\_CARA\_ELEM***

***AFFE\_CHAR\_MECA***

#### ***Calculation of the dynamic modes***

***structure in blocked base***

***( $D_x=D_y=D_z=0$ )***

***MACRO\_MATR\_ASSE***

***POST\_ELEM***

***MACRO\_MODE\_MECA***

#### ***Calculation des 1731 modes static***

***structure in flexible foundation***

***and bases blocked***

***( $D_x=D_y=D_z=0$ )***

***MODE\_STATIQUE***

#### ***Definition bases modal and***

***Projection of M, K, C on the basis***

***DEFI\_BASE\_MODAL***

#### ***1st Stage***

***MACR\_ELEM\_DYNA***

#### ***Impression of the data for***

***the calculation of ISS by MISS3D***

***IMPR\_MACR\_ELEM***

***IMPR\_MISS\_3D***

## ***Launching of MISS3D***

### ***2nd Stage***

#### ***MACRO\_MISS\_3D***

***Restitution on the basis of physical  
transitory answer resulting from MISS3D***

#### ***LIRE\_MISS\_3D***

### ***3rd Stage***

***Calculation of the spectra  
and of the transfer transfer functions***

#### ***Order***

#### ***RECU\_FONCTION***

#### ***Code\_Aster***

#### ***CALC\_FONCTION***

#### ***End***

***Appear 5.3-a: Synoptic of calculation on flexible foundation with the totality of the static modes***

*The command files are given in Appendix 2.*

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## ***5.4***

***Method of calculation on flexible foundation with some modes of  
foundation selected***

### ***5.4.1 Principal stages of the method***

***For the calculation of ISS, PROMISS3D needs a base made up at the same time of null clean modes  
on***

*the interface ground-structure and other nonnull modes on this interface. This base corresponds to one interface of type CRAIG\_BAMPTON. For the first modes, one generally takes the modes clean of the structure obtained by blocking displacements on the interface (bases blocked) and for the seconds, one takes static the modes known as “constrained”, successively obtained while imposing a unit displacement of each degree of freedom of each node of the interface ( foundation).*

*The principle of the method implemented here consists in replacing the constrained static modes plethoric by clean modes of foundation in small number calculated on carpet of springs of ground and selected according to an established criterion.*

*Several stages are necessary to conclude calculation:*

#### **5.4.2 Determination of the carpet of springs to be placed under the foundation.**

*The values of the stiffnesses of the springs equivalent on the laminated ground of the building are given with*

*through a calculation of the transfer transfer functions under harmonic request of module 1 at the time of the study*

*with rigid foundation (cf [§5.2]).*

*One obtains the 6 values of total stiffness within the competence of the laminated ground:  $K_x$  (N/m),  $K_y$  (N/m),  $K_z$  (N/m),*

*$K_x$  (N.m),  $K_y$  (N.m),  $K_z$  (N.m). These stiffnesses, independent of the frequency, are distributed with proportion of surfaces of the elements around the nodes of the foundation thanks to the operand RIGI\_PARASOL of order AFFE\_CARA\_ELEM [U4.42.01] of Code\_Aster.*

#### **5.4.3 The calculation of the dynamic modes of the structure**

*This calculation is carried out on basis embedded with order MODE\_ITER\_SIMULT (one applies to all nodes of the foundation the following boundary condition:  $D_x=D_y=D_z=Dr_x=Dr_y=Dr_z=0$ ).*

#### **5.4.4 The calculation of the clean modes of foundation on carpet of spring**

*During calculation, one dissociates the modes with nonnull displacements of the infrastructure (to erase)*

*modes of the superstructure (buildings...) by considering that only the foundation raft is heavy. This is*

*realized while applying, with the elements not modelling the foundation, a material of which mass voluminal is null. One avoids thus, during the construction of the modal base gathering the modes of foundation and dynamic of the structure, to consider the clean modes twice of superstructure.*

*One enriches then the modal base established with [§5.4.3], via order DEFI\_BASE\_MODALE, by first calculated modes which all are of the modes of foundation since are rejected towards the high ones*

*frequencies all modes of the superstructure.*

### 5.4.5 Selection of the modes

*While reducing considerably the number of constrained modes of foundation one can manage to find the solution in answer and frequency of resonance obtained with the preceding method putting in work the totality of the static modes (cf [§5.3]) and allowing a saving of time of substantial calculation.*

*One judges that the method of reduction is interesting, in term of saving of time, when the number clean modes of foundation on carpet of spring is with most equal to the third of the number of modes statics on flexible foundation (for this study, the method is interesting if the number of modes of foundation on carpet of spring is lower than  $1731/3$  500 modes cf [§5.3]).*

*To refine the selection of the modes, one can use the method recommended by E. Balmes [bib2] which consist in retaining only the modes of foundation whose Eigen frequency remains lower than twice the cut-off frequency used during the calculation of the dynamic modes [Figure 5.4.5-a].*

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*Construction of the modal base of Ritz  $Q$  containing the dynamic modes and them modes of foundation with:*

*$N$  = a number of dynamic modes*

*$N$  = a number of modes of foundation*

*( $N$  must be with most equal to 500 for the building)*

*$N = N + n$  = an optimal number of modes*

*DEFI\_BASE\_MODAL*

*Classification of the ddl of the structure*

*total starting from the classification of*

*the modal base of Ritz  $Q$*

*NUME\_DDL\_GENE*

***Projection of the matrices of mass  
and of rigidity associated with calculation with  
dynamic modes on the modal basis Q***

***PROJ\_MATR\_BASE***

***Calculation of the modes generalized with the matrices  
of mass and rigidity projected and restitution  
modes orthogonalized on the physical basis***

***MODE\_ITER\_SIMULT***

***REST\_BASE\_PHYS***

***Cut-off frequency used  
during dynamic calculation***

***For the building  $f_c=23$  Hz***

***Determination of the optimal number  
modes of foundation***

***$N = N-n$***

***such as NR counts all the modes  
whose frequency is at the maximum  
equalize with  $2x f_c$  (for the building 46 Hz)***

***Appear 5.4.5-a: Optimization of the number of modes of foundation***

***The course of complete calculation with reduction of the modes of foundation is made way  
following [Figure 5.4.5-b]:***

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***Warnings:***

***\* For the modes of foundation, contrary to the calculation of the dynamic modes, the nodes of***

*to erase do not have any constraint on their displacements. To calculate the macronutrient dynamics of the structure it is thus necessary to adapt two classifications related to limiting conditions different (blocking with the interface for the dynamic modes or carpet from specific springs for modes of foundation).*

*\*\* One avoids, during the construction of the modal base (gathering the modes of foundation and dynamic of the structure), to twice take into account the clean modes of principal under structures: internal enclosures, structures,... by considering that only the foundation raft is heavy and while applying to the elements modelling the superstructure of materials with density quasi null (=10<sup>-3</sup> kg/m<sup>3</sup>).*

*Grid small island*

*LIRE\_MAILLAGE*

*DEFI\_MATERIAU*

*Definition of the model*

*AFFE\_MATERIAU*

*Boundary condition*

*AFFE\_MODELE*

*AFFE\_CARA\_ELEM*

*AFFE\_CHAR\_MECA*

*Calculation of the dynamic modes*

*MACRO\_MATR\_ASSE*

*structure in embedded base*

*(NUME\_DDL: num\_dyn*

*(Dx=Dy=Dz=Drx=Dry=Drz=0)*

*\**

*CHAMP\_MATER: mat\_dy*

*\*\* N)*

*POST\_ELEM*

*MACRO\_MODE\_MECA*

*Calculation of the modes of foundations*

*on carpet of spring while considering*

*that only the foundation raft is heavy.*

*No Boundary conditions on*

*AFFE\_MATERIAU*

*the foundation*

*AFFE\_CARA\_ELEM*

*(RIGI\_PARASOL)*

*MACRO\_MATR\_ASSE*

*Definition bases modal and*

*(NUME\_DDL: num*

*\*\_fon*

*Projection of M, K, C on the basis*

*CHAMP\_MATER: mat\_f*

*\*\* one)*

*POST\_ELEM*

*DEFI\_BASE\_MODAL*

*MACRO\_MODE\_MECA*

*(NUME\_REF: num\_dyn)*

*MACR\_ELEM\_DYNA*

*Impression of the data for*

*the calculation of ISS by MISS3D*

*IMPR\_MACR\_ELEM*

*IMPR\_MISS\_3D*

*Launching of MISS3D*

*MACRO\_MISS\_3D*

*Restitution on the basis of physical*

*transitory answer resulting from MISS3D*

*LIRE\_MISS\_3D*

*Calculation of the spectra*

*transfer transfer functions*

*Order of Code\_Aster*

*RECU\_FONCTION*

*CALC\_FONCTION*

*End*

*Appear 5.4.5-b: Synoptic of calculation with modes of foundation on carpet of spring*

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*One can carry out a parametric study on the number of modes of foundation. Method put in*



*work was evaluated [bib4] and consisted in making a continuation on a basis containing the 171 modes dynamic and 500 modes of foundation and to retain at the time of the definition of the modal base only 80, then 30 and finally 20 modes of foundation. This operation was carried out by modifying in continuation it a number of modes of foundation by operand NMAX\_MODE of order DEFI\_BASE\_MODAL, then by starting again the chain of call to the successive operators starting from this operator until postprocessing.*

*It should be noted that, on this study, when one uses the method of reduction of the modes, one finds that only forty modes of foundation are necessary to reproduce the effect induced by 1731 static modes.*

## **6 Bibliography**

[1]

*D. CLOUTEAU: User's manual of PROMISS3D - MISS2D, revision 6.3, by (LMSSM Central school of Paris)*

[2]

*E. BALMES: Use of generalized interfaces dismantle of freedom in component synthesis mode IMAC 1996*

[3]

*V. GUYONVARH - G. DEVESA: Methods of calculation of the seismic excitations to the works CPP N4. HP-52/99/006/A*

[4]

*V. GUYONVARH - G. DEVESA: Methods to consider the interaction ground-structure on the small island*

*nuclear power EPR with Code\_Aster and MISS3D. HP-62/00/007/A*

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**Appendix 1 files of setting in data of PROMISS3D**

\*

**\* File miss01.21 (.optmiss)**

\*

\*

**FREQ 0.1 20. 0.1**

**Z0 -11.6**

**SURFING**

\*

**\* File miss01a.22 (.sol)**

\*

**TITR**

**GROUND PENLY**

**MATERIAL 4**

**RO E NAKED ETA BETA**

**2150 4480.E06 0.40 0.08 0.**

**2070 1421.E06 0.45 0.114 0.**

**2150 1305.E06 0.45 0.16 0.**

**2400 6000.E06 0.45 0.06 0.**

**3 SLEEP**

**43.9 1 RECEP SUBDUE**

**31 2 SUBDUE**

**38.5 3 SUBDUE**

**SUBS SUBDUE 4**

**SOURCE 1 3D**

**FORCE HORIZ POSI 1**

**ALGO DEPL**

**\* SPEC 0.12/16384**

**SPEC CAR**

**OFFSET 110/400**

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**Appendix 2 Command files Aster**

**Initial common Left A2.1**

# \*\*\*\*\*

# **Command file = miss01.com m**

# \*\*\*\*\*

**BEGINNING ();**

#

**email = LIRE\_MAILLAGE ();**

#

#

# -----

# **definitions of the model and the group of meshes**

# -----

#

#

**INCLUDE (UNIT = 11);**

#

# -----

# **definition of materials**

# -----

#

**INCLUDE (UNIT = 12);**

#

# -----

# **definition of the characteristics of the elements**

# -----

#

**INCLUDE (UNIT = 13);**

#

# -----

**# definition of the foundation**

# -----

**&mail = DEFI\_GROUP (**  
**GRID = email,**  
**CREA\_GROUP\_NO = \_F (**  
**GROUP\_MA = 'SRADIER',**  
**)**  
**);**

## **A2.2 rigid Case Foundation**

#

#####

**# CONDITION OF RIGIDITY OF THE FOUNDATION RAFT**  
**# BOUNDARY CONDITION BASES BLOQUEE IN DYNAMICS**

#

**ch\_cldyn = AFFE\_CHAR\_MECA (**  
**MODEL = model,**

**DDL\_IMPO = \_F (GROUP\_NO = 'SRADIER',**

**DX = 0. ,**

**DY = 0. ,**

**DZ = 0. ,**

**DRX = 0. ,**

**DRY = 0. ,**

**DRZ = 0. ,**

**)**,

**);**

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***\*\*\*\*\****

***# RESOLUTION OF THE DYNAMIC MODAL PROBLEM***

***#***

***# CALCULATIONS ELEMENTARY of the matrices of mass and stiffness***

***# CLASSIFICATION of the unknown factors of the problem***

***# ASSEMBLY of the matrices of mass and stiffness***

***#***

***#***

***MACRO\_MATR\_ASSE (model MODELE=,***

***CHAM\_MATER= MATER,***

***CARA\_ELEM= elem,***

***CHARGE= ch\_cldyn,***

***NUME\_DDL= num\_dyn,***

***MATR\_ASSE=\_F (MATRICE= matrigi,***

***OPTION= "RIGI\_MECA"),***

***MATR\_ASSE=\_F (MATRICE= matmass,***

***OPTION= "MASS\_MECA"),***

***MATR\_ASSE=\_F (MATRICE= matamor,***

***OPTION= "AMOR\_MECA"),***

***);***

***#***

***#-----***

***# calculation of the masses***

***#-----***

***#***

***#***

***#***

***masses = POST\_ELEM (***

***MODEL = model,***

***INFORMATION = 1***

***CHAM\_MATER = to subdue,***

***CARA\_ELEM = elem,***

```
MASS_INER =_F (  
ALL = "YES"  
),  
);  
#  
#  
# -----  
# calculation of the clean modes by successive bands  
# -----  
#  
#  
mod_dyn = MACRO_MODE_MECA (MATR_A= matrigi, MATR_B= matmass,  
  CALC_FREQ =_F (  
  FREQ = (0.1, 7. , 10. , 12. , 14. , 16. , 17. , 19. ,  
  21., 23.),  
),  
NORM_MODE=_F (MASS_INER=masses),  
FILTRE_MODE=_F (SEUIL= 1.D-3),  
IMPRESSION=_F (),  
);  
#
```

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```
#####  
# CONDITION OF RIGIDITY OF THE FOUNDATION RAFT  
# BOUNDARY CONDITION BASES BLOQUEE IN STATICS  
#####
```

```
ch_clsta = AFFE_CHAR_MECA (  
MODEL = model,
```

```
DDL_IMPO = _F (GROUP_NO = ' PO',  
DX  
= 0.,
```

```
DY = 0. ,
```

```
DZ = 0. ,
```

```
DRX = 0. ,
```

```
DRY = 0. ,
```

```
DRZ = 0. ,
```

),

*LIAISON\_SOLIDE =\_F (GROUP\_NO = 'SRADIER'),*  
);

*\*\*\*\*\**

*# RESOLUTION OF THE STATIC MODAL PROBLEM*

*#*

*# CALCULATIONS ELEMENTARY of the matrices of mass and stiffness*

*# CLASSIFICATION of the unknown factors of the problem*

*# ASSEMBLY of the matrices of mass and stiffness*

*#*

*MACRO\_MATR\_ASSE (model MODELE=,*

*SOLVEUR=\_F (METHODE= "MULT\_FRONT"),*

*CARA\_ELEM= elem,*

*CHARGE= ch\_clsta,*

*CHAM\_MATER= MATER,*

*NUME\_DDL= num\_sta,*

*MATR\_ASSE=\_F (MATRICE= rigistat, OPTION= "RIGI\_MECA"),*

*(MATRICE= massetat, OPTION= "MASS\_MECA"),*

*);*

*#*

*#*

*# CALCULATION OF THE DYNAMIC MACRONUTRIENT =*

*#-----*

*#*

*mod\_sta = MODE\_STATIQUE (MATR\_RIGI= rigistat,*

*MATR\_MASS= massetat,*

*DDL\_IMPO=\_F (GROUP\_NO= "PO",*

*TOUT\_CMP= "YES"),*

*);*

*basmo = DEFI\_BASE\_MODAL (*

*RITZ=\_F (MODE\_MECA= mod\_dyn),*

*RITZ=\_F (MODE\_STAT= mod\_sta,*

*NMAX\_MODE= 6),*

*NUME\_REF= num\_dyn);*

*#*

*mael = MACR\_ELEM\_DYNA (BASE\_MODAL= basmo,*

*MATR\_RIGI= matrigi,*

*MATR\_MASS= matmass,*



*OPTION= "RITZ");*

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---

**Code\_Aster** ®

*Version*

*6.4*

*Titrate:*

*Interaction ground-structure with the Code\_Aster-PROMISS3D interface Dates*

*:*

*09/06/04*

*Author (S):*

**G. DEVESA, V. GUYONVARH** *Key*

*:*

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***A2.3 flexible Case Foundation with all the static modes***

*#*

*#####*

***# CONDITION OF RIGIDITY OF THE FOUNDATION RAFT***

***# BOUNDARY CONDITION BASES BLOQUEE IN DYNAMICS***

*#*

***ch\_cldyn = AFFE\_CHAR\_MECA (***

***MODEL = model,***

***DDL\_IMPO = \_F (GROUP\_NO = ' SRADIER',***

***DX = 0. ,***

***DY = 0. ,***

***DZ = 0. ,***

***),***

***);***

#####

**# RESOLUTION OF THE DYNAMIC MODAL PROBLEM**

#

**# CALCULATIONS ELEMENTARY of the matrices of mass and stiffness**

**# CLASSIFICATION of the unknown factors of the problem**

**# ASSEMBLY of the matrices of mass and stiffness**

#

#

**MACRO\_MATR\_ASSE (model MODELE=,**

**CHAM\_MATER= MATER,**

**CARA\_ELEM= elem,**

**CHARGE= ch\_cldyn,**

**NUME\_DDL= num\_dyn,**

**MATR\_ASSE=\_F (MATRICE= matrigi,**

**OPTION= "RIGI\_MECA"),**

**MATR\_ASSE=\_F (MATRICE= matmass,**

**OPTION= "MASS\_MECA"),**

**MATR\_ASSE=\_F (MATRICE= matamor,**

**OPTION= "AMOR\_MECA"),**

**);**

#

#-----

**# calculation of the masses**

#-----

#

#

#

**masses = POST\_ELEM (**

**MODEL = model,**

**INFORMATION = 1,**

**CHAM\_MATER = to subdue,**

**CARA\_ELEM = elem,**

**MASS\_INER = \_F (**

**ALL = "YES"**

**),**

**);**

#

#

**Instruction manual**

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---

**Code\_Aster ®**

**Version**

**6.4*****Titrate:******Interaction ground-structure with the Code\_Aster-PROMISS3D interface Dates******:******09/06/04******Author (S):******G. DEVESA, V. GUYONVARH Key******:******U2.06.07-B Page******: 33/42***

```

# -----
# calculation of the clean modes by successive bands
# -----
#
#
mod_dyn = MACRO_MODE_MECA (MATR_A= matrigi, MATR_B= matmass,
CALC_FREQ =_F (
FREQ = (0.1, 7. , 10. , 12. , 14. , 16. , 17. , 19. ,
21., 23.),
),
NORM_MODE=_F (MASS_INER=masses),
FILTRE_MODE=_F (SEUIL= 1.D-3),
IMPRESSION=_F (),
);
#
# CALCULATION OF THE DYNAMIC MACRONUTRIENT =
#-----
#
#
mod_sta = MODE_STATIQUE (MATR_RIGI= matrigi,
MATR_MASS= matmass,
DDL_IMPO=_F (GROUP_NO= "SRADIER",
AVEC_CMP= ("DX", "DY", "DZ"),
),
);

basmo = DEFI_BASE_MODALE (
RITZ=_F (MODE_MECA= mod_dyn),
# 577 nodes has the interface
# => 577*3=1731 static modes
RITZ =_F (NMAX_MODE= 1800,

```

*MODE\_STAT=mod\_sta),  
NUME\_REF= num\_dyn);*

*#*

*mael = MACR\_ELEM\_DYNA (BASE\_MODALE= basmo,  
MATR\_RIGI= matrigi,  
MATR\_MASS= matmass,  
OPTION= "RITZ");*

#### *A2.4 flexible Case Foundation with reduction of modes*

*#*

*\*\*\*\*\**

*# CONDITION OF RIGIDITY OF THE FOUNDATION RAFT  
# BOUNDARY CONDITION BASES BLOQUEE IN DYNAMICS*

*#*

*ch\_cldyn = AFFE\_CHAR\_MECA (  
MODEL = model,*

*DDL\_IMPO = \_F (GROUP\_NO = 'SRADIER',*

*DX = 0. ,*

*DY = 0. ,*

*DZ = 0. ,*

*DRX = 0. ,*

*DRY = 0. ,*

*DRZ = 0. ,*

*),*

*);*

*#*

*Instruction manual*

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**Code\_Aster** ®

**Version**

**6.4**

**Titrate:**

**Interaction ground-structure with the Code\_Aster-PROMISS3D interface Dates**

**:**

**09/06/04**

**Author (S):**

**G. DEVESA, V. GUYONVARH Key**

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\*\*\*\*\*

**# RESOLUTION OF THE DYNAMIC MODAL PROBLEM**

**#**

**# CALCULATIONS ELEMENTARY of the matrices of mass and stiffness**

**# CLASSIFICATION of the unknown factors of the problem**

**# ASSEMBLY of the matrices of mass and stiffness**

**#**

**#**

**MACRO\_MATR\_ASSE (model MODELE=,**

**CHAM\_MATER= MATER,**

**CARA\_ELEM= elem,**

**CHARGE= ch\_cldyn,**

**NUME\_DDL= num\_dyn,**

**MATR\_ASSE=\_F (MATRICE= matrigi,**

**OPTION= "RIGI\_MECA"),**

**MATR\_ASSE=\_F (MATRICE= matmass,**

**OPTION= "MASS\_MECA"),**

**MATR\_ASSE=\_F (MATRICE= matamor,**

**OPTION= "AMOR\_MECA"),**

**);**

**#**

**#-----**

**# calculation of the masses**

**#-----**

**#**

**#**

**#**

**masses = POST\_ELEM (**

**MODEL = model,**

```
INFORMATION = 1,  
CHAM_MATER = to subdue,  
CARA_ELEM = elem,  
MASS_INER = _F (  
ALL = "YES"  
),  
);  
#  
#  
# -----  
# calculation of the clean modes by successive bands  
# -----  
#  
#  
mod_dyn = MACRO_MODE_MECA (MATR_A= matrigi, MATR_B= matmass,  
CALC_FREQ = _F (  
FREQ = (0.1, 7. , 10. , 12. , 14. , 16. , 17. , 19. ,  
21., 23.),  
),  
NORM_MODE=_F (MASS_INER=masses),  
FILTRE_MODE=_F (SEUIL= 1.D-3),  
IMPRESSION=_F (),  
);  
#  
#  
#
```

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**Version**  
**6.4**

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**Interaction ground-structure with the Code\_Aster-PROMISS3D interface Dates**  
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**09/06/04**  
**Author (S):**  
**G. DEVESA, V. GUYONVARH Key**  
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```

#####
# DEFINITION OF CHARACTERISTICS OF GROUND TAKEN INTO ACCOUNT
# BY A CARPET OF SPRINGS
#####
# GROUND HOMOGENEOUS PENLY
# =====
#
elemb = AFFE_CARA_ELEM (...(idem other cases),...
RIGI_PARASOL= _F (
GROUP_MA= "SRADIER",
COEF_GROUP= 1. ,
GROUP_NO_CENTRE= "PO",
CARA= "K_TR_D_N",
VALE= (5.4E11, 5.4E11, 6.0E11,
6.5E14, 6.5E14, 1.09E15),
),
);

#
#
#####
# RESOLUTION OF THE MODAL PROBLEM OF FOUNDATION
# =====
#
# CALCULATIONS ELEMENTARY of the matrices of mass and stiffness
# CLASSIFICATION of the unknown factors of the problem
# ASSEMBLY of the matrices of mass and stiffness
#
#
MACRO_MATR_ASSE (model MODELE=,
SOLVEUR= _F (METHODE= "MULT_FRONT"),
CARA_ELEM= elemb,
# CHARGE= ch_clsta,
CHAM_MATER= materb,
NUME_DDL= num_stab,
MATR_ASSE= _F (MATRICE= rigistat, OPTION= "RIGI_MECA"),
(MATRICE= massetat, OPTION= "MASS_MECA"),
);
#
#
#-----

```

*# calculation of the masses reduced to the foundation*

*#-----*

*#*  
*#*  
*#*

*masseb = POST\_ELEM (*  
*MODEL = model,*  
*INFORMATION = 1,*  
*CHAM\_MATER = materb,*  
*CARA\_ELEM = elemb,*  
*MASS\_INER = \_F (*  
*ALL = "YES"*  
*),*  
*);*

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---

*Code\_Aster ®*  
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*#*  
*#*  
*# -----*

*# calculation of the clean modes by successive bands*

*# -----*  
*#*

*# the calculation of the modes of "foundation" is carried out from*  
*# the structure on which one keeps only the mass of the foundation raft*  
*# because one wants that the modes with displacement not no one of the foundation*  
*# and one do not want to recover second once the local modes of*  
*# structure (mode of swinging of the enclosures, of IF,....).*  
*#*



*# the method of reduction of the modes is interesting  
 # when the number of modes of “foundation” is with most equal to the third  
 # of the number of static modes of reference. For the ilot, one has  
 # 577 nodes on the interface is  $577*3=1731$  static modes.  
 # Using IMPR\_STURMs one established the frequency band which  
 # enables us to keep 500 modes.*

```
#
mod_sta = MACRO_MODE_MECA (MATR_A= rigistat, MATR_B= massetat,
CALC_FREQ =_F (
FREQ = (0.1, 60. , 100. , 130. , 160. , 200. , 300. ,
2000., 4000., 6000.),
),
NORM_MODE=_F (MASS_INER=masseb),
# FILTRE_MODE=_F (SEUIL= 1.D-3),
IMPRESSION=_F (),
);
#
```

*# One defines our modal base while combining during our 1st test  
 # 171 dynamic modes of the structure in base encastree and 80  
 # “static” modes (foundation) with foundation on carpet of spring.  
 #*

```
basmo = DEFI_BASE_MODAL (
RITZ=_F (MODE_MECA= mod_dyn),
RITZ=_F (MODE_MECA= mod_sta,
NMAX_MODE= 80),
NUME_REF= num_dyn);
```

```
mael = MACR_ELEM_DYNA (BASE_MODAL= basmo,
MATR_RIGI= matrigi,
MATR_MASS= matmass,
OPTION= “RITZ”);
Instruction manual
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```

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**Common Left A2.5: writing of the file .raster and launching of PROMISS3D**

```

#-----
# READING OF the ACCELEROGRAMMES (Penly),
#-----
#
#-----
# DEFI_FONCTION = UL 31
# Accelerogramme = acc1.c2
# (resulting from the spectrum of ground Penly),
#-----
# DEFI_FONCTION = UL 32
# Accelerogramme = acc2.c2
# (resulting from the spectrum of ground Penly),
#-----
# DEFI_FONCTION = UL 33
# Accelerogramme = acc3.c2
# (resulting from the spectrum of ground Penly),
#
INCLUDE (UNIT = 31);
#
acce_x = CALC_FONCTION (
COMB =_F (
FUNCTION = acce1,
COEF = 9.81,
),
);
#
INCLUDE (UNIT = 32);
#
acce_y = CALC_FONCTION (
COMB =_F (
FUNCTION = acce2,
COEF = 9.81,
),
);
#

```

**INCLUDE (UNIT = 33);**

**#**

**acce\_z = CALC\_FONCTION (**

**COMB = \_F (**

**FUNCTION = acce3,**

**COEF = 6.54,**

**),**

**);**

**#**

**# PREPROCESSING OF PROMISS3D=**

**#-----**

**# GRID AND IMPEDANCES Of INTERFACE**

**#**

**IMPR\_MACR\_ELEM (**

**MACR\_ELEM\_DYNA = mael,**

**FORMAT = "MISS\_3D",**

**SOUS\_TITRE = "miss01",**

**IMPR\_MODE\_STAT= "YES",**

**IMPR\_MODE\_MECA= "NOT",**

**AMOR\_REDUIT = \_F (**

**#**

**7.00000E-02, 7.00000E-02, 7.00000E-02, 7.00000E-02, 7.00000E-02,**

**5.00000E-02, 5.00000E-02, 7.00000E-02, 7.00000E-02, 7.00000E-02,**

**7.00000E-02, 7.00000E-02, 7.00000E-02, 7.00000E-02, 7.00000E-02,**

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---

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**Titrate:**

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**Author (S):**

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**7.00000E-02, 7.00000E-02, 7.00000E-02, 7.00000E-02, 7.00000E-02,**

**7.00000E-02, 7.00000E-02, 7.00000E-02, 7.00000E-02, 7.00000E-02,**



```
#  
#  
IMPR_MISS_3D (MACR_ELEM_DYNA= mael,  
FREQ_INIT= 0. , FREQ_FIN= 20. PAS= 0.1,  
EXCIT_SOL=_F (DIRECTION= (1. , 0. , 0.), NOM_CHAM= "ACCE",  
FONC_SIGNAL= fo1),  
EXCIT_SOL=_F (DIRECTION= (1. , 0. , 0.), NOM_CHAM= "ACCE",  
FONC_SIGNAL= fo1),  
EXCIT_SOL=_F (DIRECTION= (1. , 0. , 0.), NOM_CHAM= "ACCE",  
FONC_SIGNAL= fo1),  
);  
#  
#  
#
```

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---

*Code\_Aster* ®

*Version*

*6.4*

*Titrate:*

*Interaction ground-structure with the Code\_Aster-PROMISS3D interface Dates*

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*# TRANSMISSION OF GIVE ASTER A PROMISS3D*

*# CREATION OF the FILE = nom\_etude.RASTER ON UNIT 26*

```
IMPR_MISS_3D (  
MACR_ELEM_DYNA = mael,  
INST_INIT = 0. ,  
INST_FIN = 20. ,  
NOT = 0.01,  
EXCIT_SOL = _F (  
DIRECTION = (1. , 0. , 0.),  
NOM_CHAM = "ACCE",  
FONC_SIGNAL = acce_x,  
),
```

```
EXCIT_SOL =_F (  
DIRECTION = (1. , 0. , 0.),  
NOM_CHAM = "ACCE",  
FONC_SIGNAL = acce_y,  
)  
EXCIT_SOL =_F (  
DIRECTION = (1. , 0. , 0.),  
NOM_CHAM = "ACCE",  
FONC_SIGNAL = acce_z,  
)  
);  
END ();  
#  
# TREATMENT OF PROMISS3D BY EXEC_LOGICIEL  
#-----  
#  
# Response transitory of the structure  
# subjected to the seismic loading  
#  
CONTINUATION ();  
MACRO_MISS_3D (  
OPTION =_F (TOUT= "YES"),  
PROJET= "miss01",  
REPertoire= ". /uaster/miss01/",  
UNITE_IMPR_ASTER= 26,  
UNITE_OPTI_MISS= 21,  
UNITE_MODELE_SOL= 22,  
);  
END ();
```

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---

*Code\_Aster* ®  
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*6.4*

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*Interaction ground-structure with the Code\_Aster-PROMISS3D interface Dates*  
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*Author (S):*  
*G. DEVESA, V. GUYONVARH Key*  
*:*

**U2.06.07-B Page****: 40/42****Common Left A2.6: postprocessing of PROMISS3D and examination**

```

#
#=====
# Programs = miss01a_FDT.com m
# CALCULATION OF THE TRANSFER TRANSFER FUNCTIONS
#=====
#
CONTINUATION ();
#
#=====
# CALCULATION OF THE TRANSFER TRANSFER FUNCTIONS
# ON the NUCLEAR ILOT
# One gives here as example that postprocessing on the Structures
# interns with 1.50m
#=====
#
#
dyna = LIRE_MISS_3D (MACR_ELEM_DYNA= mael,
TYPE_RESU= "HARMO",
TITRE= "HARM_ACCE_EPR",
UNITE=28);
#
#
#-----
# STRUCTURE INTERNAL
#-----
#
# Z=1.50 m
#=====
#
Hsi1x = RECU_FONCTION (
RESULTAT= dyna,
GROUP_NO= "NSIEZ3",
NOM_CHAM= "ACCE",
NOM_CMP= "DX");
#
#
IMPR_COURBE (FORMAT = "AGRAF",

```

**FILE** = "AGRAF",  
**EXIT** = "COLOR",  
**TITRE\_GRAPHIQUE** = "Functions IF 1.50m has",  
**ECHELLE\_X** = "FLAX",  
**ECHELLE\_Y** = "FLAX",  
**LABEL\_X** = "frequency (Hz)",  
**PRESENTATION** = ' PAYSAGE',  
**DATE** = ' OUI',  
**CURVE** = \_F (  
**FUNCTION** = Hsi1x),  
**CURVE** = \_F (  
**PARTIE** = "IMAG",  
**FUNCTION** = Hsi1x),  
);

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---



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#=====

# Programs = miss01a\_trans.com m

# CALCULATION OF THE SPECTRA OF ANSWER

#=====

#

CONTINUATION ();

#

#-----

#

CONTINUATION AFTER CALCULATION MISS

#-----

#

#=====

# CALCULATION OF THE TRANSITORY ANSWERS

# ON the NUCLEAR ILOT

# One gives as example calculations on the internal structures

#=====

#

resugene = LIRE\_MISS\_3D (MACR\_ELEM\_DYNA = mael,

TYPE\_RESU = "TRANS",

TITRATE = "TRANSIT",

UNITE=28);

#

l\_freq = (

0.200, 0.350, 0.500, 0.650, 0.950,

1.100, 1.250, 1.400 1.550, 1.700,

1.850, 2.000, 2.150, 2.300, 2.450, 2.600,

2.750, 2.900, 3.075, 3.300, 3.525, 3.800,

4.100, 4.400, 4.700, 5.000, 5.375,  
5.750, 6.125, 6.500, 6.875,  
7.250, 7.625, 8.000, 8.750, 9.500, 10.250,  
11.000, 11.750, 12.500, 13.250, 14.000, 14.750,  
16.000, 17.500, 20.000, 23.500, 28.000, 32.500,  
37.000, 41.500, 46.000, 50.500, 56.000, 62.000,  
74.000, 80.000, 86.000, 92.000, 98.000 );

*l\_amor\_s* = (0.04);

#----- *Internal structures A 1.50 m* -----

#

*SIAZdXr* = *RECU\_FONCTION* (  
*RESULT* = *resugene*,  
*NOM\_CHAM* = "ACCE",  
*TITRE* = "ABSOLUTE ACCELERATION IF Z=1.50 m O DEGR EXT. IN X",  
*GROUP\_NO* = "NSIAZ3"  
*NOM\_CMP* = "DX", *INTERPOL* = "FLAX",

);

# =====

# *CALCULATION OF THE SPECTRA*

# =====

*SIAZdXs* = *CALC\_FONCTION* (  
*SPEC\_OSCI* = *\_F* (  
*FUNCTION* = *SIAZdXr*,  
*FREQ* = *l\_freq*,  
*AMOR\_REDUIT* = *l\_amor\_s*));

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---

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*Titrate:*

*Interaction ground-structure with the Code\_Aster-PROMISS3D interface Dates*

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09/06/04

*Author (S):*

**G. DEVESA, V. GUYONVARH** *Key*

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*Titrate:*

*Note of use of FOURIER modeling*

*Date*

:

07/05/04

*Author (S):*

***X. DESROCHES*** *Key*

:

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*Organization (S): EDF-R & D /AMA*

***Instruction manual***

***U2.07 booklet: Method to reduce the size of modeling***

***Document: U2.07.01***

***Note of use of FOURIER modeling***

***1 Goal***

***The analysis of Fourier is intended to calculate the response of structures for axisymmetric geometry solicited by nonaxisymmetric loadings broken up into Fourier series.***

***Limitations:***

- the decomposition of the loading in Fourier series is supposed to be made by the user,***
- the Aster establishment relates to only isotropic or orthotropic materials,***
- in thermics, there does not exist total order making it possible to solve a problem on several harmonics. Calculation must be done harmonic by harmonic.***

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***Code\_Aster ®***

***Version***

***6.4***

***Titrate:***

***Note of use of FOURIER modeling***

**Date**

:

**07/05/04**

**Author (S):**

**X. DESROCHES Key**

:

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## **2 Notations**

**All the fields considered (forces, displacements, strains, stresses, flow) are expressed in cylindrical co-ordinates with following convention on the order of the components:**

**Z**

**radial component according to R**

**axial component according to Z**

**component tangential (or circumferential) according to**

**Example: ( $u_r, u_z, U$ )**

**( $F_r, f_z, F$ )**

**R**

**$u_z$**

**U**

**$u_r$**

**The grid is localised in plan (R, Z), the symmetry of revolution being done around axis OZ. trihedron (R, Z,) is directed in the direct direction.**

**Z**

**R**

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### ***3 Modeling, loadings***

*To affect the axisymmetric finite elements Fourier on the grid, the operator is used AFFE\_MODELE in the following way:*

*Mo = AFFE\_MODELE (*

*GRID = my,*

*AFFE*

*=*

*\_F*

*(*

*ALL*

*=*

*“YES”,*

*PHENOMENON*

*=*

*“MECHANICAL”*

*or*

*“THERMAL”,*

*MODELING*

*=*

*“AXIS\_FOURIER”*

*)*

*);*

*The decomposition in Fourier series of the loading must be made as a preliminary by the user*

*cos*

*0*

*L*

*sin*

*0*

*L*

*NR*

*S*

*has*

*that is to say F =*

*cos L*

*F (R, Z) +*

*sin L*

*F (R, Z)*

*L*

*L*

*l=0*

*0*

*- sin*

*0*

*cos*

*L*

*L*

*S (has)*

*S (has)*

*S (has)*

*S (has)*

*with F*

*=*

*,*

*,*

*L*  
*(Fr fz F*  
*L*  
*L*  
*L*  
*)*

*The loads S*  
*has*

*L*  
*F and L*  
*F are introduced harmonic by harmonic and type by type by the operator*  
*AFFE\_CHAR\_MECA. One does not specify the mode nor the type on this level.*

*Example: one supposes a loading in pressure distributed symmetrical mode 1 and pure torsion*  
*(antisymmetric mode 0).*

*One will write:*

```
ch1sym = AFFE_CHAR_MECA  
(  
Model = Mo,  
PRES_REP  
=  
_F  
(  
GROUP_MA  
=  
"grma",
```

```
CLOSE = p));  
ch0anti = AFFE_CHAR_MECA  
(  
Model = Mo,
```



*FORCE\_NODALE*

=  
*\_F*  
(  
*FZ*  
=  
*F*,

*NODE = "NI"))*);

*The boundary conditions of the Dirichlet type will be introduced into a load with share:*

*to chdir = AFFE\_CHAR\_MECA (*  
*Model = Mo,*  
*DDL\_IMPO=*  
*\_F (*  
*GROUP\_NO*  
*=*  
*"grno",*  
*DX*  
*=*  
*0.,*  
*DY*  
*=*  
*0.,*  
*DZ*  
*=*  
*0.,)*  
*)*  
*;*

*The acceptable loadings by the elements of Fourier are:*

***in elasticity:***

**Elements**

**Nature of the loading**

**Key word** AFFE\_CHAR\_MECA

Temperature

TEMP\_CALCULEE

TRIA3 - TRIA6

Forces of volume

FORCE\_INTERNE

QUAD4 - QUAD8 - QUAD9

Rotation

ROTATION

Gravity

GRAVITY

Specific forces

FORCE\_NODALE

SEG2 - SEG3

Pressure

PRES\_REP

Surface forces

FORCE\_CONTOUR

**in thermics:**

**Elements**

**Nature of the loading**

**Key word** AFFE\_CHAR\_THER

Surface Source

of

heat

SOURCE

Edge

Imposed normal flow

FLUX\_REP

Exchange

EXCHANGE

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### ***4 Resolution with Aster***

*Once the loading broken up into harmonics of Fourier, harmonics being uncoupled them from/to each other (with a number of different Fourier), it is necessary to assemble and solve as many systems linear that there are harmonics.*

*Moreover, the nonanisotropic material being supposed, for the same number of harmonic, the modes symmetrical and antisymmetric are uncoupled. One will have to thus make as many resolutions (with corresponding load) that there are couples (harmonic, mode) different.*

*The establishment in Aster is different according to whether the phenomenon is thermal or mechanical.*

#### ***4.1 Thermics***

***In thermics, there is no total order making it possible to calculate several directly harmonics. One must thus proceed harmonic by harmonic. Moreover, calculations of matrix and second elementary members can be done only with orders CALC\_MATR\_ELEM and CALC\_VECT\_ELEM (and not by order THER\_LINEAIRE).***

***The mode of Fourier is to be introduced into CALC\_MATR\_ELEM by single-ended spanner word MODE\_FOURIER.***

***type of the harmonic is not necessary, the matrices (and vectors) being independent of the type. type is only taken into account with the recombination of Fourier.***

***It is important to assemble the matrices and vectors corresponding to the various harmonics with same classification in order to be able to recombine the fields results. The operator NUME\_DDL who built classification is thus used once for the first harmonic, classification thus created being re-used for all the other harmonics. This is possible if they were differentiated loads of Dirichlet of the loadings themselves (see example [§6.1]).***

#### ***4.2 Mechanics***

***The order making it possible to treat several harmonics is MACRO\_ELAS\_MULT [U4.51.02]. In***

*this macro, the harmonics is regarded as loading cases and one thus does as much of resolutions that there are harmonics. As in thermics, it is necessary to differentiate the loads from Dirichlet, who must be identical for all the harmonics, of the loadings themselves, which can vary.*

*One obtains a structure of data RESULT containing all the fields corresponding to calculated harmonics (see example [§6.2]).*

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## *5 Postprocessings*

### *5.1 Thermics*

*• The calculation of flows is done by operator CALC\_CHAM\_ELEM by specifying the number of the harmonic by single-ended spanner word MODE\_FOURIER.*

*The options of calculation of flow remain the standard options:*

*FLUX\_ELNO\_TEMP to calculate flows with the nodes by element*

*FLUX\_ELGA\_TEMP to calculate flows at the points of Gauss*

*The order of the components of the vector flow is (,*

*R,*

*Z*

*).*

• *The recombination of Fourier on the temperatures is done starting from operator COMB\_CHAM\_NO [U4.72.02]. it makes it possible to obtain the temperatures in various angular sections introduced by the user.*

*The recombination of Fourier on flows is made in COMB\_CHAM\_ELEM [U4.72.03] according to even principle.*

## **5.2 Mechanics**

• *The calculation of the strains and the stresses is done by operator CALC\_CHAM\_ELEM in specifying the number of the harmonic by single-ended spanner word MODE\_FOURIER.*

*The options of calculation remain the standard options:*

*EPSI\_ELNO\_DEPL to calculate the deformations with the nodes by element*

*SIEF\_ELGA\_DEPL to calculate the constraints at the points of Gauss*

*SIGM\_ELNO\_DEPL to calculate the constraints with the nodes by element*

*The order of the components of the tensor of the deformations (resp. constraints) is (rr, zz, rz, R, Z) (resp. rr, zz, rz, R, Z).*

• *The recombination of Fourier can be done either by fields, or starting from a structure of data RESULT.*

*- by fields: in a way similar to thermics, recombination of Fourier on displacements is done in operator COMB\_CHAM\_NO [U4.72.02], that on the deformations and forced in COMB\_CHAM\_ELEM [U4.72.03],*

*- starting from a result: operator COMB\_FOURIER [U4.83.31] allows to recombine all them harmonics of the fields appearing in the structure of data RESULT. This recombination can be done on a list of angles.*

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## **6 Examples**

### **6.1**

***Thermics: calculation on 2 harmonics***

```
% CAS-TEST THERMAL HARMONIC FOURIER 1 AND 2
% MODELING: ELEMENTS THERMICS AXIS_FOURIER (QUAD4)
%
BEGINNING ();
email = LIRE_MAILLAGE ();
to subdue = DEFI_MATERIAU (
  THER = _F (LAMBDA =1.
,
  RHO_CP =1. ));
chmat = AFFE_MATERIAU (
  GRID = email,
  AFFE
=
  _F
(
  ALL
=
  "YES",
  MATER
=
  to subdue
)
)
;

moth = AFFE_MODELE
(GRID = email,
AFFE
=
_F
(
ALL
=
"YES",
PHENOMENON
=
"THERMAL",
```

**MODELING**

```
=
"AXIS_FOURIER",
)
)
;
%
% boundary conditions of Dirichlet
% -----
%
to chdir = AFFE_CHAR_THER (MODEL = moth,
```

**TEMP\_IMPO**

```
=
_F
(
GROUP_NO
=
"noe_cyl",
TEMP=0.
)
)
;
%
% loading harmonic 1
% -----
%
chth1 = AFFE_CHAR_THER (MODEL = moth,
```

**SOURCE**

```
=
_F
(
ALL
=
"YES", SOUR
=
-3.
)
)
;
%
% loading harmonic 2
% -----
%
chth2 = AFFE_CHAR_THER (MODEL = moth,
```

**SOURCE**

```

=
_F
(
ALL
=
“YES”, SOUR
=
-1.
)
)
;
%
% Resolution harmonic 1
% -----
%
mtr1 = CALC_MATR_ELEM (OPTION = “RIGI_THER”,
MODEL
=
moth,
CHAM_MATER
=
chmat,
MODE_FOURIER
=
1,
CHARGE
=
(to chdir,
chth1)
)
;

vct1 = CALC_VECT_ELEM (OPTION = “CHAR_THER”,
CHARGE
=
(to chdir,
chth1)
)
;

naked = NUME_DDL (MATR_RIGI = mtr1,
METHOD
=
“LDLT”

```



```
,  
RENUM  
=  
"RCMK"  
)  
;  
  
mtra1 = ASSE_MATRICE (  
MATR_ELEM = mtre1,  
NUME_DDL  
=  
naked  
)  
;
```

```
vcta1 = ASSE_VECTEUR (  
VECT_ELEM = vcter1,  
NUME_DDL  
=  
naked  
)  
;
```

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```
&mtra1 = FACT_LDLT (MATR_ASSE = mtra1);
```

```
tmod1 = RESO_LDLT (MATR_FACT = mtra1,
```

```
CHAM_NO  
=  
vcta1  
)  
;  
%  
% Resolution harmonic 2  
% -----  
%  
mtre2 = CALC_MATR_ELEM (OPTION = "RIGI_THER",
```

```
MODEL = moth,  
CHAM_MATER  
=  
chmat,  
MODE_FOURIER  
=  
2,  
CHARGE  
=  
(to chdir,  
chth2)  
)  
;
```

```
vcter2 = CALC_VECT_ELEM (OPTION = "CHAR_THER",  
CHARGE  
=  
(to chdir,  
chth2)  
)  
;
```

```
mtra2 = ASSE_MATRICE (  
MATR_ELEM = mtre2,  
NUME_DDL  
=  
naked  
)  
;
```

```
vcta2 = ASSE_VECTEUR (  
VECT_ELEM = vcter2,  
NUME_DDL  
=  
naked  
)  
;
```

```
&mtra2 = FACT_LDLT (  
MATR_ASSE = mtra2);
```

```
tmod2 = RESO_LDLT  
(  
MATR_FACT = mtra2,  
CHAM_NO  
=  
vcta2  
)  
;
```

```
%  
% Recombination of Fourier section 0.  
% -----  
%
```

```
tpr00 = COMB_CHAM_NO (COMB_FOURIER = _F (  
CHAM_NO = tmod1,  
NUME_MODE  
=  
1,  
TYPE_MODE  
=  
“SYME”),  
(  
CHAM_NO  
  
=  
tmod2,  
NUME_MODE  
=  
2,  
TYPE_MODE  
=  
“SYME”),
```

```
ENG = 0. );  
%  
% Recombination of Fourier section 45.  
% -----  
%  
tpr45 = COMB_CHAM_NO (COMB_FOURIER = _F (CHAM_NO = tmod1,  
NUME_MODE  
=  
1,  
TYPE_MODE  
=  
"SYME"),  
(  
CHAM_NO  
  
=  
tmod2,  
NUME_MODE  
=  
2,  
TYPE_MODE  
=  
"SYME"),  
ENG  
=  
45.  
)  
;  
  
END ();
```

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**6.2**

***Mechanics: calculation and recombination of Fourier on 2 harmonics***

**BEGINNING ();**

**m = LIRE\_MAILLAGE ();**

**Mo = AFFE\_MODELE**

(

**GRID = m,**

**AFFE =**

**\_F**

(

**ALL =**

**“YES”,**

**PHENOMENON**

**= “MECHANICAL”,**

**MODELING**

**=**

**“axis\_fourier”**

**));**

**my = DEFINI\_MATERIAU (**

**ELAS**

**=\_F (E =**

**72.,**

***NAKED***

***= 0.3,***

***RHO***

***= 0.***

***));***

***cm = AFFE\_MATERIAU (***

***GRID = m,***

***AFFE =***

***\_F***

***(***

***ALL =***

***“YES”,***

**MATER**

= *my*

));  
**bloqu = AFFE\_CHAR\_MECA\_F (**  
**MODEL**  
**= Mo,**

**DDL\_IMPO = \_F (**  
**NODE**  
**= "N1",**  
**DX = 0. , DY = 0. , DZ = 0. )**

**(**  
**NODE**  
**=**  
**"N2", DY**  
**=**  
**0.,**

**)**  
**(**  
**NODE**  
**=**  
**"N3", DY**  
**=**  
**0.,**

**)**;  
**CH = AFFE\_CHAR\_MECA**  
**(**  
**MODEL**  
**= Mo,**

**PRES\_REP = \_F (**  
**GROUP\_MA = "end", CLOSE = 100. )**

**)**;  
**%**  
**% FOURIER CALCULATION ON THE 2 FIRST SYMMETRICAL HARMONICS**  
**resu = MACRO\_ELAS\_MULT (MODEL**

*= Mo,*  
*CHAM\_MATER*  
*=*  
*cm,*  
*CHAR\_MECA\_GLOBAL*  
*=*  
*bloqu,*  
*CAS\_CHARGE= (*  
*\_F*  
*(*  
*MODE\_FOURIER*  
*=*  
*1,*  
*TYPE\_MODE*  
*=*  
*“SYME”,*

*CHAR\_MECA*  
*= CH,*  
*OPTION*  
*=*  
*“SIGM\_ELNO\_DEPL”,*

*SOUS\_TITRE = “mode Fourier 1 SYME”),*  
*\_F*  
*(*  
*MODE\_FOURIER*  
*=*



2,  
**TYPE\_MODE**  
=  
"SYME",

**CHAR\_MECA**  
= CH,  
**OPTION**  
=  
"SIGM\_ELNO\_DEPL",

**SOUS\_TITRE** = "Fourier mode 2 SYME"),

);  
%  
% **CALCULATION OF THE NODAL REACTIONS BY CALC\_NO**  
%  
% **&RESU = CALC\_NO (RESULT =**  
**resu,**  
**EXCIT**  
=  
**\_F (**  
**CHARGE**  
=  
**CH**

),  
**OPTION**  
=  
**“REAC\_NODA”**,

**CHAM\_MATER=**  
**cm**

);  
**angl1 = 45.**  
;  
**angl2 = 135.**  
;  
%  
**% RECOMBINATION OF FOURIER ON DISPLACEMENTS, REACTIONS AND FORCED**  
%  
**% co\_four = COMB\_FOURIER (**  
**RESULT =**  
**resu,**  
**NOM\_CHAM**  
=  
(  
**“DEPL”**,  
**“REAC\_NODA”**,

**“SIGM\_ELNO\_DEPL”**,  
)  
**ENG =**

(  
*angl1*,  
*angl2*  
)

);  
**END ();**  
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***Note of use of the static under-structuring***

***Summary***

*This document is an introduction to the use of the static under-structuring.*

*While being based on a detailed example, whose command file is presented in appendix,*

*one will read paragraphs 1, 2, 3, 4;*

*one will refer to the description of the specific orders:*

*MACR\_ELEM\_STAT [U4.44.01]*

*DEFI\_MALLAGE [U4.12.04] and,*

*DEPL\_INTERNE [U4.65.01],*

*one will return to the detailed comments of the command file [§6].*

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## *1 General information*

*The static under-structuring established in Aster is usable in linear mechanics and in nonlinear mechanics on linear parts of a model. It can be done a priori with several levels: a substructure can contain other substructures of lower level.*

*All the types of elements of the “mechanical” phenomenon are accepted thus that all them loadings supported by these elements.*

*The under-structuring is currently established within the framework of the ordinary orders [U4.4-] and [U4.5-]. It is however not established within the framework of the total orders:*

**MECA\_STATIQUE, CALC\_ELEM, CALC\_NO, POST\_ELEM,...**

***An exception exists: orders STAT\_NON\_LINE and DYNA\_NON\_LINE accept static macronutrients (see [§2]).***

***The static under-structuring consists in “condensing” statically the problem to be treated: one is eliminated certain number of unknown factors (interns). There then remain the unknown factors known as “external” in less large numbers.***

***It is a method which reduces the size of the problem. One can thus expect savings of time CPU from them and in occupation of the discs. This static condensation applies naturally to the matrix of rigidity and of mass and with the second members representing the various loadings. In this case, method of condensation can be interpreted algebraically like a resolution of the system linear by the method “of elimination”. The solution of a linear problem of statics is thus not modified by the under-structuring. On the other hand, it is possible to condense the matrix statically of mass (condensation of Guyan) but in this case the research of the clean modes of the structure condensed is deteriorated by the method of under-structuring (see for example IMBERT [bib1]). It exist other methods of under-structuring for the problems of dynamics in Aster [U4.55].***

***The theoretical principles of the static under-structuring are well explained in the book of IMBERT [bib1] and handbooks PERMAS [bib2].***

***The use of the static under-structuring into nonlinear is approached in a first chapter distinct.***

***In the continuation of this document, one will suppose known these theoretical principles and one will not be interested that with the aspects “user”. For that, one will be useful oneself much of an example: the case test SSLP100 of handbook of validation Aster. We tested, through this case test, to illustrate a great number of possibilities of the software, by complicating voluntarily the test:***

- under-structuring on several levels (2),***
- use of a macronutrient to generate by successive rotations several under structures,***
- boundary conditions and loadings on several levels,***
- mix ordinary substructures and finite elements,***

•  
“following” loading or not.

*The command file of this case test which one numbered the lines is given in appendix of it document. When one wants to refer to line N of this file, one will write {line N}.*

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*2*

*Use of macronutrients in STAT\_NON\_LINE (or  
DYNA\_NON\_LINE)*

*One can make a nonlinear calculation with STAT\_NON\_LINE [U4.51.03] on a model containing of macronutrients. The interest of this type of calculation is a possible profit of performances (memory and/or CPU).*

*So that calculation with macronutrients is more economic, it is necessary that the model has the broad ones*

*linear elastic zones (possibly repetitive). It is necessary as that these elastic zones (as one will condense in macronutrients) have a border as small as possible. A favorable situation will be for example the case of an entirely elastic structure with a small zone of plasticity confined [Figure 2-a].*

*rubber band*

*fissure*

*zone of potential plasticity*

*Appear 2-a*

*One will then condense all the elastic part on the only nodes of the interface with the zone of potential plasticity.*

*The use of macronutrients in STAT\_NON\_LINE (see case tests SSLP100C and D) is conditioned by the following requirements:*

- each macronutrient must be elastic linear, its temperature should not vary with the course time,*
- it cannot y have contact with macronutrients,*
- the loadings assigned to the macronutrients “constant” (are not multiplied by “FONC\_MULT”),*
- the macronutrients should not undergo great rotations,*
- “research linear” is not possible.*

*Once calculation makes with STAT\_NON\_LINE, the post usual treatments (CALC\_ELEM, CALC\_NO, POST\_ELEM) will not have an effect that on the ordinary finite elements of the model (the macronutrients are been unaware of). If one wants to examine for example the state of stress inside a macronutrient, it is necessary to use the basic commands: CREA\_CHAMP/EXTR, DEPL\_INTERNE,... (see [§4.3] and [§4.4]).*

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**3**

***Presentation of the case test being used as example***

**E**

**F3**

**F2**

**B3**

**C**

**G**

**B2**

**N12**

**N9**

**F1**

**N6**

**B1**

**N11**

**N8**

**F**

**N3**

**N5**

**H**

**D**

**N2**

**B**

**N1**

**O**

**With**

**N4**

**N7**

**N10**

**N14**

**N16**

**N18**

**N20**  
**N13**  
**N15**  
**N17**  
**N19**  
**I**  
**P1**  
**F4**  
**J**

***It is about a plane structure subjected to the boundary conditions following:***

***.  
on side [GH]:  
 $U + v = 0$   
(slipping support)***

***.  
nodes B1, B2, B3:  
 $U = v = 0$***

***.  
node J:  
 $U = 2.0$***

***.  
loading case 1: chf1: pressure distributed on ADFH  $p = 10.0$***

***.  
loading case 2: chf2: specific forces on the nodes F1, F2, F3, F4 and P1,***

***$F_y = -20.0$***

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#### ***4 Treatment of the case test by the method of under-structuring***

**.  
the initial grid contains only the meshes (and the nodes) of polygone IJBCDA,**

**.  
one defines a macronutrient (S\_1) corresponding to polygone ABCD,**

**.  
the macronutrient (S\_1) is repeated 2 times per rotation around 0,**

**.  
one obtains then the macronutrient (S\_123) corresponding to polygone ABCEGHFD,**

**.  
the final model (on which one makes the resolution) is obtained while adding to the macronutrient (S\_123) finite elements of quadrilateral IJBA.**

### **5 General organization of calculations and definitions**

#### **5.1 Construction of the total model**

**The principle of the establishment of the static under-structuring in Aster is that of a step ascending:**

**a model having been defined, one condenses it (operator MACR\_ELEM\_STAT) on some of its nodes. One then obtains a macronutrient which, functionally resembles new much finite element “larger”. This macronutrient can then be integrated in a model of level superior (operators DEFI\_MAILLAGE and AFFE\_MODELE). This new model can then be digested in its turn and so on without limitation a priori of the number of levels.**

**Definition:**

**.  
the nodes on which a macronutrient is condensed are known as “external” (the others are “interns”),**

**.  
level: it is a notion useful for comprehension of the text of orders; any level described relations of structuring between the various models and the various macronutrients.**

*For us, it is an entirety. The operation of condensation increases the level by + 1: one model of level N gives by condensation a macronutrient of level N + 1 which will be integrated into a model of level N + 1,*

*operator MACR\_ELEM\_STAT is the only operator allowing to create a macronutrient in static under-structuring,*

*operator DEFI\_MAILLAGE is the only operator using the macronutrients in static under-structuring.*

*For our example:*

*MO\_1 {line 22} is the model moreover low level (- 2),*

*S\_1 {lines 45, 59} is the intermediate macronutrient of level (- 1),*

*MA\_123 and MO\_123 {lines 68, 87} represent the grid and the model of level intermediary (- 1),*

*S\_123 {line 104} is the macronutrient of higher level (0),*

*MAG0, MAG and MOG {lines 120, 125, 129} represent grids and a model moreover high level (0): the distinction between grids MAG0 and MAG will be explained to [§6.6] and [§6.7].*

*The structuring of the model of higher level MOG can arise graphically by one tree structure, distinction between macronutrient and substructure being explained in the paragraph according to.*

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**MODEL MOG**

**Complete structure**

**level 0**

**finite elements**

**S\_123 substructure**

**ordinary**

**S\_123 macronutrient**

**polygone IJBA**

**polygone ABCEGHFD**

**MODEL MO\_123**

**polygone ABCEGHFD**

**level -1**

**S\_1 substructure**

**S-2 substructure**

**S\_3 substructure**

**S\_1 macronutrient**

**S-1 macronutrient**

**S\_1 macronutrient**

**polygone ABCD**

**polygone DCEF**

**polygone FEGH**

**model MO\_1**

**model MO\_1**

**model MO\_1**

**polygone ABCD**

**polygone DCEF**

**polygone FEGH**

**level -2**

**finite elements**

**finite elements**

**finite elements**

**ordinary**

**ordinary**

**ordinary**

**polygone ABCD**

*polygône DCEF*  
*polygône FEGH*

## 5.2 *macronutrient and substructure*

*One calls macronutrient the result of operator MACR\_ELEM\_STAT: it is a condensed model on its external nodes.*

*One calls substructure an occurrence of a macronutrient in a of the same model level. A substructure is a macronutrient put in position in physical space. The position of one substructure is given by the co-ordinates of the nodes of the super-mesh which is associated for him.*

*The same macronutrient can give rise to several substructures by defining several positions: in our example, the S\_1 macronutrient generates 3 substructures S\_1, S\_2 and S\_3 by suitable rotations.*

*A substructure is to some extent a new “finite element”. The macronutrient is the “type” of this element: one affects a macronutrient on a super-mesh to form a substructure.*

*One calls super-mesh, the geometrical support of a substructure. It is a named object included in a grid. A super-mesh, like an ordinary mesh, is only one ordered list of names nodes.*

*Like an ordinary finite element, a substructure has:*

- *an “elementary” matrix of rigidity (and/or of mass, damping,...),*
- *“elementary” vectors of loading,*
- *a mesh support (one will speak about super-mesh),*
- *nodes carrying of the ddl.*

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***With the difference of an ordinary finite element, a substructure has several limitations:***

***.***

***the mesh support is not a simple type: TRIA3,..., HEXA20: certain postprocessings are thus not possible,***

***.***

***it does not have type\_élément, not functions of form,...***

***.***

***the only options of calculation available are RIGI\_MECA, MASS\_MECA and CHAR\_MECA,***

***.***

***the nodes can be nodes of LAGRANGE coming from the dualisation from internal conditions kinematics.***

***Identification of the substructures and the macronutrients:***

***The macronutrients are concepts named by the user.***

***Substructures (as the ordinary finite elements) are identified by the name of super-meshes which support them.***

***In our example:***

***.***

***S\_1 and S\_123 are the two macronutrients defined by the user {lines 45 and 104},***

***.***

***S\_1, S\_2, S\_3, S\_123 are the names of the super-meshes (and thus of the substructures) that the user gives during the construction of grids MA\_123 and MAG0.***

***Note:***

***There is no possible confusion (by the program) between a substructure and one of the same macronutrient name (here S\_1 and S\_123 although that does not facilitate the reading of the file orders!).***

### 5.3

#### *Redescende in the substructures*

*The ascending step, that we have just detailed, makes it possible to build the total model, or final, (mog) on which one carries out the resolution:*

.  
*CALC\_MATR\_ELEM*

.  
*CALC\_VECT\_ELEM*

.  
*ASSE\_MATRICE*  
*{lines 151-184}*

.  
...

.  
*RESO\_LDLT*

*This resolution has as a result the field of displacements of the nodes of the total model. These nodes are:*

.  
*nodes of the ordinary finite elements of the model (here quadrilateral IJBA),*  
.  
*external nodes of the substructures of the model: (here only one substructure: S\_123).*

*To find the field of displacements on the internal nodes of the substructures, it is necessary then “to go down again” the tree structure of the substructures thanks to operator DEPL\_INTERNE.*

*This operator calculates the field of displacements on all the nodes of the substructure from the data of the field of displacements on its external nodes.*

*For our example and load 1:*

.  
*UIS\_123*  
*{line 193}*  
*is displacement on the substructure*  
*S\_123*



•  
**UIS\_1**  
*{line 197}*  
*is displacement on the substructure*  
**S\_1**

•  
**UIS\_2**  
*{line 199}*  
*is displacement on the substructure*  
**S\_2**

•  
**UIS\_3**  
*{line 201}*  
*is displacement on the substructure*  
**S\_3**

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## **5.4 Postprocessings**

*Usual postprocessings: calculation of the deformations, of the constraints,... can only be made by the ordinary finite elements which only know the concept of function of interpolation.*

*One will be able to thus calculate the constraints in a given point of the structure only with the model containing the ordinary finite element containing this point. For that, it will have been necessary to calculate the field of*

*displacements on this model:*

*Example:*

•  
*to calculate the constraints on quadrilateral IJBA the model will be used: MOG and them displacements: U1*

•  
*to calculate the constraints on polygône DCEF the model will be used: MO\_1 and them displacements: UIS\_2*

*Note:*

*Since order CALC\_CHAM\_ELEM “was strongly degreased”, it is necessary to use CALC\_ELEM but for that, one is obliged to create a SD evol\_elas by the order CREA\_RESU.*

**6**

*Some comments on the command file*

*The purpose of the few comments which follow are to illustrate the orders which intervene in static under-structuring. The comprehension of these comments supposes obviously the reading precondition of the notes of use of the orders concerned:*

•  
*Orders specific to the static under-structuring:*

-  
*MACR\_ELEM\_STAT [U4.44.01]*

-  
*DEFI\_MAILLAGE [U4.12.04]*

-  
*DEPL\_INTERNE [U4.65.01]*

•  
*Orders modified for the static under-structuring:*

-  
*AFFE\_MODELE [U4.22.01]*

-  
*CAL\_VECT\_ELEM [U4.41.02]*

•  
*Orders useful for the static under-structuring:*

-  
*ASSE\_MAILLAGE [U4.12.02]*

-  
**DEFI\_GROUP [U4.12.03]**

**6.1 Operator**

**AFFE\_MODELE {line 22}**

*Since one wants to build a macronutrient starting from polygône ABCD and that the grid my contains all the elements of IJBCDA, one cannot employ the assignment: ALL: “YES”.*

*It is necessary to affect only the group of mesh ABCD (grsd2) and not to forget to affect the elements edge AD (grma14) because of the loading of pressure.*

**6.2 Operator**

**MACR\_ELEM\_STAT {lines 45-59}**

.  
*The example illustrates the fact that one can define the macronutrient in several stages successive (use of operator MACR\_ELEM\_STAT 3 times: {lines 45, 50 and 56} with symbol of enrichment &).*

*In the first call, one defines truly the macronutrient:*

-  
*its “volume”: the model mo\_1*

-  
*its external nodes {line 48}*

- *the material field and the conditions kinematics which are applied to him {line 47}.*

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*At the time of the 2 following calls {line 50 and 56}, one enriches the structure of data of macronutrient:*

- *calculation of the matrix of condensed rigidity {line 52}*
- *calculation of two “loading cases” {lines 53 and 58}.*

*This possibility of enriching the macronutrient makes it possible “to repair a lapse of memory” without setting out again with zero:*

- *addition of a new loading case,*
- *calculation of the mass condensed for a method of Guyan.*

*Definition of the loading case 1: CHF1 {line 53}*

*This loading case is following (SUIV = “YES”) because the pressure is a loading which acts always according to the normal at the edge.*

*The fact of having specified like load CHBL\_1, is not used for nothing here because the conditions kinematics are null  $DX = 0.0$   $DY = 0.0$  {line 29}.*

### **6.3 Operator**

**DEFI\_MAILLAGE {lines 68, 84}**

*{line 70}: one defines a substructure (and the super-mesh support) by giving him the same one which the macronutrient that one to him names. It is not prohibited.*

*{line 74}*

*All the geometrically confused nodes “are unified”:*

*the side CD of S\_1 merges with side AB of S\_2,*

*the side CD of S\_2 merges with side AB of S\_3.*

*{line 76}*

*node*

*C, which has as a name N12 in initial grid MA, will have as a name NN112*

*in grid MA\_123,*

-

*node*

*E, which is the image of C of grid MA in the S\_2 substructure will have for name NN212.*

*This node E can also be regarded as the image of the node B in substructure S\_3 it could thus have had name NN310 but the convention of sticking together of the super-meshes [U4.12.04] chooses the first denomination.*

.

*{line 77}*

*Node A (N1), which had been named NN11 with line 76, is famous in N1. It is of even for the N4 nodes, N7 and N10.*

*This renaming is necessary in the sight of the assembly of the grids which one will make {line 125} because this assembly is made by pooling of the of the same nodes name.*

.

*{line 82}*

*One defines the group of nodes GH which will serve {line 107} for the definition of the outside of S\_123 macronutrient.*

#### **6.4 Operators**

*AFFE\_MODELE and AFFE\_CHAR\_MECA {lines 86, 89}*

.

*{line 87}*

*All super-meshes MA\_123 “are activated”: one affects the S\_1 macronutrient to them.*

.

*{line 91}*

*The node NN33 which is the N3 node of the S\_3 substructure is subjected to a condition of slipping support.*

#### **6.5 Operator**

*MACR\_ELEM\_STAT {lines 104, 111}*

.

*{line 109}*

*The kinematic load CHBL\_123 which corresponds to the support slipping on GH is introduced into the S\_123 macronutrient. It is advised in the note [U4.44.01] to introduce this condition at the highest level: one could have done it at the total level bus GH belongs to outside of S\_123.*

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**.**

**{line 109}**

**For the S\_123 macronutrient, one gives the same name of loading case CHF1 as for S\_1 macronutrient because the convention of definition of a loading case results in adding:**

**-**

**the loadings defined by the key word CHARGES (here: chbl\_123 which is not used for nothing bus imposed displacements are null),**

**-**

**loading cases possibly present on the substructures included in model: here chf1 which is present in S\_1, S\_2, S\_3.**

## **6.6 Operator**

**DEFI\_MAILLAGE {line 120}**

**.**

**{line 123} the nodes of MAG0 will have the same name as the nodes of the macronutrients being used for its definition (S\_123).**

**The nodes of MAG0 will be thus:**

**side AB: N1, N4, N7, N10**

**side GH: NN33, NN36, NN39, NN312**

**Grid MAG0 contains only one super-mesh and not ordinary mesh.**

## **6.7 Operator**

**ASSE\_MAILLAGE {line 125}**

**The grid final (or total) contains:**

•  
*all meshes QUAD4 of initial grid MA,*

•  
*the S\_123 super-mesh of grid MAG0.*

*The super-mesh is connected to meshes QUAD4 thanks to the identity of the names of the N1 nodes, N2, N7, N10 in grids MA and MAG0.*

**6.8**  
*Calculation at the total level {lines 129-184}*

•  
*{line 130} in the total grid, which contains all the meshes of my, one only affects those of quadrilateral IJBA.*

•  
*{line 131} one affects the S\_123 substructure; the model thus contains: a substructure (S\_123) and of the ordinary finite elements (IJBA).*

•  
*{line 165} one should not forget to indicate the loading case CHF1 which was defined in line 32 and which forwards by the two macronutrients S\_1 and S\_123 via name CHF1.*

**6.9 Operator**  
*DEPL\_INTERNE*

•  
*{line 193} UIS\_123 is the field of displacements on the nodes of model MO\_123 (i.e. nodes of AB, CD, EF, GH). This field of displacements corresponds to the case of load CHF1.*

•  
*{line 199} UIS\_2 is the field of displacements on the nodes of model MO\_1 (i.e. nodes of ABCD). It should be noticed that one asked for the field of displacement on the S\_2 mesh, but there is not grid “finite elements” of this part structure.*

*This is why, the field of displacement is restored in the “local” reference mark of macronutrient S\_1 (rotation of  $-45^\circ$ ). This reference mark is the only one which allows the calculation of constraints thanks to model MO\_1.*

## **7 Bibliography**

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**J.F. IMBERT: “Analysis of the structures by finite elements”. Editions CEPADUES (1979)**

[2]

***E. SCHREM: "Handbook for linear analysis". INTES Publication UM 404 REVC.  
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**Appendix 1 command file example**

**1 # SSLP100/B**

**2 # STICK CHARGED IN STATIC SOUS-STRUCTURATION.**

**3 # MODELING: WITH SUBSTRUCTURES.**

4

#=====

5

6

**7 BEGINNING (CODE=\_F (NAME = "SSLP100B", NIV\_PUB\_WEB=' INTERNET'))**

8

**9 MA=LIRE\_MAILLAGE ()**

10

**11 ACIER=DEFI\_MATERIAU (ELAS=\_F (E = 15. , NAKED = 0.3))**

12

**13 CHMAT=AFFE\_MATERIAU (MAILLAGE=MA, AFFE=\_F (ALL = "YES", MATER = STEEL))**

14

15

#=====

16 #

**17 # CONSTRUCTION OF THE MODEL MOREOVER LOW LEVEL (- 2)**

18 #

19

#=====

20

21

**22 MO\_1=AFFE\_MODELE (MAILLAGE=MA, AFFE= (**

23

**24 \_F (GROUP\_MA = "GRSD2", MODELING = "D\_PLAN", PHENOMENON = "MECHANICAL"),**

**25 \_F (GROUP\_MA = "GRMA14", MODELING = "D\_PLAN", PHENOMENON = "MECHANICAL")))**

26

**27 CHBL\_1=AFFE\_CHAR\_MECA (MODELE=MO\_1,**

**28 # N8:**

29 **DDL\_IMPO=\_F (NODE = (“N8”), DX = 0.0, DY = 0.0)**

30 )

31

32 **CHF1\_1=AFFE\_CHAR\_MECA (MODELE=MO\_1,**

33 **PRES\_REP=\_F (GROUP\_MA = (“GRMA14”), CLOSE = 10.0))**

34

35 **CHF2\_1=AFFE\_CHAR\_MECA (MODELE=MO\_1,**

36 **FORCE\_NODALE=\_F (NODE = (“N11”), FY = -20.0))**

37

38

#=====

39 #

40 **# DEFINITION OF THE MACRONUTRIENT OF LEVEL (- 1)**

41 #

42

#=====

43

44

45 **S\_1=MACR\_ELEM\_STAT (**

46 # -----

47 **DEFINITION=\_F (MODEL = MO\_1, CHAM\_MATER = CHMAT, CHAR\_MACR\_ELEM = CHBL\_1),**

48 **OUTSIDE =\_F (NODE = (“N1”, “N4”, “N7”, “N10”), GROUP\_NO = (“GRNM13”)))**

49

50 **S\_1=MACR\_ELEM\_STAT (reuse=S\_1,**

51 # -----

52 **RIGI\_MECA=\_F (),**

53 **CAS\_CHARGE=\_F (NOM\_CAS = “CHF1”, LOAD = (CHBL\_1, CHF1\_1), SUIV = “YES”)**

54 )

55

56 **S\_1=MACR\_ELEM\_STAT (reuse=S\_1,**

57 # -----

58 **CAS\_CHARGE=\_F (NOM\_CAS = “CHF2”, LOAD = CHF2\_1, SUIV = “NOT”)**

59 )

60

61

#=====

62 #

63 **# DEFINITION OF THE MODEL OF LEVEL (- 1)**

64 #

65

#=====

66

67

68 **MA\_123=DEFI\_MALLAGE (**

69 # -----

70 **DEFI\_MAILLE= (\_F (MACR\_ELEM\_STAT = S\_1, MESH = “S\_1”),**

71 **\_F (MACR\_ELEM\_STAT = S\_1, MESH = “S\_2”, ANGL\_NAUT = (45.0)),**

72 **\_F (MACR\_ELEM\_STAT = S\_1, MESH = “S\_3”, ANGL\_NAUT = (90.0))),**

73

74 RECO\_GLOBAL=\_F (ALL = "YES"),

75

76 DEFI\_NOEUD= (\_F (ALL = "YES", PREFIX = "NN", INDEX = (3,3,2,5,)),

77 \_F (NOEUD\_FIN = "N1", MESH = "S\_1", NOEUD\_INIT = "N1"),

78 \_F (NOEUD\_FIN = "N4", MESH = "S\_1", NOEUD\_INIT = "N4"),

79 \_F (NOEUD\_FIN = "N7", MESH = "S\_1", NOEUD\_INIT = "N7"),

80 \_F (NOEUD\_FIN = "N10", MESH = "S\_1", NOEUD\_INIT = "N10"),

81

82 DEFI\_GROUP\_NO= (\_F (MESH = "S\_3", GROUP\_NO\_FIN = "GH", GROUP\_NO\_INIT = "GRNM13"),

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83 \_F (MESH = "S\_1", GROUP\_NO\_FIN = "AB", GROUP\_NO\_INIT = "GRNM11"))

84 )

85

86 MO\_123=AFFE\_MODELE (MAILLAGE=MA\_123,

87 AFFE\_SOUS\_STRUC=\_F (ALL = "YES"))

88

89 CHBL\_123=AFFE\_CHAR\_MECA (MODELE=MO\_123,

90 LIAISON\_DDL= (# GH:

91 \_F (NODE = ("NN33", "NN33"), DDL = ("DY", "DX"), COEF\_MULT = (1.0, 1.0), COEF\_IMPO = 0.0),

92 \_F (NODE = ("NN36", "NN36"), DDL = ("DY", "DX"), COEF\_MULT = (1.0, 1.0), COEF\_IMPO = 0.0),

93 \_F (NODE = ("NN39", "NN39"), DDL = ("DY", "DX"), COEF\_MULT = (1.0, 1.0), COEF\_IMPO = 0.0),

94 \_F (NODE = ("NN312", "NN312"), DDL = ("DY", "DX"), COEF\_MULT = (1.0, 1.0), COEF\_IMPO = 0.0))

95 )

96

97 #=====

98 #

99 # DEFINITION OF THE MACRONUTRIENT OF LEVEL 0

100 #

101 #=====

102

103

```

104 S_123=MACR_ELEM_STAT (
105 # -----
106 DEFINITION=_F (MODEL = MO_123, CHAR_MACR_ELEM = CHBL_123),
107 EXTERIEUR=_F (GROUP_NO = ("GH", "AB",)),
108 RIGI_MECA=_F (),
109 CAS_CHARGE= (_F (NOM_CAS = "CHF1", LOAD = CHBL_123, SUIV = "YES"),
110 _F (NOM_CAS = "CHF2", LOAD = CHBL_123, SUIV = "NOT"))
111 )
112
113 #=====
114 #
115 # DEFINITION OF THE TOTAL MODEL OF LEVEL 0
116 #
117 #=====
118
119
120 MAG0=DEFI_MAILLAGE (
121 #-----
122 DEFI_MAILLE=_F (MACR_ELEM_STAT = S_123, MESH = "S_123"),
123 DEFI_NOEUD=_F (ALL = "YES", INDEX = (1,0,1,8,)) )
124
125 MAG=ASSE_MAILLAGE (OPERATION=' SOUS_STR'
126 MAILLAGE_1=MAG0, MAILLAGE_2=MA)
127
128
129 MOG=AFFE_MODELE (MAILLAGE=MAG,
130 AFFE=_F (GROUP_MA = "GRSD1", MODELING = "D_PLAN", PHENOMENON = "MECHANICAL"),
131 AFFE_SOUS_STRUC=_F (MESH = ("S_123",)))
132
133 #=====
134 #
135 # RESOLUTION AT THE TOTAL LEVEL:
136 #
137 #=====
138
139
140 CHAGBL=AFFE_CHAR_MECA (MODELE=MOG,
141 DDL_IMPO=_F (NODE = ("N19",), DX = 2.0))
142
143 CHAGF2=AFFE_CHAR_MECA (MODELE=MOG,
144 FORCE_NODALE=_F (NODE = ("N15", "N17",), FY = -20.0))
145
146 # RIGIDITY:
147 # -----
148
149 CHMATG=AFFE_MATERIAU (MAILLAGE=MAG, AFFE=_F (ALL = "YES", MATER = STEEL))
150
151 MELGR=CALC_MATR_ELEM (OPTION=' RIGI_MECA',
152 MODELE=MOG, CHARGE=CHAGBL, CHAM_MATER=CHMATG)

```

153  
154 NUG=NUME\_DDL (MATR\_RIGI=MELGR, METHODE=' LDLT')  
155  
156 MATAS=ASSE\_MATRICE (NUME\_DDL=NUG, MATR\_ELEM=MELGR)  
157  
158 MATAS=FACT\_LDLT (reuse=MATAS, MATR\_ASSE=MATAS)  
159  
160 # 2ND MEMBERS:  
161 # -----  
162  
163 VELG1=CALC\_VECT\_ELEM (OPTION=' CHAR\_MECA',  
164 CHARGE=CHAGBL, MODELE=MOG,  
165 SOUS\_STRUC=\_F (CAS\_CHARGE = "CHF1", MESH = "S\_123")  
166 )  
167  
168 VELG2=CALC\_VECT\_ELEM (OPTION=' CHAR\_MECA',  
169 CHARGE= (CHAGF2, CHAGBL,), MODELE=MOG,  
170 # TO TEST THE KEY WORD ALL: "YES":  
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7.4

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*Note of use of the static under-structuring*

*Date:*

29/09/05

*Author (S):*

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171 # SOUS\_STRUC: (CAS\_CHARGE: "CHF2" NETS: S\_123)  
172 SOUS\_STRUC=\_F (CAS\_CHARGE = "CHF2", ALL = "YES")  
173 )  
174  
175 VECAS1=ASSE\_VECTEUR (NUME\_DDL=NUG, VECT\_ELEM=VELG1)  
176  
177 VECAS2=ASSE\_VECTEUR (NUME\_DDL=NUG, VECT\_ELEM=VELG2)  
178  
179 # RESOLUTION:  
180 # -----  
181  
182 U1=RESO\_LDLT (MATR\_FACT=MATAS, CHAM\_NO=VECAS1)

183

184 U2=RESO\_LDLT (MATR\_FACT=MATAS, CHAM\_NO=VECAS2)

185

186 #=====

187 #

188 # REDESCENTE IN THE SUBSTRUCTURES:

189 #

190 #=====

191

192

193 UIS\_123=DEPL\_INTERNE (DEPL\_GLOBAL=U1, MAILLE=' S\_123', NOM\_CAS=' CHF1')

194

195 U2S\_123=DEPL\_INTERNE (DEPL\_GLOBAL=U2, MAILLE=' S\_123', NOM\_CAS=' CHF2')

196

197 UIS\_1=DEPL\_INTERNE (DEPL\_GLOBAL=UIS\_123, MAILLE=' S\_1', NOM\_CAS=' CHF1')

198

199 UIS\_2=DEPL\_INTERNE (DEPL\_GLOBAL=UIS\_123, MAILLE=' S\_2', NOM\_CAS=' CHF1')

200

201 UIS\_3=DEPL\_INTERNE (DEPL\_GLOBAL=UIS\_123, MAILLE=' S\_3', NOM\_CAS=' CHF1')

202

203 U2S\_1=DEPL\_INTERNE (DEPL\_GLOBAL=U2S\_123, MAILLE=' S\_1', NOM\_CAS=' CHF2')

204

205 U2S\_2=DEPL\_INTERNE (DEPL\_GLOBAL=U2S\_123, MAILLE=' S\_2', NOM\_CAS=' CHF2')

206

207 U2S\_3=DEPL\_INTERNE (DEPL\_GLOBAL=U2S\_123, MAILLE=' S\_3', NOM\_CAS=' CHF2')

208

209 #=====

210 #

211 # TEST OF THE VALUES OF REFERENCE:

212 #

213 #=====

214

215

216 TEST\_RESU (

217 CHAM\_NO= (

218 # VALUES OF REFERENCE OBTAINED BY ASTER WITHOUT SUBSTRUCTURES (SSLP100A)

219 # POINTS P1, P2, P4 AT the TOTAL LEVEL:

220 \_F (CHAM\_GD = U1, NODE = "N15", NOM\_CMP = "DX",

221 VALE = 1.88327E+0, PRECISION = 1.E-5, REFERENCE = "AUTRE\_ASTER"),

222 \_F (CHAM\_GD = U1, NODE = "N15", NOM\_CMP = "DY",

223 VALE = 2.59224E-2, PRECISION = 1.E-5, REFERENCE = "AUTRE\_ASTER"),

224 ...

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**Organization (S): EDF-R & D /AMA, SINETICS**

**Instruction manual**

**U2.08 booklet: Advanced functions and control of calculations**

**Document: U2.08.01**

**Use of the indicators of error and strategies  
of adaptation of grids associated**

**Summary:**

**This document describes the use in Code\_Aster of the indicators of error and their use in a context  
of adaptation of grid. In this direction, it aims at making a synthesis intended to provide to the user the answers  
preconditions to the use of the adaptation of grids: where to find information in documentation**

**Is Code\_Aster, which the perimeter of use, which are the good practices to be implemented?**

**Examples of use come to illustrate the possibilities and the implementation of strategies of mending of meshes.**

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## 1 Introduction

*The indicators of error and the adaptation of grids are useful for the user to provide calculations them more reliable possible with respect to the errors of discretization (due to the method finite elements employee).*

*The indicators of error are calculated in postprocessing of Aster, while the adaptation of grid is carried out by call to an external program, specialized in this task, LOBSTER.*

*The goal of this document is to provide possible “point entrance” a most complete bound for the user wishing to implement this kind of techniques in its calculations. The plan of the document is then the following:*

- 1) the perimeter of use (which can one make?) ;*
- 2) references useful to read before use (where to go to seek information more deepened that those brought in this document?) ;*
- 3) a diagrammatic recall of the methodology of adaptation of grids;*
- 4) a recall of the orders and options to be used (how to write the command file?) ;*
- 5) a whole of councils on the “good practices” to implement (which are them points worthy of attention during the use?) ;*
- 6) some examples illustrating use of these techniques and councils the given previously (how to make in practice?).*

## 2 Perimeter of use

*The field of application of the indicators of error and the adaptation of grid is delimited by following constraints (one will refer to the reference documents given below for more details):*

- the errors taken into account are the errors of space discretization (thus the size of elements employed); in particular, errors of discretization temporal (or pseudo temporal in the case of non-linear materials) are apart from this perimeter;*
- the physical phenomena are limited to mechanics (linear or non-linear, Cf below) and with thermics (idem.);*
- in mechanics as in thermics, the behavior can be linear or not linear (except for the estimator of error of Zhu-Zienkiewicz in mechanics which treats only the behavior linear), knowing that the theoretical results of the indicators of error are obtained in linear field (their use in the non-linear field is thus not based on theoretical results but on an empirical observation of their interest);*
- the elements used can be unspecified for the use of the indicators of errors (except for the estimator of error of Zhu-Zienkiewicz in mechanics, which treats only the elements 2D; estimator ZZ2 does not accept that grids made up either of triangles or of*

*quadrangles); on the other hand, the use of the adaptation of grids with LOBSTER requires for the moment use of elements in the list (not, segment, triangle, tetrahedron) with exclusion of very other. These elements can be linear or quadratic.*

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### **3 References**

**useful**

**The documents [bib1] with [bib5] estimators of error and tool for adaptation of grid treat LOBSTER.**

**The documents [bib6] with [bib8] form the support of the Aster formations on the subject.**

**Concerning the choice of the finite elements, one will be able to refer to the document [bib9].**

**[1]**

**X. DESROCHES: "Estimator of error of Zhu-Zienkiewicz in elasticity 2D". [R4.10.01], 1994.**

**[2]**

**X. DESROCHES: "Estimator of error in residue". [R4.10.02], 2000.**

**[3]**

**O. BOITEAU: "Indicating of space error in residue for transitory thermics". [R4.10.03], 2001.**

**[4]**

**G. NICOLAS & Al [http://www.code\\_aster.org/outils/homard](http://www.code_aster.org/outils/homard)**

**[5]**

**G. NICOLAS: "Macro-order MACR\_ADAP\_MAIL". Doc. [U7.03.01].**

**[6]**

**O. BOITEAU: Case-test. "Mechanical FORMA04 adaptive Grid on a beam in inflection". Doc. [V6.03.119]**

**[7]**

**O. BOITEAU: Case-test. "FORMA05 thermomechanical adaptive Grid on a cylinder head fissured". Doc. [V6.03.120]**

[8]

*O. BOITEAU: Run and Indicating TP “of error and adaptation of grid. State of the art and establishment in Code\_Aster”. [http://www.code\\_aster.org/utilisation/formations](http://www.code_aster.org/utilisation/formations)*

[9]

*S. MICHEL-PONNELLE*

: «

*Note of use on the choice of the finite elements*

».

*Doc. [U2.01.10]*

### *Principle general*

*The indicators of error used in Aster are indicators a posteriori, one gives one below diagram specifying their use. One will find in the case-tests [bib6] and [bib7] like in the continuation this document of the examples of use of the functionalities of the process control language Aster (based on Python) adapted to this use.*

*1) Definition of the data of calculation (in*

*1) Definition of the data of calculation (in*

*private individual grid)*

*private individual initial grid)*

*2) Resolution of the problem*

*2) Resolution of the problem*

*3) Calculation of the indicators of error (post-*

*3) Calculation of the indicators of error (post-*

*treatment)*

*treatment)*

*4) Adaptation of the grid (based on one of*

*indicators calculated at stage 3)*

*Use of the indicators of error*

*Use of the adaptation of grid*

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## 4

*Recall of the orders and options Aster to be used*

## 4.1

*Estimator of error in mechanics of Zhu-Zienkiewicz*

*The calculation of the estimator of error is carried out directly in operator CALC\_ELEM with options:*

*OPTION= `ERRE\_ELEM\_NOZ1' for estimator ZZ1;*

*OPTION= `ERRE\_ELEM\_NOZ2' for estimator ZZ2.*

*The calculation of the field (with the nodes) of smoothed constraints can separately be started (not very useful in practical):*

*OPTION= `SIGM\_NOZ1\_ELGA' for smoothing ZZ1*

*OPTION= `SIGM\_NOZ2\_ELGA' for smoothing ZZ2*

*The estimator provides:*

*· a field by element comprising 3 components:*

*“ERREST”*: the absolute error estimated on the element (K);

*K*

*“NUEST”*: the relative error estimated on the element rel (K)

*( )*

*= 100×*

*;*

*(K) 2*

*2*

*+ H 0, K*

*“SIGCAL”*: the standard of energy of the calculated solution H

*;*

*0, K*

*· of the exit-listing comprising same information at the total level.*

## 4.2

*Estimator of error in mechanics of the residue type*

*For calculating the indicator of error, it is necessary to carry out the calculation of the field (with the nodes by elements) of*

*constraints to normalize the error, by operator CALC\_ELEM:*

*OPTION= `SIGM\_ELNO\_DEPL' in elasticity (after MECA\_STATIQUE);*

*OPTION= `SIEF\_ELNO\_ELGA' into non-linear (after STAT\_NON\_LINE).*

*The calculation of the estimator of error itself is also carried out in operator CALC\_ELEM with the options:*

*OPTION= `ERRE\_ELGA\_NORE' for calculation at the points of Gauss;*

*OPTION= `ERRE\_ELNO\_ELGA' for calculation with the nodes by elements.*

**The estimator provides:**

· **a field by element comprising 3 components:**

**“ERREST”**: the absolute error estimated on the element (K);

**K**

**“NUEST”**: the relative error estimated on the element rel (K)

( )

= 100×

;

(K) 2

2

+ H 0, K

**“SIGCAL”**: the standard of energy of the calculated solution H

.

0, K

· **of the exit-listing comprising same information at the total level.**

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**4.3**

**Estimator of error in thermics (of residues type)**

**The calculation of the estimator of error is carried out in operator CALC\_ELEM with the options:**

**OPTION= `ERTH\_ELEM\_TEMP' for calculation by elements;**

**OPTION= `ERTH\_ELNO\_TEMP' for calculation by elements with the nodes.**

**The estimator provides the following components (one will notice that all the fields are accessible individually, one will underline the interest in the examples of it):**

**Absolute error**

**Relative error**

**Term of standardization**

***N 1***

**+**

***N 1***

**+**

***N 1***

**+**

***N 1***

**+**

***R, flight (K)***

***R, flight (K)***

***NR R, flight (K)***

***Term***

**=**

**×**

***: HK S, H***

***0, K***

***voluminal***

***n+***

***NR R, flight (K)***

**.**

***100***

***1***

***TERMVO***

***TERMV2***

***TERMV1***

***N 1***

**+**

***N 1***

**+**

***1***

***R, jump (K)***

***R, jump (K)***

***Term of jump***

**×**

***N 1***

***2***

**+**

***N 1***

***H***  
**+**  
***l***  
***T***

***F***  
**, *H***

***n+***  
***NR, jump (K): =***

***(K)***  
***NR R jump (K)***

**.**  
***100***  
***l***

**,**  
***2 2***  
***N***

***K***

***F***  
***0, F***

***TERMSA***  
***TERMS2***  
***TERMS1***

***N l***  
**+**

***N l***  
**+**

***l***  
***R, flow (K)***  
***R, flow (K)***  
***Term of flow***  
***×100***

***N***  
***NR l***

**+**  
***2***

***l***  
**+**

***R, flow (K)***  
***N***

***: = H G***

*N I*  
+  
*NR*  
*F*  
, *H*  
*R, flow (K)*  
.  
*0, F*

*TERMFL*  
*TERMF2*  
*TERMF1*

*N I*  
+

*N I*  
+

*l*  
*R, éch (K)*  
*R, éch (K)*  
*Term*

×  
*N*  
*NR I*

+  
*2*  
*l*  
+  
*R, éch (K): = HF (*  
*ext.*  
*HT) N*

*of exchange*

*n+*  
*NR*  
, *H*  
*R éch (K)*

.  
*100*  
*l*  
,  
*0, F*



**TERMEC**  
**TERME2**  
**TERME1**

***n+1***  
***1***

***n+***

***n+***  
***NR 1***  
***1***

***R***  
***(K) =: n+***  
***NR R I, (K)***  
***R (***  
***1 K)***  
***R (K) =***  
***: n+***  
***R I, (K)***

***Total***  
***×***

***I***  
***n+***  
***NR***  
***I***  
***R***  
***(K)***

***.***  
***100***  
***1***

**ERTABS**  
**ERTREL**  
**TERMNO**

***For correct use, it is necessary to pay attention to the following points (cf R7.10.03 documentation):***

- preliminary call “FLUX\_ELNO\_TEMP” obligatory before the calculation of the indicators of errors;***
- homogeneity enters the parameter setting of the thermal solver and the tool for postprocessing;***
- particular rules of overload concerning the loadings (generation of alarm <A> in case of non-observance);***
- calculation on all the grid associated with the model (generation of <F> error in the event of non-observance) between two steps of time contiguous or not (generation of alarm <A> in the event of non-observance);***
- all the elements 2D-plan/axi and 3D are treated (except PYRAM: generation of alarm <A>);***

- *all the limiting conditions except ECHANGE\_PAROI, FLUX\_NL and RAYO are taken into account (generation of alarm <A> in the event of use of ECHANGE\_PAROI, FLUX\_NL or RAYO);*
- *the grid tolerates the “outlines” but requires “to be cleaned a little” (not of SEG/FACE intercalated in surfaces/volumes, problem of symmetrization, points double: generation of alarm <A> or <F> error).*

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*4.4*

*Adaptation of grid with LOBSTER*

*Macro-order MACR\_ADAP\_MAIL is controlled with the following options:*

*\_F Mot-clé*

*Choice*

*ADAPTATION*

*FREE*

*“RAFF\_DERA”*

*“REFINEMENT”*

*or*

*“DERAFFINEMENT”*

*UNIFORM*

*“REFINEMENT”*

*“DERAFFINEMENT”*

*MAILLAGE\_N/NPI*

*RESULTAT\_N*

*“EVOL\_NOLI” (\*)*

*INDICATOR*

**“ERRE\_ELGA\_NORE” (\*)**

**NOM\_CMP\_INDICA**

**“ERREST” (\*)**

**CRIT\_RAFF\_PE**

*Allows to control the proportion of elements with*

**\_REL**

*to refine/déraffiner*

**\_ABS**

**CRIT\_DERA\_PE**

**\_REL**

**\_ABS**

**NIVE\_MAX**

*Max. level of refinement*

**NIVE\_MIN**

*Level min. of refinement*

*(\*) example given on a non-linear calculation, use of the indicator in absolute residue.*

*Other possible options:*

- *update of fields on new grid (MAJ\_CHAMP); one cannot (still) put up to date of the fields at the points of Gauss (like the variables intern for example);*
- *diagnoses on the quality of the grid (QUALITY, INTERPENETRATION, SIZE, CONNEXITY).*

*Precautions for use:*

- *adaptation of a total grid (not of selection by meshes, groups of meshes, nodes, group nodes);*
- *the groups of meshes are adapted, on the other hand the groups of nodes are left unchanged (it is thus necessary to be compelled to impose boundary conditions on groups of meshes and not of the groups of nodes); it is thus necessary to proscribe (but it is a rule of good feel) the direct use of meshes and nodes at the time them assignments to prefer the concept to him of group meshes;*
- *the recoveries (by the key word “CONTINUATION”) are to be avoided: LOBSTER loses the hierarchy then refined elements: the first grid of the continuation is considered by LOBSTER an initial grid (without possibility of déraffiner for example);*
- *one recalls that the adaptation by LOBSTER accepts only nodes, NOT, SEG, SORTED or TETRA, of degree 1 or 2, in a grid conforms in related zones or not, in the same way dimension or not;*
- *LOBSTER does not carry out yet the follow-up of curve (it is based on the provided elements: by example, if the grid of a circle is provided in the initial grid by its approximation in NR segments of order 1, LOBSTER will refine possibly the NR segments but the circle will be always considering geometrically like a succession of these NR segments).*

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## **4.5 Lookahead**

*of one  
grid*

*The diagnosis on the quality of a grid activable in the macro **MACR\_ADAP\_MAIL** can also be obtained independently by the macro **MACR\_INFO\_MAIL**. It makes it possible to carry out the checks*

*following:*

- to check the agreement of the grid with the initial geometry (in mass, dimension, in surface and in volume);*
- to list the **GROUP\_MA** and **GROUP\_NO**, for a good modeling of the boundary conditions;*
- to diagnose possible problems (symmetrization or connexity, elements of outline, bad taking into account of boundary conditions, interpenetration of elements);*

**H**

- to evaluate the quality of the grid by the indicator*

**K**

**K =**

*(standardized to 1 for*

**K**

*equilateral triangles/tetrahedrons; by superior definition to 1). An empirical criterion can be proposed: for example, at least 50% of EFs < 1.5, at least 90% of EFs < 2, not elements with the top of 10.*

5

*The Councils and good practice*

- Choix of the indicator of error in mechanics: the user has the choice between **ZZ1** (first version*

indicator of Zhu-Zienkiewicz), ZZ2 (second version of the indicator of Zhu-Zienkiewicz), and the indicator in residues. The two first have an applicability enough reduces (2D linear for ZZ1 and ZZ2, only one standard of finite element in all the grid for ZZ2): for a “standard” use, one will prefer the indicator in residues.

- The sequence “thermomechanical operators/“UNIFORM” MACR\_ADAP\_MAIL option” (i.e without indicator of error) allows to make converge properly, automatically and easily a grid. It is however necessary to take guard with the number of degrees of freedom generated! This constitutes a solution of facility, rapid and robust, but quickly extremely expensive (rather to reserve to evaluate if there are large errors of discretization or for small studies).

- The sequence “thermomechanical operators/“FREE” MACR\_ADAP\_MAIL option” (i.e with indicator of error) allows to make converge in the most optimal possible way (taking into account the tools available) grid. This method requires more efforts than the preceding one but the number of generated degrees of freedom is proportionally much weaker.

- The sequence “operators thermomechanical/MACR\_ADAP\_MAIL” can be carried out effectively in a loop Python (of type “for buckles”), with possibly a test of exit (of type “while buckles”).

- The quality of the elements is impacted little by the process of refinement/déraffinement. Taking into account the choices operated in HOMARD®, it can even improve in 3D!

- MACR\_ADAP\_MAIL does not have process of regularization, therefore a bad grid initial a bad adapted grid will probably produce!

- The linear elements are disadvised in mechanics. The good practice is rather: P1 lumpé in thermics (PLAN\_DIAG, AXIS\_DIAG, 3D\_DIAG) and P2 (possibly under-integrated) in mechanics, cf [bib9].

- The choice of the type of finite elements premium on the quality of the meshes on which come to rest the elements (cf example of the beam below).

- The type of indicator and its mode of standardization can affect the grid

**K**  
adapted. For example, in mechanics,  $rel(K)$

( )  
= 100×

. This way of

(K) 2

2

+ H 0, K

to standardize can be dangerous: if there are zones where the standard of constraints is weak, the error will border 100% on this zone; if there are zones where the standard of constraints is very high (singularities for example), the error will be weak on this zone. It is not obviously not the required result. It is thus necessary to use the absolute indicator preferably, with less knowledge precisely than one makes.

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- *In thermics, one can also “juggle” with the components of the thermal indicator and of boundary conditions, “fictitious” or not, to direct the construction of a refined grid or déraffiné by zones.*
  - *In the event of presence of singularities, it is advised to select the number of elements on which refinement carries by a fraction of elements to refine “CRIT\_RAFF\_PE” (and not by the quantum of elements presenting a superior error at a fraction of the total error “CRIT\_RAFF\_REL”). Indeed, in the case of a singularity, by using “CRIT\_RAFF\_REL”, with boils of one or two iterations of adaptation, only the elements touching the singularity will be refined. By using “CRIT\_RAFF\_PE”, other zones will be able to continue to be refined. Finally criterion “CRIT\_RAFF\_ABS” (choice by fixed barrier of error) is to be held for the cases where the user knows the problem considered very well.*
  - *As a “simple postprocessing” of the thermomechanical problem, the indicator cannot unfortunately not to provide a more reliable diagnosis in the zones where the resolution of initial problem stumbles. It is thus preferable to begin a process of adjustment, with one grid refined already a little “with the hand”.*
  - *Into thermomechanical, various strategies of adaptation of grid are offered to the user:*
    - *to only adapt the grid according to a thermal criterion,*
    - *to only adapt the grid according to a mechanical criterion,*
    - *to adapt jointly or separately (i.e with one or two loops of adaptation); in clearly to chain or couple the first two strategies.*
- Good practice during such a thermomechanical calculation led to use two grids and with to interpolate the thermal field P1 on the mechanical grid P2 (via operator PROJ\_CHAMP). If one wishes to work only with one grid, one can decline one of the strategies via option MAJ\_CHAMP of MACR\_ADAP\_MAIL. That allows, while adapting the following grid a criterion, to update the complementary field on the new adapted grid.*

*· In thermics, to carry out an adaptation of grid based on the indicator ERTH\_ELNO\_ELEM during a transient, one should not forget to start the calculation of the step time following with the old EVOL\_THER updated on the new grid.*

## **6 Examples of use**

### **6.1 Mechanical example (beam 2D)**

*It is about a metal beam (steel 16MND5,  $E = 210.103$  Mpa,  $\nu = 0.2$ ) in inflection. Calculation rubber band (MECA\_STATIQUE or STAT\_NON\_LINE) in modeling forced plane (C\_PLAN). Initial grids in TRIA3 or TRIA6.*

**GM12**  
**PRES\_REP=0.1 NR**  
**Y**  
**GM14**  
**X**  
**10**  
**GM13**  
**DX=0**  
**GM10**  
**100**  
**DY=0**

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**6.1.1 Use  
of  
MACR\_INFO\_MAIL**

*The macro MACR\_INFO\_MAIL is launched in the command file by the following block. Grid is arranged here in a Python table: MA [num\_calc] could be replaced by a name more conventional in the absence of use of loops Python.*

**MACR\_INFO\_MAIL (MAILLAGE=MA [num\_calc],  
QUALITE=' OUI',  
INTERPENETRATION=' OUI',  
CONNEXITE=' OUI',  
TAILLE=' OUI')**

*And one obtains in the file of message:*

**ANALYZE GRID**

=====

**Grid has to analyze**

**MA\_0**

**Creation date: Friday September 27, 2002 has 15. 58 mn 20 S**

**Dimension: 2**

**Degree: 1**

**It is a starting grid.**

**Maximum direction / Unit / Minimum /**

-----

**X / UNKNOWN / 0. / 100.00**

**Y / UNKNOWN / 0. / 10.000**

**INTERPENETRATION OF THE ELEMENTS**

=====

\*\*\*\*\*

\* \*

**\* Summary on the active faces \***

\* \*

**\* No problem was meets. \***

\* \*

\*\*\*\*\*

**QUALITY OF THE ELEMENTS**

=====



\*\*\*\*\*

*\* Quality of the triangles of the grid of calculation \**  
*\* Recall: quality is equal to the report/ratio of the diameter \**  
*\* of the triangle on the radius of the inscribed circle, \**  
*\* standardizes has 1 for a regular triangle. \**

\*\*\*\*\*

*\* Minimum: 1.0117 Maximum: 2.0158 \**

\*\*\*\*\*

\*\*\*\*\*

*\* Function of distribution \**

*\* \**

*\* Values \* a Number of elements \**  
*\* Minis < < Maximum \* by class \* office plurality \**  
*\*\* in %. numbers \* in %. numbers \**

\*\*\*\*\*

*\* 1.00 < 1.05 \* 14.75 . 9 \* 14.75 . 9 \**  
*\* 1.05 < 1.10 \* 42.62 . 26 \* 57.38 . 35 \**  
*\* 1.10 < 1.15 \* 16.39 . 10 \* 73.77 . 45 \**  
*\* 1.15 < 1.20 \* 1.64 . 1 \* 75.41 . 46 \**  
*\* 1.20 < 1.25 \* 6.56 . 4 \* 81.97 . 50 \**  
*\* 1.25 < 1.30 \* 11.48 . 7 \* 93.44 . 57 \**  
*\* 1.30 < 1.35 \* 0.00 . 0 \* 93.44 . 57 \**  
*\* 1.35 < 1.40 \* 3.28 . 2 \* 96.72 . 59 \**

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*\* 1.40 < 1.45 \* 0.00 . 0 \* 96.72 . 59 \**

\* **1.45 < 1.50 \* 0.00 . 0 \* 96.72 . 59 \***  
 \* **1.50 < 1.55 \* 0.00 . 0 \* 96.72 . 59 \***  
 \* **1.55 < 1.60 \* 0.00 . 0 \* 96.72 . 59 \***  
 \* **1.60 < 1.65 \* 0.00 . 0 \* 96.72 . 59 \***  
 \* **1.65 < 1.70 \* 0.00 . 0 \* 96.72 . 59 \***  
 \* **1.70 < 1.75 \* 1.64 . 1 \* 98.36 . 60 \***  
 \* **1.75 < 1.80 \* 0.00 . 0 \* 98.36 . 60 \***  
 \* **1.80 < 1.85 \* 0.00 . 0 \* 98.36 . 60 \***  
 \* **1.85 < 1.90 \* 0.00 . 0 \* 98.36 . 60 \***  
 \* **1.90 < 1.95 \* 0.00 . 0 \* 98.36 . 60 \***  
 \* **1.95 < 2.00 \* 0.00 . 0 \* 98.36 . 60 \***  
 \* **2.00 < 2.05 \* 1.64 . 1 \* 100.00 . 61 \***  
 \* **2.05 < 2.10 \* 0.00 . 0 \* 100.00 . 61 \***  
 \* **2.10 < 2.15 \* 0.00 . 0 \* 100.00 . 61 \***  
 \* **2.15 < 2.20 \* 0.00 . 0 \* 100.00 . 61 \***  
 \* **2.20 < 2.25 \* 0.00 . 0 \* 100.00 . 61 \***  
 \* **2.25 < 2.30 \* 0.00 . 0 \* 100.00 . 61 \***  
 \* **2.30 < 2.35 \* 0.00 . 0 \* 100.00 . 61 \***  
 \* **2.35 < 2.40 \* 0.00 . 0 \* 100.00 . 61 \***  
 \* **2.40 < 2.45 \* 0.00 . 0 \* 100.00 . 61 \***  
 \* **2.45 < 2.50 \* 0.00 . 0 \* 100.00 . 61 \***  
 \* **2.50 < inf. \* 0.00 . 0 \* 100.00 . 61 \***

\*\*\*\*\*

**A NUMBER Of ENTITIES OF CALCULATION**

=====

\*\*\*\*\*

**\* Nodes \***

\*\*\*\*\*

**\* Numbers total \* 48 \***

\*\*\*\*\*

\*\*\*\*\*

**\* Mesh-points \***

\*\*\*\*\*

**\* Numbers total \* 2 \***

\*\*\*\*\*

\*\*\*\*\*

**\* Edges \***

\*\*\*\*\*

**\* Total \* 15 number \***

**\*. of which edges isolees \* 0 \***

**\*. of which edges of edge of areas 2D \* 15 \***

**\*. of which edges intern with the faces/volumes \* 0 \***

\*\*\*\*\*

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\*\*\*\*\*

**\* Faces \***

\*\*\*\*\*

**\* Numbers total \* 61 \***

\*\*\*\*\*

**CONNEXITY OF THE ENTITIES OF CALCULATION**

=====

\*\*\*\*\*

**\* The faces are in only one block. \***

\*\*\*\*\*

**SIZES OF THE SOUS-DOMAINES OF CALCULATION**

=====

**Direction / Unit****X / UNKNOWN****Y / UNKNOWN**

\*\*\*\*\*  
**\* Under-fields 2D \***  
 \*\*\*\*\*  
**\*Numero\* Name \* Surface \***  
 \*\*\*\*\*  
**\* -4 \* FAMILLE\_MAILLE\_-4 \_\_\_\_\_ \* 1000.0 \***  
 \*\*\*\*\*  
**\* Total: \* 1000.0 \***  
 \*\*\*\*\*

\*\*\*\*\*  
**\* 1D Under-fields \***  
 \*\*\*\*\*  
**\*Numero\* Name \* Length \***  
 \*\*\*\*\*  
**\* -3 \* FAMILLE\_MAILLE\_-3 \_\_\_\_\_ \* 10.000 \***  
**\* -2 \* FAMILLE\_MAILLE\_-2 \_\_\_\_\_ \* 50.000 \***  
**\* -1 \* FAMILLE\_MAILLE\_-1 \_\_\_\_\_ \* 40.000 \***  
 \*\*\*\*\*  
**\* Total: \* 100.00 \***  
 \*\*\*\*\*

**One learns by this message:**

- *extreme co-ordinates of the grids;*
- *the absence of problem of interpenetration;*
- *a histogram of the geometrical quality of the elements (one will observe the good quality of it grid);*
- *the number of nodes, meshes points, edges, faces;*
- *the connexity of the grid;*
- *the size of the fields defined by the groups of meshes (this description is not very readable, nevertheless, it will be observed that the field 2D of the beam is well of surface 1000 like envisaged).*

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### ***6.1.2 Use***

***of  
UNIFORM MACR\_ADAP\_MAIL option***

***In a loop Python, uniform refinement is required by the following call. Notice important: a subtlety in the loops Python, it is necessary to declare the concept outgoing before using it***

***with the order CO.***

***# SUBTLETY MACRO\_COMMANDE WITH RESPECT TO THE ENTRIES***

***MA [num\_calc1]=CO ("MA\_%d' % (num\_calc1))***

***# REFINEMENT UNIFORM VIA LOBSTER***

***# GRID STARTING: MA [num\_calc]***

***# GRID Of ARRIVES: MA [num\_calc1]***

***MACR\_ADAP\_MAIL (***

***ADAPTATION=\_F (***

***UNIFORM = "REFINEMENT",***

***MAILLAGE\_N = MA [num\_calc],***

***MAILLAGE\_NP1 = MA [num\_calc1],),***

***QUALITE=' OUI',***

***INTERPENETRATION=' OUI',***

***TAILLE=' OUI',***

***CONNEXITE=' OUI')***

***Let us observe the results obtained, by comparing a linear grid (TRIA3) and a quadratic grid (TRIA6), initial grid being presented on [Figure 6.1.2-a]. On the curves presenting the evolution energy and arrow of the beam according to the number of refinement, cf [Figure 6.1.2-b] and [Figure 6.1.2-c], two conclusions are essential:***

- on the one hand the quadratic elements show their obvious superiority;***
- in addition, mending of meshes (here very simplistic since it is uniform) proves its interest:***

*initial linear grid being very far from being sufficiently refined, mending of meshes makes it possible to obtain good results after some iterations.*

*Appear 6.1.2-a: Initial grid*

*Appear 6.1.2-b: Evolution of energy with*

*Appear 6.1.2-c: Evolution of the arrow with*

*the number of refinements*

*the number of refinements*

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*6.1.3 Use*

*of*

*FREE MACR\_ADAP\_MAIL option*

*The first question to regulate during the use of free refinement with LOBSTER is the choice of the indicator of error and its component. Here, according to the principles stated in the paragraph of councils, the choice was made use the indicator in residue (even if in this case, one is in perimeter of use of the indicators of Zhu-Zienkiewicz). On the other hand, this example compares them*

*components absolute and standardized indicator in order to illustrate the prudence which the use imposes of the standardized component.*

*The grid is here linear in order to clearly illustrate the effect of the adaptation of grid, because one*

*saw*

*previously that the initial grid gives already results of good quality with elements of order 2.*

*Free refinement on the absolute component (for the relative component, it is enough to change in extract below `NOM_CMP_INDICA='ERREST'` in `NOM_CMP_INDICA='NUEST'`) is activated by following orders:*

**# SUBTLETY MACRO\_COMMANDE WITH RESPECT TO THE ENTRIES**

**MA [num\_calc1]=CO (“MA\_%d’ % (num\_calc1))**

**# REFINEMENT FREE VIA LOBSTER**

**# GRID STARTING: MA [num\_calc]**

**# GRID Of ARRIVES: MA [num\_calc1]**

**MACR\_ADAP\_MAIL (**

**ADAPTATION=\_F (**

**FREE = “RAFF\_DERA”,**

**MAILLAGE\_N = MA [num\_calc],**

**MAILLAGE\_NP1 = MA [num\_calc1],**

**RESULTAT\_N=DEPLA [num\_calc],**

**INDICATEUR='ERRE\_ELGA\_NORE',**

**NOM\_CMP\_INDICA='ERREST',**

**CRIT\_RAFF\_PE=0.2,**

**CRIT\_DERA\_PE=0.2),**

**QUALITE='OUI',**

**INTERPENETRATION='OUI',**

**TAILLE='OUI',**

**CONNEXITE='OUI')**

*If one compares the results on the arrow with “absolute” component and the “relative” component according to the number of nodes (cf [Figure 6.1.3-a] where one added the same evolution for refinement uniform), one observes:*

- free refinement with the component absolute converges more quickly towards the reference that uniform refinement (from where interest of to make free refinement);*
- free refinement with the component relative converges more slowly towards reference that uniform refinement, which is at first sight surprising.*

*Appear 6.1.3-a: Evolution of energy in*

***function of the number of nodes***

***This last point is explained if one traces the three fields from the indicator of error, which is made on [Figure 6.1.3-b] - [Figure 6.1.3-d].***

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***Appear 6.1.3-b: Absolute component***

***Appear 6.1.3-c: Constraint of standardization normalizes***

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**Appear 6.1.3-d: Standardized component**

***It appears clearly that the fact that the standard of the standardized constraint is weak in a zone (neutral fibre of the beam in particular) where refinement is less necessary than elsewhere (see the error***

***K  
absolute) the result of standardization rel returns (K)***

***( )  
= 100×  
random. Indeed,***

***(K) 2  
2  
+ H***

***0, K  
it is pointed out that zones with constraint of null standardization will be regarded as having one error of 100%: if it is necessary to refine in this zone, that will be good (though that will mask the others***

***zones to refine), if refinement is less necessary, that will be bad. It is thus necessary well to analyze its problem before using the relative component of the indicator of error, the absolute component being able to be regarded as surer. In particular, it seems to us that the use of the error standardized is not possible that after analysis by the user of the chart of constraint of standardization.***

**6.2  
Thermoelastic example (simplified cylinder head)**

**The following structure is considered:**

**Y  
3  
8  
4  
20  
3  
10**

3  
6  
3  
X  
55

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***subjected to the following loadings:***

***GM33***

***OUTGOING FLOW***

***2***

***=-400 W/m***

***GM36***

***GM34***

***2***

***ECHANGE= (1000 W/m °C, 350°C)***

***PRES\_REP= 0.1N***

***Y***

***GM35***

***X***

***GM37***

***2***

**ECHANGE= (5000 W/m °C, 150°C)**

**GM39/GM40**

**DX=DY=0**

*Initially, one is interested in thermics only to underline the possibility of using decomposition of the various terms of error. Indeed, within the framework of a “standard” use (i.e. when all the terms of error interest the user), will have to be chosen the total error (“ERTABS” or “ERTREL”); on the other hand, if the user is particularly interested by good taking into account of the boundary conditions, it can thus direct refinement by using the different ones*

*terms (of flow or exchange in this case). For example, on the basis of the grid [Figure 6.2-a] - one will note that this grid checks one of our councils which is to start from a “reasonable” grid - one carry out a refinement on the relative total error, cf the result [Figure 6.2-b]:*

**# GRID STARTING: CHECHMATE [num\_calc]**

**# GRID Of ARRIVES: CHECHMATE [num\_calc1]**

**MACR\_ADAP\_MAIL (**

**ADAPTATION=\_F (**

**FREE = “RAFF\_DERA”,**

**MAILLAGE\_N = CHECHMATE [num\_calc],**

**MAILLAGE\_NP1 = CHECHMATE [num\_calc1],**

**RESULTAT\_N=TEMP [num\_calc],**

**INDICATEUR=' ERTH\_ELEM\_TEMP',**

**NOM\_CMP\_INDICA=' ERTREL',**

**CRIT\_RAFF\_PE=0.1,**

**CRIT\_DERA\_PE=0.1,**

**),**

**QUALITE=' OUI',**

**INTERPENETRATION=' OUI',**

**TAILLE=' OUI',**

**CONNEXITE=' OUI')**

*and a refinement on the term of exchange, cf the result appears (10):*

**# GRID STARTING: CHECHMATE [num\_calc]**

**# GRID Of ARRIVES: CHECHMATE [num\_calc1]**

**MACR\_ADAP\_MAIL (**

**ADAPTATION=\_F (**

**FREE = “RAFF\_DERA”,**

**MAILLAGE\_N = CHECHMATE [num\_calc],**

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*MAILLAGE\_NP1 = CHECHMATE [num\_calc1],*

*RESULTAT\_N=TEMP [num\_calc],*

*INDICATEUR=' EARTH\_ELEM\_TEMP',*

*NOM\_CMP\_INDICA=' TERME2',*

*CRIT\_RAFF\_PE=0.1,*

*CRIT\_DERA\_PE=0.1,*

*),*

*QUALITE=' OUI',*

*INTERPENETRATION=' OUI',*

*TAILLE=' OUI',*

*CONNEXITE=' OUI')*

*It is observed obviously that the adapted grids strongly differ. In the second case of appear, refinement was indeed directed towards drillings, seats of the conditions of exchanges.*

**Appear 6.2-a: Initial grid**

**Appear 6.2-b: Grid refined starting from the relative total error**

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### ***Appear 6.2-c: Grid refined starting from the relative error on the term of exchange***

*One is interested now in coupled thermoelastic calculation. This problem remains rather simple since it one step of time has there. According to the councils given previously, one carries out this calculation coupled on two different grids: a “thermal” grid linear on which will be based lumpés elements and a “mechanical” grid quadratic, the passage of the one with the other being carried out by operator “PROJ\_CHAMP”.*

*More precisely: with each stage of the loop of refinement, one starts by calculating temperature on the thermal grid:*

```
TEMP [num_calc] =THER_LINEAIRE (  
MODELE=MOT [num_calc],  
CHAM_MATER=CHMATT [num_calc],  
EXCIT= (  
_F (LOAD = CHT [num_calc]),  
_F (LOAD = CLIMT [num_calc],),)  
)
```

*then one projects this temperature on the mechanical grid (one created a model beforehand thermics MOT2 related to the mechanical grid):*

```
TEMP2 [num_calc] =PROJ_CHAMP (  
METHODE='ELEM',  
RESULTAT=TEMP [num_calc],  
MODELE_1=MOT [num_calc],  
MODELE_2=MOT2 [num_calc],  
TOUT_ORDRE='OUI')
```

*One uses this temperature under the boundary conditions of mechanical calculation:*

```
CLIMM [num_calc] =AFFE_CHAR_MECA (  
MODELE=MOM [num_calc],  
TEMP_CALCULEE=TEMP2 [num_calc],  
DDL_IMPO= (_F (GROUP_NO=' GM39', DX=0.0, DY=0.0),  
_F (GROUP_NO=' GM40', DX=0.0, DY=0.0),),)
```

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*mechanical calculation is carried out:*

```
DEPLA [num_calc] =STAT_NON_LINE (MODELE=MOM [num_calc],  
CHAM_MATER=CHMATM [num_calc],  
EXCIT= (_F (CHARGE=CLIMM [num_calc],),  
_F (CHARGE=CHM [num_calc],  
FONC_MULT=F_INST,)),  
COMP_INCR= (_F (RELATION=' ELAS',  
TOUT=' OUI',)),  
INCREMENT=_F (LIST_INST=L_INST),)
```

*One calculates the indicators of thermal and mechanical error:*

```
TEMP [num_calc] =CALC_ELEM (reuse=TEMP [num_calc],  
RESULTAT=TEMP [num_calc],  
MODELE=MOT [num_calc],  
TOUT=' OUI',  
TOUT_ORDRE=' OUI',  
CHAM_MATER=CHMATT [num_calc],
```

```
EXCIT= (  
_F (LOAD = CHT [num_calc]),  
_F (LOAD = CLIMT [num_calc],),),  
OPTION= (  
“FLUX_ELNO_TEMP”,  
“ERTH_ELEM_TEMP”,  
“ERTH_ELNO_ELEM”,),)
```

```
DEPLA [num_calc] = CALC_ELEM (reuse=DEPLA [num_calc],  
RESULTAT=DEPLA [num_calc],  
MODELE=MOM [num_calc],  
TOUT=' OUI',  
CHAM_MATER=CHMATM [num_calc],  
EXCIT= (_F (CHARGE=CLIMM [num_calc]),  
_F (CHARGE=CHM [num_calc],),),  
TOUT_ORDRE=' OUI',  
OPTION= (  
“SIEF_ELNO_ELGA”,  
“ERRE_ELGA_NORE”,),)
```

*then one connects with the adaptation of the thermal and mechanical grids*

```
MACR_ADAP_MAIL (  
ADAPTATION=_F (  
FREE = “RAFF_DERA”,
```

```
MAILLAGE_N = CHECHMATE [num_calc],  
MAILLAGE_NP1 = CHECHMATE [num_calc1],  
RESULTAT_N=TEMP [num_calc],  
INDICATEUR=' ERTH_ELEM_TEMP',  
NOM_CMP_INDICA=' ERTREL',  
CRIT_RAFF_PE=0.1,  
CRIT_DERA_PE=0.1,
```

```
),  
QUALITE=' OUI',  
INTERPENETRATION=' OUI',  
TAILLE=' OUI',  
CONNEXITE=' OUI')
```

```
MACR_ADAP_MAIL (  

```



*ADAPTATION= \_F (*  
*FREE = "RAFF\_DERA",*

*MAILLAGE\_N = MAM [num\_calc],*  
*MAILLAGE\_NP1 = MAM [num\_calc1],*  
*RESULTAT\_N=DEPLA [num\_calc],*

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*INDICATEUR=' ERRE\_ELGA\_NORE',*

*NOM\_CMP\_INDICA=' NUEST',*

*CRIT\_RAFF\_PE=0.1,*

*CRIT\_DERA\_PE=0.1,*

*),*

*QUALITE=' OUI',*

*INTERPENETRATION=' OUI',*

*TAILLE=' OUI',*

*CONNEXITE=' OUI')*

*Before starting again at the following stage...*

### ***6.3 Example***

#### ***thermoplastic***

*One considers the structure of following revolution (modelled into axisymmetric):*

where the grayed parts are plastic, the elastic remainder. The loading is applied in 2 stages:

- the first consists of a purely mechanical loading (pressure on the zone with arrows on the diagram), with a phase of load followed by a phase of discharge;
- the second consists of a transitory thermal loading (condition of exchange on lower parts and higher of the structure).

### **6.3.1 Strategy of mending of meshes and list of moments**

**The loading is discretized according to a list of moments, it raises the question then: which strategy to adopt with respect to mending of meshes? Indeed, according to the treated case, one can:**

- **to re-mesh with each step of calculation: the grid is then adapted to each step of calculation individually. It is then necessary to project the fields of a grid on the other (what is not still completely possible in non-linear mechanics);**
- **to re-mesh only once, at the end it calculation, and to start again calculation since the beginning with new grid.**

**The first strategy is to be adopted if the zones of refinement evolve/move much, us in will see an example in following thermal calculation; the second can be adopted if the zones of refinement evolve/move little, as in this mechanical case where it is a question of following growth of a plastic zone.**

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### 6.3.2 Calculation mechanics

*For mechanical calculation, one thus adopts the following strategy:*

- 1) calculation of all the list of moments;
- 2) mending of meshes
- ;
- 3) repetition of (1 & 2) until the satisfactory result.

*It is not so much the implementation in Aster which is interesting in this case (which differs from the settings*

*in work the preceding ones only by the fact that several moments ago of calculation) that the results obtained by adaptation of grid on a non-linear case. For recall, calls for calculation indicators of error and for mending of meshes are as follows:*

*V1 [num\_calc] =CALC\_ELEM (reuse =V1 [num\_calc],*

*MODELE=MO1 [num\_calc],*

*CHAM\_MATER=CM1 [num\_calc],*

*INST=-1.0,*

*OPTION= (“ERRE\_ELGA\_NORE”),*

*RESULTAT=V1 [num\_calc],)*

*MA [num\_calc+1] =CO (“MA\_%d' % (num\_calc+1))*

*MACR\_ADAP\_MAIL (*

*ADAPTATION=\_F (*

*FREE = “REFINEMENT”,*

*MAILLAGE\_N = MA [num\_calc],*

*MAILLAGE\_NP1 = MA [num\_calc+1],*

*RESULTAT\_N = V1 [num\_calc],*

*INDICATOR = “ERRE\_ELGA\_NORE”,*

*NOM\_CMP\_INDICA=' ERREST',*

*NUME\_ORDRE = 4,*

*CRIT\_RAFF\_PE = 0.1,*

*NIVE\_MAX = 5),*

*QUALITE=' OUI',*

*INTERPENETRATION=' NON',*

*TAILLE=' OUI',*

*CONNEXITE=' OUI'*

)

*To judge contribution of mending of meshes, let us look at the radial constraints on the segment indicated on*

*[Figure 6.3.2-a], which is compared with a “reference” obtained by 3 uniform mendings of meshes: profit*

*the mendings of meshes based on the indicator of error is visible.*

*Line of postprocessing*

### ***Appear 6.3.2-a: Place of postprocessing***

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### ***Appear 6.3.2-b: Profile of constraint***

*One will find on the figures [Figure 6.3.2-c] and [Figure 6.3.2-d] the initial grid and the grid after 3 mendings of meshes based on the indicator of error.*

*An indication of the size (and thus of the time) of calculations between the calculation of reference (3 refinements uniforms) and calculation with 3 refinements based on the indicator of error is given in the table [Table 6.3.2-1].*

#### ***A number of nodes***

##### ***Computing time***

*Grid of reference*

*175 000*

*~3000 S*

*3 free refinements (either 4 calculations)*

*8 500*

*~60 S*

#### ***Table 6.3.2-1: indication of performances***

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***Appear 6.3.2-c: Initial grid***

***Appear 6.3.2-d: Grid after 3 mendings of meshes***

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### ***6.3.3 Calculation of the thermal transient***

***It is a question in this calculation case a thermal transient, two conditions of exchanges being imposed***

***in bottom and top of the structure. As the zone which will present a strong variation in temperature goes***

***to move in the structure (projection of a face), the strategy adopted for mending of meshes will hold some***

***count: it is necessary to reactualize the grid during the transient regularly. In practice, one subdivides the list of moments in blocks, inside these blocks of moments of calculation the grid will be the same one (and it***

***mending of meshes intervenes at the end of the block). There are thus 3 overlapping loops:***

***1) the loop on the NR blocks of moments;***

***2) the loop on mendings of meshes of the current block;***

***3) the loop (hidden in THER\_LINEAIRE) over the moments of the block.***

***That gives in the command file:***

***for num\_inst\_raff in arranges (1, nb\_raff-1):***

***The loop on the blocks of moments***

***num\_inst\_debut = (num\_inst\_raff-1) \*pas\_raff+1***  
***num\_inst\_fin = (num\_inst\_raff) \*pas\_raff***

***for num\_calc in arranges (1, nb\_calc-1):***

***The loop on mendings of meshes***

***yew (num\_calc == 1) gold (num\_inst\_raff == 1):***

***yew (num\_inst\_raff == 1):***

***If it is about the first block, a calculation is begun (thus not the “reuse one”)***

***EV [I] =THER\_LINEAIRE (MODELE=MOTH [I],***  
***CHAM\_MATER=CHMAT [I],***  
***EXCIT= (\_F (CHARGE=CHBF [I]),,***  
***\_F (CHARGE=CHFL [I]),),***  
***INCREMENT=\_F (LIST\_INST=LIST,***  
***NUME\_INIT=num\_inst\_debut-1,***  
***NUME\_FIN=num\_inst\_fin,),)***  
***else:***

***If it is about the initial grid of the block of moment (i.e. the last grid of the block of moment precedent), one again did not create grid (one thus did not carry out a PROJ\_CHAMP) and it is necessary***

***to go to seek the initial temperature in the result of the preceding block (last moment of the block precedent):***

***EV [I] =THER\_LINEAIRE (reuse=EV [I],***

***MODELE=MOTH [I],***  
***CHAM\_MATER=CHMAT [I],***

***TEMP\_INIT=\_F (EVOL\_THER=EV [I],***

***NUME\_INIT=num\_inst\_debut-1,***

***),***  
***EXCIT= (\_F (CHARGE=CHBF [I]),,***

*\_F (CHARGE=CHFL [I],),),  
INCREMENT=\_F (LIST\_INST=LIST,  
NUME\_INIT=num\_inst\_debut-1,  
NUME\_FIN=num\_inst\_fin,))*

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*Lastly, if it is about a mending of meshes, one will seek the initial temperature in a CHAM\_NO calculated with*

*moment of mending of meshes (cf further mending of meshes):*

*else:*

*EV [I] =THER\_LINEAIRE (  
MODELE=MOTH [I],  
CHAM\_MATER=CHMAT [I],*

*TEMP\_INIT = \_F (CHAM\_NO = CT),  
EXCIT= (\_F (CHARGE=CHBF [I],),  
\_F (CHARGE=CHFL [I],),),  
INCREMENT=\_F (LIST\_INST=LIST,  
NUME\_INIT=num\_inst\_debut-1,  
NUME\_FIN=num\_inst\_fin,))*



*yew num\_calc! = (nb\_calc-2):*

*It is necessary to re-mesh...*

*One starts by calculating the indicator of error:*

*EV [I] =CALC\_ELEM (reuse=EV [I],  
NUME\_ORDRE=num\_inst\_fin,*

*RESULTAT=EV [I],*

*MODELE=MOTH [I],*

*TOUT=' OUI',*

*CHAM\_MATER=CHMAT [I],  
EXCIT= (\_F (CHARGE=CHBF [I]),,  
\_F (CHARGE=CHFL [I]),),)*

*OPTION= (  
"FLUX\_ELNO\_TEMP",  
"ERTH\_ELEM\_TEMP",  
"ERTH\_ELNO\_ELEM"),)*

*MATHS [i+1] =CO ("MATH\_%d' % (i+1))*

*yew (detr\_ct == 1):  
TO DESTROY (CONCEPT=\_F (NOM=' CT'),)*

*yew num\_inst\_raff == 1:*

*If the first block is treated, there is no field of temperature to project on the new grid:*

*MACR\_ADAP\_MAIL (  
ADAPTATION=\_F (  
FREE = "RAFF\_DERA",*

*MAILLAGE\_N = MATHS [I],  
MAILLAGE\_NP1 = MATHS [i+1],*

*RESULTAT\_N=EV [I],*

*INDICATEUR=' ERTH\_ELEM\_TEMP',*

*NUME\_ORDRE = num\_inst\_fin,*

*NOM\_CMP\_INDICA=' ERTREL',*

*CRIT\_RAFF\_PE=0.03,*

*CRIT\_DERA\_PE=0.2,*

*NIVE\_MAX=4,*

*),  
QUALITE=' OUI',  
INTERPENETRATION=' OUI',  
TAILLE=' OUI',  
CONNEXITE=' OUI')*

*else:  
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*if the block of moment is not the first, it is necessary to project the temperature of the last moment of calculation of preceding block in a CHAM\_NO (called “CT here”) in order to use this CHAM\_NO as temperature initial on the new grid:*

*MACR\_ADAP\_MAIL (*  
*ADAPTATION=\_F (*  
*FREE = “RAFF\_DERA”,*

*MAILLAGE\_N = MATHS [I],*  
*MAILLAGE\_NP1 = MATHS [i+1],*

*RESULTAT\_N=EV [I],*

*INDICATEUR=' ERTH\_ELEM\_TEMP',*

*NUME\_ORDRE = num\_inst\_fin,*

*NOM\_CMP\_INDICA=' ERTREL',*

*CRIT\_RAFF\_PE=0.03,*

*CRIT\_DERA\_PE=0.2,*

*NIVE\_MAX=4,*

*),*

*MAJ\_CHAM=\_F (*

*RESULTAT= (“EV\_%d' % (I)),*

*NOM\_CHAM=' TEMP',*

**NUME\_ORDRE=num\_inst\_debut-1,**  
**CHAM\_MAJ=CO (“CT”),**  
**TYPE\_CHAM=' CHAM\_NO\_TEMP\_R',**  
**),**  
**QUALITE=' OUI',**  
**INTERPENETRATION=' OUI',**  
**TAILLE=' OUI',**  
**CONNEXITE=' OUI')**  
  
**detr\_ct = 1**  
  
**i=i+1**

*One defines the concepts Aster members in the grid:*

**MOTH [I] =AFFE\_MODELE (**  
**MAILLAGE=MATH [I],**  
**AFFE=\_F (TOUT=' OUI',**  
**PHENOMENE=' THERMIQUE',**  
**MODELISATION=' AXIS\_DIAG',),)**  
**#----- REORIENTATION OF GROUPS OF EDGE**

**#**

**MATHS [I] =MODI\_MAILLAGE (reuse =MATH [I],**  
**MAILLAGE=MATH [I],**  
**ORIE\_PEAU\_2D=\_F (GROUP\_MA= (“GM58”, “GM42”,**  
**“GM45”, “GM57”, “GM56”),),**  
**MODELE=MOTH [I],**  
**INFO=1,);**  
**#----- ASSIGNMENT THERMAL CHARACTERISTICS**

**-----**

**#**

**CHMAT [I] =AFFE\_MATERIAU (MAILLAGE=MATH [I],**  
**AFFE= (\_F (GROUP\_MA= (“GM47”, “GM48”),**  
**MATER=MATHPL,**  
**TEMP\_REF=20.0,)**  
**\_F (GROUP\_MA= (“GM46”),**  
**MATER=MATHBO,**  
**TEMP\_REF=20.0,),),)**

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```
CHFL [I] =AFFE_CHAR_THER_F (MODELE=MOTH [I],  
FLUX_REP=_F (GROUP_MA= ("GM57",),  
FLUN=ZERO,))  
# LOADING EXCHANGE ON PLATE Lower Side  
# CONNECTS COLD - HOT BRANCH  
#
```

```
CHBF [I] =AFFE_CHAR_THER_F (MODELE=MOTH [I],  
ECHANGE= (_F (GROUP_MA= ("GM45",),  
COEF_H=HP,  
TEMP_EXT=TBF,)),  
_F (GROUP_MA= ("GM42", "GM58"),  
COEF_H=HB,  
TEMP_EXT=TBF,)),))
```

```
# LOADING EXCHANGE ON PLATE Higher Side
```

```
# SHOCK 4th CATEGORY
```

```
#
```

```
CHTS4 [I] =AFFE_CHAR_THER_F (MODELE=MOTH [I],  
ECHANGE=_F (GROUP_MA= ("GM56"),  
COEF_H=HS,  
TEMP_EXT=TS4,))
```

*If one looks at the results at the last moment calculated, in particular the temperature on the line of post-*

*treatment already used in mechanics, cf [Figure 6.3.3-c], one notes the interest of the adaptation of grid. As one will be able to note it on the grids initial and adapted (with the last step of time), Cf [Figure 6.3.3-a] [Figure 6.3.3-b], the grid did not change in the vicinity close to this line of examination: the improvement of the calculated temperature comes from the zones that one refined by elsewhere. It will be also noticed that the refined grid is not very intuitive: it is there too about one of interest of the automatic adaptation of grid.*

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***Appear 6.3.3-a: Initial grid***

***Appear 6.3.3-b: Grid refined with the last  
no computing time***

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***Appear 6.3.3-c: Profile of temperature***

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## ***Note of use of calculations of sensitivity***

### ***Summary:***

***To calculate the sensitivity of a result to a given parameter supposes two interventions:***

- to define a data as being a significant parameter,*
- to activate the effective calculation of the sensitivity.*

*This document presents the whole of the operations to be made for that. It details each order concerned. An example illustrates the recommendations progressively.*

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**1 Introduction**

*Whatever the type of problem considered, thermal, mechanical, etc, Code\_Aster produces two types of results: buildings or total. It can be a field distributed on the grid, like temperature or constraints, or it can be a total value, like the rate of refund of energy. But in both cases, we represent ourselves this result like a function of data. These data are of varied origin. We find as follows:*

- *geometry of the field of calculation,*

- *mode of discretization through the choice of the grid,*
- *boundary conditions, like the imposed temperatures or displacements,*
- *loadings, like the sources of energy or the imposed pressures,*
- *material properties,*
- *choices of calculation, like the criteria of convergence.*

*The list is not exhaustive. Obviously, the result is sensitive to each one of these data. But obviously we do not propose automatic calculation of all the sensitivities. It is even of many cases where a quantified evaluation does not have a direction. Such as for example quantifying the sensitivity to*

*choice of the method of resolution of the matrix system related to calculation? Calculations of sensitivity available with Code\_Aster are restricted with the cases where the data is a real parameter, clearly identified in the data file, and where we know to derive the function which binds this data to the result.*

*Let us take some examples:*

- *choice of the grid: not, because it is not a real parameter,*
- *value of displacement or imposed pressure: yes,*
- *a number of steps of time: not, because it is an entirety,*
- *property of materials: yes and not; yes if the significant value is a pure Young modulus, not if one is interested in a property given by a curve point by point,*
- *criterion of convergence: not, because we do not know to derive the result,*
- *etc*

*We will detail the possibilities for each type of problem. It is enough to keep present at the spirit regulate stated higher: Code\_Aster treats only the cases where the result is in the form  $U(p)$ , where  $U$*

*$p$  is a visible real parameter and where the partial derivative exist. Then Code\_Aster will produce this*

*$p$*

*derivative partial, of comparable nature total or local that the result, this derivative being calculated with not nominal of operation.*

*The physical direction attached to the value of this derivative is far from being manifest. That to say of a derivative*

*of constraint compared to a value of imposed pressure which would be worth 1,983? Without same speech of*

*units... How to interpret these results? As we have just seen it, Code\_Aster calculates one partial derivative. The use of the derivatives is double in our opinion: a help with the comprehension of studied phenomenon or an insertion in a more total process.*

*Initially, the knowledge of derived from a result compared to parameters enriches the analysis by the phenomenon. That makes it possible for example to locate the zones where the influence of one change is largest. In the same way, one will be able to compare the respective influence of two data similar. If one must make a parametric study, one will be able to choose to do it only on the most significant parameters. Attention nevertheless to compare derivative homogeneous: sensitivities to an external pressure and a pressure interns for example.*

*Into the second time, one will be able to inject the values of the derivative obtained in a process iterative. It is the case of the algorithms of optimization, of retiming, which converge while being based on value of the function and its derivative. It is also the case of calculations of mechanics reliability engineer using method FORM.*

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***An example emblematic***

*We will illustrate the possibilities offered by Code\_Aster by examining an academic example in mechanics. This example will be followed until the development of its command set.*

*We consider a formed part of three materials. This part is embedded on its edge left. Two pressures are applied to the higher faces. We are interested in constraints in third material. More particularly, we would like to know the sensitivities*

*of these constraints to the various Young moduli and the imposed pressures.*

*Pressure A*  
*P Pressure B*  
*P*

*E and*  
*E and*

*Material 1: 1*

*1*  
*Material 2: 2*

*2*

*Material 3: E3 and*  
*3*

*Like let us know we it, the stress field is a function of the data:*

*= ( , , , ,*

*With*

*B*

*I*

*I*

*)*

*...*

*method,*

*grid,*

*geometry,*

*.*

*In accordance with the rules stated higher, Code\_Aster will be able to calculate each one of the*

*derivative*

*partial*

,  
,  
,  
,  
,

*To 1*

2  
3

*The result is a field expressed at the points of Gauss of each element; it is a tensor of*

*components,*

,  
*xx yy etc In the same way, the result  
will be a field expressed with*

*points of Gauss of each element. Each one of its components will be the derivative partial of*

*xx  
yy  
corresponding component of:*

,  
*, etc We will obtain them thus automatically*

*With*

*derivative partial of all the components of the tensor of the constraints compared to each one of  
parameters mentioned.*

*Before going further in the description of the calculation of sensitivity, we will specify the data  
numerical of the problem, expressed in international system.*

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With

$P = 1000$

$B$

$P = 8000$

$= 430000$

$1$

$= 380000$

$2$

$= 0.33$

$1$

,

$= 0.38$

$2$

,



0,06

0,06

0,06

= 130000

3

= 0 27

3

,

0,01

0,055

0,015

0,05

*By solving the static problem of mechanics in plane deformation, we obtain the fields of displacement and of constraint following.*

***Zone 1***

***Zone 2***

***Zone 3***

***Minis***

***Maximum***

***Minis***

***Maximum***

***Minis***

***Maximum***

***ux***

-0,0052 0,0066 -0,0072 0,0082 -0,0068 -0,0034

U y

-0,0150 0 -0,0313

-0,0143

-0,0174

-0,0131

xx

-189 468

68 192

-25 980

23 721

-20 213

-6 427

yy

-280 144

15 453

-8 827

23 335

-3 826

204

zz

-154 972

22 160

-11 165

77 065

-5 787

-1 935

xy

-140 950

2 859

-11 182

149

-6 466

1 974

*This stage of description, the reader is invited to test his physical direction and its appreciation of mechanical behaviors.*

**Question 1:** *To which pressures*

*and*

*, the stress field in the zone n° 3 is*

*more sensitive?*

**Question 2:** *Which is the order of influence of the three Young moduli 1*

, 2,3 on this same field  
constraints?

*If the answers are given randomly, a rapid calculation shows that 8,3% of the readers will find them two good answers. Users of Code\_Aster being experts, the rate of good answers will be very largely higher. We will decide between them with the following question:*

***Subsidiary question:*** *In which report/ratio are the maximum of the three derived ones xx in the zone*

*I*  
*n°3?*

*In the next chapter, we will show how to implement calculation with Code\_Aster which will answer these questions. The reader will see in chapter 4 if its answers were the maid...*

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***3***

***How to set up a calculation of sensitivity***

***3.1 Essence***

***A calculation of sensitivity is done thanks to the introduction of the concept of “significant parameter”. Otherwise***

***known as, if one wants to derive compared to the Young modulus from the one from materials from the field, one will define one***

**“significant parameter” which will represent this Young modulus. This parameter will be seen under two aspects:**

- like a constant equalizes with the face value of the Young modulus,
- as a concept by report/ratio to which one can derive.

For each desired derivation, one will carry out the following operations:

- to define the significant parameter with its value by the order: `DEFI_PARA_SENSI`,
- to use this significant parameter everywhere where its value intervenes in the orders (loadings, materials,...),
- to ask the operator of resolution to derive the result, with the key word: `SENSIBILITE= (...)`.

## 3.2

### **To define the significant parameters**

To define a significant parameter meets this double aim: to introduce into calculation a concept which is equal to the face value of the data and which is recognized like “sensitive”. For that, one uses order `DEFI_PARA_SENSI` [U4.31.06]. Its syntax is similar to that well-known of `DEFI_CONSTANTE`:

`PA = DEFI_PARA_SENSI (VALE = 1000.)`

One must thus thus define all the significant parameters of simulation.

We draw the attention to this

: the definition of a significant parameter does not engage automatically the calculation of the derivative. Calculation will be made only for the indicated parameters

later on. One can thus define much a priori and, for a given simulation, not derive of it that compared to some, even none. The thus definite data in excess will be used like simple constants.

In our example, we will define has minimum the five parameters for which we want to obtain derivatives:

`PA=DEFI_PARA_SENSI (VALE=1000.)`

`PB=DEFI_PARA_SENSI (VALE=8000.)`

`E1=DEFI_PARA_SENSI (VALE=430000.)`

`E2=DEFI_PARA_SENSI (VALE=380000.0)`

`E3=DEFI_PARA_SENSI (VALE=130000.0)`

In accordance with the preceding remark, nothing prohibits to us to define other parameters sensitive, even if we do not intend to be useful to us about it a priori.

*NU3=DEFI\_PARA\_SENSI (VALE=0.27)*

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### 3.3

#### **To use the significant parameters**

*The data associated with a significant parameter intervenes in general in a loading or in definition of a material. Each one of these orders will be activated by providing the parameter sensitive like entry. This entry will be seen by the order like a constant function being worth the value declared in the definition of the parameter.*

*In our example, the loadings in pressure will be declared as follows:*

```
pressure =  
AFFE_CHAR_MECA_F (MODELE=model  
PRES_REP= (_F (GROUP_MA=' BORD_H_1',  
PRES=PA),  
_F (GROUP_MA=' BORD_H_2',  
PRES=PB)  
)  
  
)
```

*The definition of three materials does without the same manner:*

```
mater_1 = DEFI_MATERIAU (ELAS_FO=_F (E=E1, NU=NU1))  
mater_2 = DEFI_MATERIAU (ELAS_FO=_F (E=E2, NU=NU2))  
mater_3 = DEFI_MATERIAU (ELAS_FO=_F (E=E3, NU=NU3))
```

*One will note that to use a concept of the type “parameter significant” instead of a numerical value*

*imply to use the definitions by functions of the loadings or materials. However, that remains similar to the cases where the values are defined by concepts of the type “constant”, technique well known users of Code\_Aster.*

### **3.4**

#### ***To launch the derivation of the principal field***

*Once the significant parameters were defined and used, it only remains to launch derivation. That is done while inserting the key word SENSITIVITY in the operator of calculation. This key word is followed list parameters by report/ratio to which one wishes to derive [U4.50.02]. In our example, us let us have:*

```
resultat=MECA_STATIQUE (
MODELE=modele,
CHAM_MATER=ch_mater,
EXCIT= (_F (CHARGE=encastre
```

```
),
_F (CHARGE=pression)),
```

```
SENSIBILITE= (E1, E2, E3, Pa, PB))
```

*This order will calculate simultaneously the field of displacements and the five field of the derivative this same displacement compared to each definite significant parameter. All these fields are expressed on the nodes of the grid.*

*For each type of problem, we will obtain the derivation of the principal field thus: temperature in thermics, displacement in static mechanics, etc*

### **3.5**

#### ***To derive the secondary fields***

*Principal field, are deduced from the secondary fields: heat flow, deformations, forced, etc These operations are activated by orders CALC\_ELEM and CALC\_NO. Thus the tensor of constraints is created by:*

```
resultat=CALC_ELEM (reuse =resultat,  
RESULTAT=resultat,  
MODELE=modele,  
CHAM_MATER=ch_mater,  
EXCIT= (_F  
(CHARGE=encastre),
```

```
_F (CHARGE=pression),  
OPTION=  
("SIEF_ELGA_DEPL",  
"SIEF_ELNO_ELGA")  
)
```

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*To obtain the derivative of the constraints, it is enough to insert the key word SENSITIVITY followed by*



*the list of  
significant parameters concerned.*

*resultat=*CALC\_ELEM (*reuse =resultat*,  
*RESULTAT=resultat*,  
*SENSIBILITE= (E1*,  
*E2*,  
*E3*,  
*Pa*,  
*PB)*,  
*MODELE=modele*,  
*CHAM\_MATER=ch\_mater*,  
*EXCIT= (\_F*  
*(CHARGE=encastre)*,

*\_F (CHARGE=pression)*,  
*OPTION=*  
*(“SIEF\_ELGA\_DEPL”*,  
*“SIEF\_ELNO\_ELGA”*  
*)*

*resultat=*CALC\_NO (*reuse=resultat*,  
*RESULTAT=resultat*,  
*SENSIBILITE= (E1*,  
*E2*,  
*E3)*,  
*OPTION=' SIGM\_NOEU\_DEPL'*)

**Note:**

- *When the key word SENSITIVITY is inserted in an order CALC\_ELEM or CALC\_NO, only the derived field are calculated.*
- *To calculate the derivative of a field to the elements, it is necessary as a preliminary to have calculated it standard field. On the other hand, that is useless for a field with the nodes because the operator CALC\_NO is satisfied to make an average with the nodes of a field to the elements.*

**3.6**

***Post-to treat the results***

*To print the fields of derivatives, it is enough to insert the key word SENSITIVITY in the order IMPR\_RESU. Here still, that will start only the impression of the derived fields compared to parameters concerned:*

```
IMPR_RESU (RESU=_F (FORMAT='MED',
RESULTAT=resultat)
)
```

```
IMPR_RESU (RESU=_F (FORMAT='MED',
RESULTAT=resultat,
```

```
SENSIBILITE= (E1, E2, E3, Pa, PB)))
```

*All the options of the order are obviously accessible.*

```
IMPR_RESU (RESU=_F (RESULTAT=resultat,
SENSIBILITE=
(E1,
E2,
E3,
Pa,
PB),
NOM_CHAM=
“SIEF_ELGA_DEPL”,
GROUP_MA='ZONE_3',
VALE_MAX='OUI',
VALE_MIN='OUI')
)
```

*Beyond the impression, all the orders which handle the results were equipped with key word SENSITIVITY: EXTR\_RESU, POST\_RELEVE\_T etc operation is similar to standard: the order carries out the operation required but on the selected derived fields and exclusively on them.*

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**4**

***Example: calculation, comments and results***

*Here the complete command set associated the example describes in chapter 2.*

*BEGINNING (CODE=\_F (NOM=' SENSM06A', NIV\_PUB\_WEB=' INTERNET'))*

*#*

*# 1. Grid*

*# 1.1. Reading of the grid*

*#*

*PRE\_GMSH (MODI\_QUAD=' OUI')*

*maill\_0=LIRE\_MAILLAGE ()*

*#*

*# 1.2. Naming of the groups*

*#*

*maill\_0= DEFI\_GROUP (reuse =maill\_0,*

*MAILLAGE=maill\_0,*

*CREA\_GROUP\_MA*

*=(*

*\_F (GROUP\_MA=' GM11', NOM=' BORD\_H\_1'),*

*\_F (GROUP\_MA=' GM12',*

*NOM=' BORD\_H\_2'),*

*\_F (GROUP\_MA=' GM13',*

*NOM=' BORD\_GAU'),*

*\_F (GROUP\_MA=' GM21',*

*NOM=' ZONE\_1'),*

*\_F (GROUP\_MA=' GM22',*

*NOM=' ZONE\_2'),*

```
_F (GROUP_MA=' GM23', NOM=' ZONE_3')),  
  
CREA_GROUP_NO=_F (GROUP_MA= ("GM1", "GM2", "GM3", "GM4"),  
  
NOM= ("COIN_BG", "COIN_BD", "COIN_HD", "COIN_HG"))  
#  
# 2. Definition of the functions  
# 2.1. Definition of the significant parameters  
#  
PA=DEFI_PARA_SENSI (VALE=1000.)  
PB=DEFI_PARA_SENSI (VALE=8000)  
E1=DEFI_PARA_SENSI (VALE=430000.)  
E2=DEFI_PARA_SENSI (VALE=380000.)  
E3=DEFI_PARA_SENSI (VALE=130000.)  
NU3=DEFI_PARA_SENSI (VALE=0.27)  
#  
# 2.2 Definition of the constants  
#  
NU1=DEFI_CONSTANTE (VALE=0.33)  
NU2=DEFI_CONSTANTE (VALE=0.38)  
#  
# 3. Definition of materials  
#  
mater_1=DEFI_MATERIAU (ELAS_FO=_F (E=E1,  
NU=NU1)  
)  
  
mater_2=DEFI_MATERIAU (ELAS_FO=_F (E=E2,  
NU=NU2)  
)  
  
mater_3=DEFI_MATERIAU (ELAS_FO=_F (E=E3,  
NU=NU3)  
)  
#  
# 4. The model  
#  
modele=AFFE_MODELE (MAILLAGE=maill_0,  
AFFE=_F  
(  
TOUT=' OUI',  
  
PHENOMENE=' MECANIQUE',
```

*MODELISATION=' D\_PLAN'))*

*#*

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*# 5. Loadings*

*#*

*encastre=AFFE\_CHAR\_MECA (MODELE=modele,  
DDL\_IMPO=\_F (GROUP\_NO=' COIN-BG',  
DY=0.0)*

*FACE\_IMPO=\_F (GROUP\_MA=' BORD\_GAU', DNOR=0.0))*

*pression=AFFE\_CHAR\_MECA\_F (MODELE=modele,  
PRES\_REP= (\_F (GROUP\_MA=' BORD\_H\_1',  
PRES=PA),*

*\_F (GROUP\_MA=' BORD\_H\_2', PRES=PB))*

*#*

*# 6. Installation of materials*

*#*

*ch\_mater=AFFE\_MATERIAU (MAILLAGE=maill\_0,  
MODELE=modele,  
AFFE= (\_F (GROUP\_MA=' ZONE\_1',  
MATER=mater\_1),*

```

_F (GROUP_MA=' ZONE_2', MATER=mater_2),
_F (GROUP_MA=' ZONE_3', MATER=mater_3)) )
#
# 7. Calculation with derivations
#
resultat=MECA_STATIQUE (MODELE=modele,
CHAM_MATER=ch_mater,
EXCIT= (_F (CHARGE=encastre),
_F (CHARGE=pression)),
SENSIBILITE= (E1, E2, E3, Pa, PB))
#
# 8. Other fields
# 8.1. Standard constraints
#
resultat=CALC_ELEM (reuse =resultat,
RESULTAT=resultat,
MODELE=modele,
CHAM_MATER=ch_mater,
EXCIT= (_F (CHARGE=encastre),
_F (CHARGE=pression)),
OPTION= (“SIEF_ELGA_DEPL”, “SIGM_ELNO_DEPL”))
#
# 8.2. The derivative of the constraints at the points of Gauss
#
resultat=CALC_ELEM (reuse =resultat,
RESULTAT=resultat,
SENSIBILITE= (E1, E2, E3, Pa, PB),
MODELE=modele,
CHAM_MATER=ch_mater,
EXCIT= (_F (CHARGE=encastre),
_F (CHARGE=pression)),

```

*OPTION= (“SIEF\_ELGA\_DEPL”, “SIGM\_ELNO\_DEPL”))*

*#*

*# 8.3. The derivative of the constraints to the nodes*

*#*

*resultat= CALC\_NO (reuse =resultat,*

*RESULTAT=resultat,*

*SENSIBILITE= (E1, E2, E3),*

*EXCIT= (\_F (CHARGE=encastre),*

*\_F (CHARGE=pression)),*

*OPTION= ' SIGM\_NOEU\_DEPL')*

*#*

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*# 9. Impressions of the results*

*#*

*# 9.1. The standard result*

*#*

*DEFUFI (IMPRESSION=\_F (NOM=' RESUGMSH', UNITE=37))*

*#*

*IMPR\_RESU (RESU=\_F (FORMAT=' GMSH', RESULTAT=resultat,*  
*FICHER=' RESUGMSH'))*

*#*

*IMPR\_RESU (RESU=\_F (FORMAT=' MED',*  
*RESULTAT=resultat))*

*#*

*# 9.2. The result of the derivative*

*#*

*IMPR\_RESU (RESU=\_F (FORMAT='MED',  
RESULTAT=resultat,*

*SENSIBILITE= (E1, E2, E3, Pa, PB)))*

*#*

*# 9.3. Extreme values of displacement and the constraints in each  
zone*

*#*

*IMPR\_RESU (RESU=\_F (RESULTAT=resultat,  
NOM\_CHAM= ("DEPL",  
"SIEF\_ELGA\_DEPL"),  
GROUP\_MA='ZONE\_1',  
VALE\_MAX='OUI',  
VALE\_MIN='OUI',  
FORMAT\_R='1PE12.5'))*

*#*

*IMPR\_RESU (RESU=\_F (RESULTAT=resultat,  
NOM\_CHAM= ("DEPL",  
"SIEF\_ELGA\_DEPL"),  
GROUP\_MA='ZONE\_2',  
VALE\_MAX='OUI',  
VALE\_MIN='OUI',  
FORMAT\_R='1PE12.5'))*

*#*

*IMPR\_RESU (RESU=\_F (RESULTAT=resultat,  
NOM\_CHAM= ("DEPL",  
"SIEF\_ELGA\_DEPL"),  
GROUP\_MA='ZONE\_3',  
VALE\_MAX='OUI',  
VALE\_MIN='OUI',  
FORMAT\_R='1PE12.5'))*

*#*

*# 9.4. Extreme values of derived from the constraints in zone 3*

*#*

*IMPR\_RESU (RESU=\_F (RESULTAT=resultat,  
SENSIBILITE= (E1, E2, E3, Pa, PB),  
NOM\_CHAM='SIEF\_ELGA\_DEPL',  
GROUP\_MA='ZONE\_3',  
VALE\_MAX='OUI',  
VALE\_MIN='OUI',  
FORMAT\_R='1PE12.3'))*



#

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*# 9.5. Test of nonregression on a component of derived from constraint*

#

*TEST\_RESU (RESU=\_F (RESULTAT=resultat,*

*SENSIBILITE=E3,*

*NOM\_CHAM=' SIGM\_NOEU\_DEPL', NOM\_CMP=' SIXX',*

*NUME\_ORDRE=1, GROUP\_NO=' COIN\_BD',*

*VALE=3.160121E-5, CRITERE=' RELATIF', PRECISION=1e-05,*

*REFERENCE=' NON\_REGRESSION'))*

#

*END ()*

*It is time to approach the result of our contest of chapter 2. Here extreme values of derived from the constraints compared to the two pressures and, in zone 3.*

***Derived compared to***

***Derived compared to***

***Minis***

***Maximum***

***Minis***

## **Maximum**

xx

-0,0068 0,0868 -2,537 -0,8063

yy

-0,0107 0,0107 -0,4770 0,0256

zz

-0,0046 0,0245 -0,7264 -0,2427

xy

-0,0206 0,0050 -0,8057 0,0250

*We note that the stress field is more sensitive to than with, the maximum report/ratio being located between 30 and 50.*

*For question 2 and the subsidiary question, we examine in the zone n° 3, the extreme values derivative of the stress field compared to the three Young moduli 1*

*, 2*

*and*

*3.*

## **Derived compared to 1**

**Derived compared to 2 Derived compared to 3**

**Maximum Mini minis Maximum Mini Maximum**

xx

-0,0014 0,0127 -0,0023 0,0173 -0,0577 -0,0273

yy

-0,0052 0,0043 -0,0083 0,0021 -0,0008 0,0161

zz

-0,0009 0,0044 -0,0024 0,0049 -0,0157 -0,0043

xy

-0,0028 0,0068 -0,0046 0,0048 -0,0182 0,0075

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*On these results, we note that the first two Young moduli have the same one roughly speaking influence on the stress field in the zone n° 3, with a light preponderance of 2. But their influence is exceeded by that of third parameter 3. If we look at the maxima of sensitivity in absolute value, we have the following reports/ratios:*

*xx*

*= 33*

*,*

*3*

*xx*

*= 54*

*,*

*4*

*xx*

*3*

*2*

*1*

*max*

*max*

*max*

yy

= 94

,

1

yy

= 10

,

3

yy

3

2

1

*max*

*max*

*max*

zz

= ,

3 20

zz

= 57

,

3

zz

3

2

1

*max*

*max*

*max*

$xy$

$= ,$   
 $3 \ 79$

$xy$   
 $= ,$   
 $2 \ 68$

$xy$

3

2

1

*max*

*max*

*max*

*Congratulations with the readers who will have found the good solutions!*

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***5 Comments***

## **Generals**

### **5.1**

#### ***Automation of the analysis of the orders***

*An attentive user who will consult the file of the messages produced by Code\_Aster will see that, by report/ratio from what had been requested, more orders were carried out. It is completely normal. The computing process of sensitivity needs to derive the unit from the orders where intervene the significant parameters. A preprocessing of the command set thus will duplicate each order by replacing its arguments by the derived arguments. New concepts are created, whose names are establish by an automatic mechanism. They are memorized in-house with calculation by order MEMO\_NOM\_SENSI. Their knowledge does not have any interest for the user insofar as all information is accessible by a couple (name from standard concept, significant name of parameter). In short, we can say that the maximum was made to simplify the task of the user.*

*Nevertheless, a reserve is essential: this mechanism of preprocessing is available only for treatment of the orders by batches. It is the default option besides of the order BEGINNING. Thus any command set produced by editor EFICAS by preserving the batch processing will be interpreted correctly. For a advanced use of the command set which involves the inactivation of batch processing, the automatic insertion of the derived orders does not take place. It is what occurs when one modifies with the hand the command set to insert basic Python instructions there. It is necessary then to make with the hand work derivation of the orders, the ones after the others, while memorizing names of the produced concepts.*

### **5.2 Performance**

***The calculation of a derivative is increasingly faster than the calculation of the minimal size.***

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***Date***

***:***

**20/12/02**

**Author (S):**

**NR. GREFFET Key**

**:**

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**Organization (S): EDF-R & D /AMA**

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**Note of calculation to buckling**

**Summary:**

**The objective of this documentation is to not present a methodological guide for an analysis of buckling**

**linear of a structure. One approaches mainly two functionalities of Code\_Aster there:**

- analysis of buckling linear, known as of Euler, through `MODE_ITER_SIMULT`, (option `TYPE_RESU: "MODE_FLAMB"`),**
- the calculation of the quasi-static evolution (operator `STAT_NON_LINE`) of the structure which presents not geometrical and behavioral linearities, which one seeks a limiting point, even the answer post-critical.**

**The first stage is, generally, a calculation of buckling of Euler, who will allow to know the modes of**

*buckling and corresponding critical loads. From the point of view of the originator, the knowledge of first mode and of its critical load is often sufficient, in order to be defined a margin of operation compared to the imposed loading: the multiplying coefficient enters the imposed loading and the critical load weakest the safety margin gives.*

### **Remarks**

- The knowledge of the first mode of buckling can also be used as indication to optimize management of nonlinear incremental calculation carried out thereafter. Indeed, with the approach of the load critical, one can then decide to modify piloting or to reduce the step of time, even to increase the iteration count of checking of balance in the method of residue, with each step of load.*
- The pace of the mode of buckling of Euler can also be used for to impose a geometrical defect initial on the structure, in order to make sure, amongst other things, that incremental nonlinear calculation will fork well on this mode.*

*The analysis of Euler being per linear definition, it does not make it possible to take into account relations of behavior inelastic or of the contact. It is then necessary to make a nonlinear calculation, which in quasi-static will be based on order STAT\_NON\_LINE of Code\_Aster. It is the traditional method incremental by residue in balance. The particular points of its use will be approached thereafter.*

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## *1 Analyze buckling of Euler*

*The calculation of the modes of buckling within the meaning of Euler [bib5] can be done by the operator of resolution problems with eigenvalues `MODE_ITER_SIMULT` (or `MODE_ITER_INV`). Within the framework of buckling, one with following typical syntax:*

```
MODP1 = MODE_ITER_SIMULT (MATR_A = RAMEP1,  
MATR_B = RAGEP1,  
TYPE_RESU = "MODE_FLAMB",  
CALC_FREQ = _F (OPTION = "BAND",  
CHAR_CRIT = (-2.4, - 2.2,),  
DIM_SOUS_ESPACE = 80,  
NMAX_ITER_SOREN = 80,))
```

*The argument of key word `MATR_A` must be the matrix of rigidity known as material, whereas the key word `MATR_B` awaits the geometrical matrix of rigidity. If operator `MODE_ITER_INV` had been employed, the arguments of key words `MATR_A` and `MATR_B` would be the same ones.*

*For recall, the modes of buckling are the clean modes of the problem to the eigenvalues according to:*

$$(K + \mu Kg) X = 0 \quad Kx = K$$

*G X*  
*K:*

*material*

*rigidity*

*of*

*stamp*

*With*

*K:*

*géométriqu*

*rigidity*

*of*

*stamp*

*E*

*G*

*:*

*eigenvalue*

*(=  $\mu$*

*- with  $\mu$ :*

*coefficient multiplica*

*T*

*tor*

*loading*

)

*Material rigidity (or rubber band) is calculated with option “RIGI\_MECA” of CALC\_MATR\_ELEM. Geometrical rigidity is calculated starting from the stress field solution of the linear problem (option “RIGI\_GEOM” of CALC\_MATR\_ELEM). Thus should have been carried out a static linear calculation before the use of MODE\_ITER\_SIMULT for buckling.*

*If the loading is composed of a fixed part (not controlled) and of a variable part, the coefficient multiplier of the loading should not, of course, relate that to the variable part. The contribution of the other part of the loading is found in the first member. Let us note FC the fixed loading and fv the controlled loading (proportional to  $\mu$ ). The problem with the eigenvalues becomes:*

$$(K + Kg (FC + \mu fv) X = 0 \quad (K + Kg (FC) X = kg (fv) X$$

*K:*

*material*

*rigidity*

*of*

*stamp*

*K G (FC):*

*géométriqu*

*rigidity*

*of*

*stamp*

*for*

*E*

*loading*

*controlled*

*not*

*With*

*Kg (fv):*

*géométriqu*

*rigidity*

*of*

*stamp*

*for*

*E*

*loading*

*variable*

*:*

*eigenvalue*

*(= -  $\mu$ )*

*In this case, it is thus necessary to solve two preliminary linear elastic problems, to be able to calculate the two different geometrical matrices of rigidity.*

*In order to be exhaustive, the presentation will relate to a structure subjected to imposed*

*displacements*

*as well as efforts, which will be the combination of a fixed loading and a variable loading that one will control with a coefficient growing being able to lead to buckling.*

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## **1.1**

### **Stage 1: Calculation (S) linear (S) preliminary (S)**

*One will be useful oneself of MECA\_STATIQUE. The structure, with a grid in elements of the type hull (elements of voluminal hulls type [bib3]), is subjected to boundary conditions of Dirichlet (CONDLIM) and of Neumann. These last break up into:*

- *WEIGHED: field of gravity,*
- *PRESPH: field of pressure imposed not controlled,*
- *PRESPS1: field of variable pressure imposed.*

*For the analysis of buckling, it is necessary to separate the constant efforts from those which variable (are controlled by a coefficient). One thus will make two linear static calculations. The first will be the case of the structure subjected to imposed displacements and the constant efforts, the second will see the structure subjected to displacements imposed and on the variable efforts.*

#### **Controlled loading:**

*RESC11P1 = MECA\_STATIQUE (MODEL = MODEL,  
CHAM\_MATER = CHMAT,  
CARA\_ELEM = CARAELEM,  
EXCIT = (\_F (LOAD = CONDLIM,),  
\_F (LOAD = PRESPS1,)),  
OPTION = "SIEF\_ELGA\_DEPL",*

*PLAN = "MOY",)*

***Loading not controlled:***

*RESC12P1 = MECA\_STATIQUE (MODEL = MODEL,  
CHAM\_MATER = CHMAT,  
CARA\_ELEM = CARAELEM,  
EXCIT = (\_F (CHARGE=CONDLIM),  
\_F (LOAD = WEIGHED),  
\_F (LOAD = PRESFH,)),  
OPTION = "SIEF\_ELGA\_DEPL",  
PLAN = "MOY",)*

*One will use the stress field to calculate the associated matrices of geometrical rigidity, for two loadings:*

*SIGC11P1 = CREA\_CHAMP (TYPE\_CHAM = "ELGA\_SIEF\_R",  
OPERATION = "EXTR",  
RESULT = RESC11P1,  
NOM\_CHAM = "SIEF\_ELGA\_DEPL",  
TYPE\_MAXI = "MINI",  
TYPE\_RESU = "VALE",)  
#  
REGC11P1 = CALC\_MATR\_ELEM (OPTION = "RIGI\_GEOM",  
MODEL = MODEL,  
CARA\_ELEM = CARAELEM,  
SIEF\_ELGA = SIGC11P1,)*

*REGC11P1 is thus the geometrical matrix of stiffness associated the variable case of loading (PRESF1).*

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*One calculates, in the same way, the geometrical matrix of stiffness for the constant loading (WEIGHED and*

*PRESPH), starting from RESC12P1:*

```
SIGC12P1 = CREA_CHAMP (TYPE_CHAM = "ELGA_SIEF_R",  
OPERATION = "EXTR",  
RESULT = RESC12P1,  
NOM_CHAM = "SIEF_ELGA_DEPL",  
TYPE_MAXI = "MINI",  
TYPE_RESU = "VALE",)
```

#

```
REGC12P1 = CALC_MATR_ELEM (OPTION = "RIGI_GEOM",  
MODEL = MODEL,  
CARA_ELEM = CARAELEM,  
SIEF_ELGA = SIGC12P1,)
```

*It remains to calculate the matrix of material rigidity for the total loading:*

```
REMEP1 = CALC_MATR_ELEM (OPTION = "RIGI_MECA",  
MODEL = MODEL,  
CHAM_MATER = CHMAT,  
CARA_ELEM = CARAELEM,  
CHARGE = (CONDLIM, WEIGHED,  
PRESPH, PRESPS1,))
```

*All the elementary matrices are calculated, the following stage is thus their assembly:*

```
NUP1 = NUME_DDL (MATR_RIGI = REMEP1,)
```

#

```
RAMC1P1 = ASSE_MATRICE (MATR_ELEM = REMEP1,  
NUME_DDL = NUP1,)
```

#

```
RAGEP1 = ASSE_MATRICE (MATR_ELEM = REGC11P1,  
NUME_DDL = NUP1,)
```

#

```
RAGC12P1 = ASSE_MATRICE (MATR_ELEM = REGC12P1,  
NUME_DDL = NUP1,)
```

*One summons then the matrices of material rigidity (RAMC1P1) and geometrical (RAGC12P1) corresponding to the case of constant loading:*

```
RAMEP1 = COMB_MATR_ASSE (COMB_R = (_F (MATR_ASSE = RAMC1P1,  
COEF_R = 1.0,)),  
_F (MATR_ASSE = RAGC12P1,  
COEF_R = 1.0,)),)
```

*The two matrices necessary to the calculation of the modes of buckling are thus built.*

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**1.2**

## **Stage 2: Calculation of the modes of Euler**

*He can be useful to make tests of STURM (operator IMPR\_STURM) on the interval of research on which one wants to find the cases of buckling. Thus, that will make it possible to optimize the size of the interval and*

*to control the good course of later modal calculation since one will know the number in advance of existing modes. Syntax is:*

```
IMPR_STURM (MATR_A = RAMEP1,  
MATR_B = RAGEP1,  
TYPE_RESU = "MODE_FLAMB",  
CHAR_CRIT_MIN = -2.4,
```



*CHAR\_CRIT\_MAX = -2.2,)*

*Once the interval of search for critical load of buckling chosen, one can then implement MODE\_ITER\_SIMULT as follows:*

```
MODP1 = MODE_ITER_SIMULT (MATR_A = RAMEP1,
MATR_B = RAGEP1,
TYPE_RESU = "MODE_FLAMB",
CALC_FREQ = _F (OPTION = "BAND",
CHAR_CRIT = (-2.4, - 2.2,),
DIM_SOUS_ESPACE = 80,
NMAX_ITER_SOREN = 80,),)
```

### **Notice**

*If the algorithm does not converge or if the number of modes is not that predicted by IMPR\_STURM, it can be useful to increase the values of DIM\_SOUS\_ESPACE and NMAX\_ITER\_SOREN.*

*One normalizes the modes [bib6], only while being useful oneself of the degrees of freedom of translation:*

```
MODP1 = NORM_MODE (reuse = MODP1
MODE = MODP1,
= "TRAN NORMALIZES",)
```

*The modes can then be post-treated.*

### **Remarks**

*It is essential to check that the geometrical stiffness of the selected model is well one option available in Code\_Aster (for example, it is not the case of the DKT).*

*A finer discretization leads normally to a fall of the critical loads.*

*The discretization must be ready to collect the modes of buckling, knowing that these modes can generate localised deformations (folds). The preliminary calculation of dynamic modes can constitute a first indication on the quality of the grid, although these modes can be very different from the modes of buckling.*

*The critical loads of the various modes are proportional to the Young modulus E.*

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***Quasistatic nonlinear study of the structure***

*This stage is justified if the structure has strong not linearities, whose analysis of Euler cannot to hold account. The operator of resolution of the nonlinear problems into quasi-static names himself STAT\_NON\_LINE [bib7].*

*These nonlinearities can be related to the material which can have an elastoplastic behavior [bib8], as in the example which will follow. The taking into account of the contact, even of friction, is another source of nonlinearities. One can also quote the case of the following loadings, like pressure ([bib1] and [bib2] for the elements of voluminal the hulls type), which requires an approach nonlinear.*

*For the study of a structure potentially unstable or likely to know a limiting point, which be thus likely to meet a junction in solution during the evolution of the loading, it is often useful to be able to choose a branch of particular solution (often the physical solution when it is a priori defined without ambiguities). For that, the user can have to introduce a defect initial which “will force” the structure to fork on the branch of particular solution. Several methods exist to define this defect.*

- One the most adapted of is of prédéformer slightly the structure according to the pace of the mode of Euler of buckling corresponding to the branch which one wants to follow. The amplitude of this predeformation must be weak, for example less 1/10ème thickness for one mean structure. The ideal being to find the defect minimal which is compatible with one satisfactory performance of the algorithm of residue in balance. Indeed, a too weak defect can involve a difficulty of convergence of the residue, mainly in the case of one*

*piloting in effort.*

- *The geometrical defect can also be defined by experimental measurements of the real part whose geometry could not be perfect.*
- *The defect can also take the form of a disturbance of the loading (misalignment, addition of a loading located,...) or of the mechanical characteristics of material (local weakening of the Young modulus, for example). He can nevertheless be then more difficult to adapt the defect to the mode of wished buckling, especially if the structure presents relatively close modes.*

## **Notice**

*In certain cases, even on the nondisturbed problem, the loading is such as it causes desired junction.*

*One of the other particular points, related to instability, is the choice of the technique of piloting of algorithm STAT\_NON\_LINE. Indeed, traditional piloting in effort is not adapted any more because it cannot*

*to collect an unstable branch of solution. In the same way, with the approach of a limiting point, convergence with*

*piloting in effort will become increasingly difficult, the matrix of tangent rigidity becoming singular. It is then necessary to reduce the increment of load and to increase the maximum number of iteration to continue calculation.*

*There are techniques of piloting [bib9] making it possible to circumvent these numerical difficulties.*

*Among*

*methods suggested by Code\_Aster, that called by length of arc [bib12] (option TYPE=' LONG\_ARC' of the key word PILOTING in STAT\_NON\_LINE), which is adapted for instabilities of the buckling type, in the case of “soft” snap-backs possible [bib13]. In the case of snap-backs more brutal, Crisfield proposes an alternative [bib13], nonavailable in version 6 of Code\_Aster.*

*Other methods exist, like that of Riks [bib14] (nonavailable either), which treats also it dynamic case.*

*If one wants only to obtain the point limits, including with a good precision, a piloting in loading can be enough, with the proviso of managing well the parameters of step of increment of load (SUBD\_PAS and SUBD\_PAS\_MINI of the key word INCREMENT) and of maximum iteration count authorized*

*(ITER\_GLOB\_MAXI of CONVERGENCE). It can also be useful, with the approach of the limiting point, of more*

*to use the tangent matrix reactualized for the solvor, since it is quasi-singular. One can then to be satisfied not to reactualize this matrix with each calculation (parameters REAC\_INCR and The REAC\_ITER) or, in worst of the cases, to adopt the basic elastic matrix (PREDICTION=' ELASTIQUE' and MATRICE=' ELASTIQUE' of the key word NEWTON).*

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*Here an example of use of STAT\_NON\_LINE for an elastoplastic calculation into large displacements ([bib4] for the elements employed, which are of voluminal hulls type), with piloting in efforts:*

```

RESU = STAT_NON_LINE (MODEL = MODEL,
CHAM_MATER = CHMAT,
CARA_ELEM = CARAELEM,
EXCIT = (_F (LOAD = CONDLIM,
TYPE_CHARGE = "FIXE_CSTE"),),
_F (LOAD = WEIGHED,
TYPE_CHARGE = "FIXE_CSTE"),),
_F (LOAD = PRESFH,
FONC_MULT = FONCMUL2,
TYPE_CHARGE = "SUIV"),),
_F (LOAD = PRESF1,
FONC_MULT = FONCMUL,
TYPE_CHARGE = "SUIV"),),),
COMP_INCR = (_F (RELATION = "VMIS_ISOT_TRAC",
COQUE_NCOU = 1,
DEFORMATION = "GREEN_GR",
GROUP_MA = ("RING", "ROOF",
"RINGS", "SGOU"),
), ),
COMP_ELAS = _F (RELATION = "ELAS",

```

COQUE\_NCOU = 1,  
DEFORMATION = "GREEN\_GR",  
GROUP\_MA = "LTIGE",),  
INCREMENT = \_F (LIST\_INST = L\_INST1,  
NUME\_INST\_FIN = 14,  
SUBD\_PAS = 4,  
SUBD\_PAS\_MINI = 1.E-9),  
NEWTON = \_F (REAC\_INCR = 1,  
PREDICTION = "TANGENT",  
STAMP = "TANGENT",  
REAC\_ITER = 1),  
CONVERGENCE = \_F (RESI\_GLOB\_RELA = 1.E-06,  
ITER\_GLOB\_MAXI = 40,  
STOP = "YES"),  
SOLVEUR = \_F (METHOD = "MULT\_FRONT",  
RENUM = "MONGREL",),)

### **Remarks**

.  
*One uses the tangent matrix reactualized with each calculation, while authorizing under step division of load.*

.  
*The imposed pressures are following efforts (TYPE\_CHARGE=' SUIV').*

.  
*In the case of a modeling in solid elements, the tensor of deformation recommended in great displacements is "SIMO\_MIEHE".*

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*If one wants to replace piloting in effort by a method by length of arc, it is enough to write:*

```
RESU = STAT_NON_LINE (MODEL = MODEL,
CHAM_MATER = CHMAT,
CARA_ELEM = CARAELEM,
EXCIT = (_F (LOAD = CONDLIM,
TYPE_CHARGE = "FIXE_CSTE"),
_F (LOAD = WEIGHED,
TYPE_CHARGE = "FIXE_CSTE"),
_F (LOAD = PRESPPH,
FONC_MULT = FONCMUL2,
TYPE_CHARGE = "SUIV"),
_F (LOAD = PRESPS1,
TYPE_CHARGE = "FIXE_PILO"),),),
COMP_INCR = (_F (RELATION = "VMIS_ISOT_TRAC",
COQUE_NCOU = 1,
DEFORMATION = "GREEN_GR",
GROUP_MA = ("RING", "ROOF",
"RINGS", "SGOU"),
), ),
COMP_ELAS = _F (RELATION = "ELAS",
COQUE_NCOU = 1,
DEFORMATION = "GREEN_GR",
GROUP_MA = "LTIGE"),),
INCREMENT = _F (LIST_INST = L_INST1,
NUME_INST_FIN = 14,
SUBD_PAS = 4,
SUBD_PAS_MINI = 1.E-9),),
NEWTON = _F (REAC_INCR = 1,
PREDICTION = "TANGENT",
STAMP = "TANGENT",
REAC_ITER = 1),),
CONVERGENCE = _F (RESI_GLOB_RELA = 1.E-06,
ITER_GLOB_MAXI = 40,
STOP = "YES"),),
PILOTING = _F (GROUP_NO = "G",
TYPE = "LONG_ARC",
NOM_CMP = ("DY"),),
COEF_MULT = 7. ),)
```

## **Remarks**

.  
*In version 6 of Code\_Aster, one cannot control following forces.*

.  
*For piloting by length of arc, it, in general, is recommended that GROUP\_NO all the structure contains.*

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*To finish, let us quote two articles of Crisfield which give a good general vision of the problems and methods related to nonlinear calculations being able to present various types of instabilities ([bib15] and [bib11]).*

*Some case-tests of treating Code\_Aster of buckling:*

*Modes of Euler:*

· *sdl504*

· *sdl505*

· *sll103*

· *sll105*

· *sll403*

· *sll404*

· *ssl110*

*Modes of Euler and nonlinear calculation:*

· *ssnl123*

*Nonlinear calculation:*

· *ssnl502*

· *ssnp305: calculation until a snap-through*

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[15]

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*Date:*

17/06/04

*Author (S):*

**S. CAMBIER, C. DESCELIERS** *Key*

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***Instruction manual***

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***Document: U2.08.05***

***Digital simulation of Monte Carlo***

***Summary:***

***This document gives the elements for the implementation of digital simulations of Monte Carlo to leave***

***command file and operators of random generation. The three principal ingredients are:***

***.  
A loop Python,***

***.  
A generator of random variables (GENE\_VARI\_ALEA) and/or a generator of matrices random (GENE\_MATR\_ALEA) for dynamics, and/or a generator of random functions (GENE\_FONC\_ALEA),***

***.  
The calculation of the statistical estimators (CALC\_FONCTION).***

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***Author (S):***

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### ***1 General information***

***The numerical method of Monte Carlo makes it possible to calculate various statistical sizes from one random variable or of a stochastic process. In the context of a mechanical calculation (or thermomechanical,...) , the principle is to obtain NS achievements of this random variable or it stochastic process then to deduce the required statistical estimates from them. Three principal stages of the Monte Carlo method are:***

- 1) Generation of a sample of NS achievements of the random data of entry of the model mechanics,***
- 2) Calculation***

***NS sizes results corresponding to these data,***

- 3) Calculation of the statistical estimators of the required sizes.***

***In the Monte Carlo method simple or direct that one uses, each NS calculations can be fact independently of the others. In order to reduce the size memory necessary, the NS generations and calculations are thus carried out sequentially in a loop with destruction of the results useless intermediaries.***

## ***2***

***Buckle Python in the command file Aster***

***In order to allow the use of a loop python in the command file, it is first of all necessary to position key word PAR\_LOT of the order BEGINNING on the value "NOT":***

***BEGINNING (CODE=\_F (NAME = "SDNS001"), PAR\_LOT='NON')***

*The loop python in it even starts with the order for, and includes all the lines of even indentation*

```
for K in arranges (1,1000):  
  COMMANDE1  
for m in arranges (1,500):  
  COMMANDE2  
  COMMANDE3
```

*In this example, one finds two loops python encased. The first, on the variable K, allows to carry out 999 times instructions COMMANDE1, the second loop python, and COMMANDE3. second internal loop python, on the variable m makes it possible COMMANDE2 to be carried out 499 times for each K going from 1 to 999.*

### ***Notice***

*There is no instruction of end of loop. The indentations alone mark the body of the instruction “for”.*

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### **3** **Generation of random variables**

*The terminology of random generators must here be taken in the broad sense. These random variables can be with values scalar, matric, or even functional calculuses (stochastic process).*

*Code\_Aster is able to generate of such random variables respectively by the orders GENE\_VARI\_ALEA, GENE\_MATR\_ALEA and GENE\_FONC\_ALEA.*

*The random variables can be parameters of the model finite elements (parameters materials, values of a play, a stiffness of thrust rubber bands, a modulus Young, etc). In it case one models uncertainties of modeling by a parametric probabilistic approach and one use GENE\_VARI\_ALEA then.*

*In dynamics of the structures, these random variables can also be the generalized matrices of mass, stiffness and damping and/or local parameters of the model to the finite elements. In this case, one models at the same time uncertainties of model and modeling by an approach not-parametric probabilist, and GENE\_MATR\_ALEA is used.*

*These random variables with scalar or matric values follow laws of built probabilities by the use of the principle of the maximum of entropy and information available (see [R4.03.05]).*

*The random variable can still be a function. Operator GENE\_FONC\_ALEA allows to generate trajectories of a monodimensional multivariate stochastic process (i.e with several components and indexed on only one variable) stationary of null average starting from its density spectral of power. In the case of a transitory dynamic calculation, one can thus generate temporal loadings known by their matrix interspectrale.*

*With less than one contrary indication using key word INIT\_ALEA, all the values generated by*

*three orders GENE\_VARI\_ALEA, GENE\_MATR\_ALEA and GENE\_FONC\_ALEA are statistically independent between them inside the same execution of Code\_Aster. A contrario, of one execution with the other, a strictly identical command file (even calls to the three orders in the same order with the same arguments) will provide the same ones exactly results. If one wishes to generate results statistically independent of an execution with the other, then it is necessary to use key word INIT\_ALEA with values raising the number of terms used in the former executions.*

**Caution:**

*The generator of random variable used is that of the module “random” of Python. It depends on the version of Python exploited by Code\_Aster. Not converged results statistically can thus vary from one version to another of Code\_Aster or one platform with the other, if the version of Python is not the same one and that between the two poured the module random evolved/moved (case between Python 2.1 and 2.3).*

**Note:**

*In version Python 2.3, the period of the generator is  $2^{**} 19937-1$  (Mr. Matsumoto and T.*

*Nishimura, Mersenne Twister: With 623-dimensionally equidistributed uniform pseudorandom number generator, ACM Transactions on Modeling and Computer Simulation vol. 8, No 1, January pp.3-30 1998.)*

**Note:**

*The module “random” of Python provides an alternative to order GENE\_VARI\_ALEA to generate random variables of which the densities are not available in this order.*

**4 Estimators statistics**

*Of a sample of NS achievements of the quantity of interest, one can deduce the estimates from them from statistical sizes like the average, the standard deviation,... The estimators must in general be calculated in two times. Initially, inside the loop of the intermediaries quantity then in a second after the loop the estimators are calculated to them-even.*

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*Let us take for example a sample of spectra of oscillators  $\{SRO (; p)\}_{1 \leq p \leq NS}$ , for which for each pulsation we wish to calculate the moments of order 1 and 2. These moments have for expression:*

*1 NS*

*m (,) =*

*SRO (,),*

*1*

*p*

*NS p 1=*

*1 NS*

*2*

*m (,) =*

*SRO (,).*

*2*

*p*

*NS p 1=*

*The two sums above are easily calculable inside the loop, it is simply necessary to differentiate the case from the initialization of the sum and the cases of incrementing from this*

*summon.*

*Here, for example, a command file purified allowing to evaluate m (,):*

*2*

*for K in arranges (1, ns+1):*

*MATM=GENE\_MATR\_ALEA (MATR\_MOYEN=MASSE, DELTA=0.2)*

*MATK=GENE\_MATR\_ALEA (MATR\_MOYEN=RIGID, DELTA=0.2)*

*MATD=GENE\_MATR\_ALEA (MATR\_MOYEN=AMORT, DELTA=0.2)*

*generation of one*





*CALC\_FONCTION. Sum SRO (, p) 2*

*,  
is stored, with the fur is as them*

*achievements are produced, in M2\_3 using key words POWER and COMB of order CALC\_FONCTION, intermediate functions M2\_0 and M2\_1 and order TO DESTROY. All various produced concepts (MATM, MATK, MATD, DYNA, SPO, A CC1, etc) must be destroyed at the end of each iteration except for M2\_3, of course. Lastly, one time the NS iterations carried out, the function  $m(,)$  is evaluated and corresponds to the object*

*2  
M2  
product at the end of the example.*

**Note:**

*When order GENE\_FONC\_ALEA is used, there is the possibility of not to use of loop python. The principle is then to generate “end to end” several temporal (key word NB\_TIRAGE in GENE\_FONC\_ALEA) and post-to treat the results with order CALC\_INTE\_SPEC. Case-test ZZZZ180 [V1.01.180] gives an example of such a use.*

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**5**  
*Example in transitory dynamics*

**Principle of deterministic calculation**

*One is based on the SDNS01a case-test concerning the response of a rectangular plate with one*

*butted elastic subjected to a deterministic impulse load.*

*One builds the solution of the average dynamic model reduced (determinist) using one traditional sequence operators (ASSE\_MATRICE, MODE\_ITER\_SIMULT, MACRO\_PROJ\_BASE ....)*

*One is interested in the answer of the system calculated by DYNA\_TRAN\_MODAL, and more exactly with*

*standardized spectra of the answers and with the temporal observations (fields of displacement, speed, acceleration, constraints, etc).*

### ***Principle of probabilistic calculation***

*The stiffnesses of thrusts are made random as well as the generalized matrices of mass, of stiffness and of damping.*

*The achievements of the corresponding stochastic transitory answer are calculated by the method of digital simulation of direct Monte Carlo with NS simulations using a loop Python the structure is:*

### ***Beginning buckles, for $p = 1, \dots, NS$ :***

*has) Generation of the pième achievements of the random variables (parametric approach) with assistance of GENE\_VARI\_ALEA.*

*Generation of the pième achievements of the random generalized matrices of mass, of stiffness and of damping using GENE\_MATR\_ALEA (nonparametric approach).*

***These matrices are not diagonal and thus require a full storage.***

*b) Calculation of the pème realization  $Q_n(T; p)$  solution of the stochastic matrix system with non-linearities of shocks, entirety  $N$  being the dimension of the small-scale model. This realization is the solution of the traditional matrix system whose matrices are the achievements previously generated. Calculation is thus carried out by DYNA\_TRAN\_MODAL.*

*c) Extraction of the physical ddls in displacement  $\&Z N(T; p)$  for preset ddls, via I operator RECU\_FONCTION.*

*Construction of the standardized spectra*

*S has ( $; p$ ) of the answers of the ddls*

*J  
&Z N(T; p) by operator CALC\_FONCTION (SPEC\_OSCI).*

*I  
D) Evaluation using operator CALC\_FONCTION of the contributions to the estimators averages  $m$*

*^  
(, ; )*

*I*

*p*

*J*

*, of the moments of order two m*

$\wedge$

( ,

; )

2

*p*

*J*

*, of the values*

*max. extremes S<sup>^</sup>*

*(; p)*

*J, max*

*and min. S<sup>^</sup>*

*(; p)*

*J, min*

*of sample for the spectra*

*standardized:*

*m*

$\wedge$

*(; p) = S (; p) + m*

$\wedge$

*(; p -)*

1

1 *J*

*J*

1 *J*

,

*m*

$\wedge$

*(; p) = S (; p) 2 + m<sup>^</sup> (; p -)*

1

2 *J*

*J*

2 *J*

,

*S<sup>^</sup>*

*(; p) = max*

*J, max*

*{S (; p S<sup>^</sup>*

),

*( ,;*

$J$   
 $J, \max$   
 $p - \}$   
 $)$   
 $1,$   
 $S^{\wedge}$   
 $(; p) = \text{Min}$   
 $J, \min$   
 $\{S (; p S^{\wedge}$   
 $\},$   
 $(, ;$   
 $J$   
 $J, \min$   
 $p - \}$   
 $)$   
 $1 .$

**End of loop.**

Following the loop, the averages, the standard deviations, the max. extreme values and min. of sample for the standardized spectra can be evaluated:

$1$   
 $1$   
 $m (,) =$   
 $m$   
 $\wedge$   
 $(; N)$   
 $1 J$   
 $1 J$   
 $S, m$   
 $(,) =$   
 $m$   
 $\wedge$   
 $(; N).$   
 $N$   
 $2 J$   
 $2 J$   
 $S$   
 $S$   
 $NS$   
 $2$   
 $(,)$   
 $J$

= m2 (,)

J

- 1

m (,)

J

,  
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**Command file purified corresponding:**

*# SDNS01A: PROBABILISTIC MODEL NONPARAMETRIQUE D A PLATE WITH ELASTIC THRUST  
BEGINNING (PAR\_LOT='NON')*

*# ----- Construction of the average model finite elements then reduction on  
elastic modes using the following orders:*

*AFFE\_MODELE, AFFE\_CARA\_ELEM, CALC\_MATR\_ELEM, ASSE\_MATRICE,  
MODE\_ITER\_SIMULT,...*

*MACRO\_PROJ\_BASE (BASE=MODE200, NB\_VECT=5,*

**PROFILE = "FULL",**

*MATR\_ASSE\_GENE= (\_F (MATRIX = CO ("MA\_G"), MATR\_ASSE = MATM),...*

*# ----- Preparation of the loop of simulations of Monte Carlo*

*ns=50 # 50 achievements of the stochastic processes (50 pullings)*

*DELTA\_M = 0.2 # scatter coefficients*

*DELTA\_K = 0.2*

**DELTA\_D = 0.2**

*# ----- Beginning of the loop of simulations of Monte Carlo  
for K in arranges (1, ns+1):*

*# Generation of the random achievements of the generalized matrices of mass,  
# stiffness and damping*

**MATM = GENE\_MATR\_ALEA (MATR\_MOYEN = MA\_G, COEF\_VAR = DELTA\_M)**

**MATK = GENE\_MATR\_ALEA (MATR\_MOYEN = RI\_G, COEF\_VAR = DELTA\_K)**

**MATD = GENE\_MATR\_ALEA (MATR\_MOYEN = AM\_G, COEF\_VAR = DELTA\_D)**

*# Generation of a random realization of the stiffness of shock*

**KN = GENE\_VARI\_ALEA (TYPE=' GAMMA',**

**BORNE\_INF=0.,**

**VALE\_MOY=25000.,**

**COEF\_VAR=0.01)**

**VKN = KN ["NO.", 1]**

*# Calculation of a random realization of the stochastic process "answer  
# dynamic"*

**DM=DYNA\_TRAN\_MODAL (METHODE=' EULER',**

**MASS\_GENE = MATM,**

**RIGI\_GENE = MATK,**

**AMOR\_GENE = MATD,**

**INCREMENT=\_F (INST\_INIT = 0. ,**

**INST\_FIN=4.,**

**NOT = 0.00005),**

**EXCIT=\_F (VECT\_GENE = IM\_G,**

**FONC\_MULT = IMPULF),**

**CHOC=\_F (NOEUD\_1 = "N3201",**

**OBSTACLE = PLANZ, PLAY = 0.002,**

**RIGI\_NOR = VKN,**

**RIGI\_TAN = 0. , COULOMB = 0.),)**

*# Calculation of the SRO of the ddl of observation 3201*

**ACC3201=RECU\_FONCTION (RESU\_GENE = DM,**

**NOM\_CHAM=' ACCE',**

**NOM\_CMP=' DZ',**

**NOEUD=' N3201')**

**SPO3201= CALC\_FONCTION (SPEC\_OSCI=\_F (**

**NATURE=' ACCE',**

**FONCTION=ACC3201,**

*METHODE=' NIGAM',  
NORME=9.81,  
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*LIST\_FREQ=LFREQ,  
AMOR\_REDUIT= (0.001)),  
INTERPOL=' LOG',)*

*# Calculation of the statistical estimates*

*yew k==1: # initialization with the first realization*

*UP3201 = CALC\_FONCTION (COMB=\_F (FONCTION=SPO3201, COEF=1.),)*

*INF3201 = CALC\_FONCTION (COMB=\_F (FONCTION=SPO3201, COEF=1.),)*

*M1\_3201 = CALC\_FONCTION (COMB=\_F (FONCTION=SPO3201, COEF=1.),)*

*M2\_3201 = CALC\_FONCTION (PUISSANCE=\_F (FONCTION=SPO3201, EXPOSANT=2),)*

*else:*

*UP1 = CALC\_FONCTION (ENVELOPPE=\_F (FONCTION= (UP3201, SPO3201),*

*CRITERE=' SUP'),) # Maximum of sample*

*INF1 = CALC\_FONCTION (ENVELOPPE=\_F (FONCTION= (INF3201, SPO3201),*

*CRITERE=' INF'),) # Minimum of sample*

*M1\_2 = CALC\_FONCTION (COMB= (\_F (FONCTION=SPO3201, COEF=1.),*

*\_F (FONCTION=M1\_3201, COEF=1.))) # Summons*

*M2 = CALC\_FONCTION (PUISSANCE=\_F (FONCTION=SPO3201, EXPOSANT=2),*

*M2\_2 = CALC\_FONCTION (COMB= (\_F (FONCTION=M2, COEF=1.),*

*\_F (FONCTION=M2\_3201, COEF=1.))) # Summons squares*

*# Renamings and destruction (bus concepts not réentrant)*

*TO DESTROY (CONCEPT=\_F (NOM= (UP3201, INF3201, M1\_3201, M2\_3201, m2)))*

*UP3201= CALC\_FONCTION (COMB=\_F (FONCTION=UP1, COEF=1.),)*

*INF3201= CALC\_FONCTION (COMB=\_F (FONCTION=INF1, COEF=1.),)*

*M1\_3201= CALC\_FONCTION (COMB=\_F (FONCTION=M1\_2, COEF=1.),)*

*M2\_3201= CALC\_FONCTION (COMB=\_F (FONCTION=M2\_2, COEF=1.),)*

*TO DESTROY (CONCEPT=\_F (NOM= (M2\_2, M1\_2, INF1, UP1)), INFO=2)*

*# end yew*

***TO DESTROY** (CONCEPT=\_F (NOM= (DM, ACC3201, SPO3201, MATM, MATD, MATK100, KN))*

*INFO=2)*

*# end for (buckles simulations M.C)*

*M13201= CALC\_FONCTION (COMB=\_F (FONCTION=M1\_3201, COEF=1. /ns),) # Calculation of average*

*M23201= CALC\_FONCTION (COMB=\_F (FONCTION=M2\_3201, COEF=1. /ns),) # Calculation of variance*

*N3201= CALC\_FONCTION (NORME=\_F (FONCTION=M13201),)*

*# Calculation of the L2 standard*

*END ()*

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***Instruction manual  
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Document: U2.09.01***

***Methodology for the realization of an analysis  
of harmfulness of defect with the tool-trade ASPIC,  
preparation of the data input***

***Summary:***

***The tool-trade ASPIC makes it possible to carry out analyses of harmfulness of defect in prickings of the CSP. This tool is composed of an automatic maillor of pricking and a solvor for the thermoelastic analyses linear. It is entirely integrated into Code\_Aster. The maillor is usable independently of the solvor. This note constitutes the methodological reference frame of a study of harmfulness of defect with ASPIC.***

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## *1 Synthesis*

*The tool-trade ASPIC makes it possible to carry out analyses of harmfulness of defect in prickings of the CSP.*

*This tool is composed of an automatic maillor of pricking and a solvor for the analyses thermoelastic linear. It is entirely integrated into Code\_Aster. The maillor is usable independently of the solvor.*

*This note aims to describe methodology for the realization of an analysis of harmfulness of defect with the tool trade ASPIC. One also endeavours to list in an exhaustive way the unit of data input ASPIC. One has in version 6.4 of Code\_Aster two macro-orders, one corresponds to the automatic maillor (MACR\_ASPIC\_MAIL), the other with the procedure of calculation itself (MACR\_ASPIC\_CALC).*

*To inform these macro-orders, it is necessary to have information on:*

- geometry of pricking,*
- boundary conditions and loadings applied at the ends (end of the pipe*

*connected BRANCH or ends of body RUN, R1 or R2),  
· the characteristics materials.*

*The results provided by the macro ordering of calculation are useful, by comparison with the criteria codified, to rule on the harmfulness or not of a defect characterized during a control.  
This document constitutes the methodological reference frame of a study of harmfulness of defect with ASPIC.*

*One finds there a description exhaustive of the data input for the macro-orders of the tool trade ASPIC. The construction of these data starting from the data provided in the DAC is entirely clarified. Finally the description of a study of analysis of harmfulness of defect on a pricking is detailed. Examples illustrate each phase of setting in data and the type of awaited result during an analysis of harmfulness.*

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## *2 Introduction*

### *2.1 Context*

*The tool-trade ASPIC makes it possible to carry out analyses of harmfulness of defect in prickings of the CSP.*

*This tool is composed of an automatic maillor of pricking and a solvor for the analyses thermoelastic linear. It is entirely integrated into Code\_Aster. The maillor is usable independently of the solvor.*

### *2.2*

*Objective of the note*

*This note aims to describe methodology for the realization of an analysis of harmfulness of defect with the tool trade ASPIC. One also endeavours to list in an exhaustive way the unit of data input ASPIC.*

*This note is based on the note written by J.P. SERMAGE, reference [bib1].*

### **2.3 Step adopted**

*This reference frame must make it possible to implement analyses of harmfulness of defects according to rules'*

*in conformity with the RSE-M [bib4]. The method of plastic correction applicable is the Kcp method. One*

*have in version 6.4 of Code\_Aster [bib5] two macro-orders, one corresponds to automatic maillor (MACR\_ASPIC\_MAIL), the other with the procedure of calculation itself (MACR\_ASPIC\_CALC).*

*To inform these macro-orders, it is necessary to have information on:*

- geometry of pricking,*
- boundary conditions and loadings applied at the ends (end of the pipe connected BRANCH or ends of body RUN, R1 or R2),*
- the characteristics materials.*

*The results provided by the macro-order of calculation are useful, by comparison with the criteria codified, to rule on the harmfulness or not of a defect characterized during a control.*

### **2.4 Plan of the note which results from this**

*The plan of the note follows the total step of an analysis of harmfulness of defect with the tool trade ASPIC.*

*Chapter 3 presents the data input of the tool trade ASPIC.*

*Chapter 4 described how to build starting from the DAC the data input ASPIC.*

*Chapter 5 points out the principle of an analysis of harmfulness of defect.*

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3

**Data input ASPIC**

### **3.1 Geometry of the grid**

**Information relating to the geometry of pricking is used to inform the macro-order MACR\_ASPIC\_MAIL [bib12]. The concept produced by this macro-order is of grid type. It contains the topological entities allowing:**

- to apply the boundary conditions and the loadings;**
- to strip the results.**

**Zmax**

**LZmax**

**½ DEXT\_TUBU**

**E\_TUBU**

**chamfer**

**L\_CHANF**

**½ DEXT\_BASE**

**extra thickness or  
under - thickness**

**E\_BASE**

**L\_BASE**

**ANGL\_SOUD**

**saddle**

**JEU\_SOUD**

**H\_SOUD**

**E\_CORP**

***center***  
***pipe***  
***1/2 DEXT\_CORPS***  
***LXmax***  
***O***  
***Center body***

***Appear 3.1-a: Description of the geometrical parameters (welding of type\_2)***

***Initially, order EXEC\_MAILLAGE makes it possible to establish the link with the software GIBI which is used to produce the grid. Parameters like: COEF\_MULT\_RC1, COEF\_MULT\_RC2,..., NB\_SECTEUR,..., RAYON\_TORE, make it possible to optimize the quality of the grid (nonexhaustive list). Then, one informs the state of refinement of the grid desired close to the welding, it can be coarse (2 nodes on the saddle and 3 nodes on the interface) or end (3 nodes on the saddle and 7 nodes on the interface).***

***“LARGE” · (default option)***  
***· “FINE”***

***One recommends the “LARGE” option for the fissured grids, the block fissures being sufficiently refined and the option “END” to carry out an analysis of harmfulness of healthy defect on prickings [bib7].***  
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***Concerning the pipe, the geometrical parameters to inform are:***



- *the thickness of the pipe in the zone of connection (E\_BASE), (reality, mm),*
- *the diameter external of pipe (DEXT\_BASE), (reality, mm),*
- *the length of the base of pipe (L\_BASE), (reality, mm),*
- *the length of chamfer (L\_CHANF), (reality, mm),*
- *the thickness of the pipe above chamfer (E\_TUBU), (reality, mm),*
- *the diameter external of the pipe above chamfer (DEXT\_TUBU), (reality, mm),*
- *the maximum dimension of pipe (Z\_MAX), (reality, mm),*
- *the type and the position of welding (TYPE\_1 or TYPE\_2).*

*The type and the position of the welding are of type\_1 if the bevel of the welding is located in the body [Figure 3.1-a], of type\_2 if the bevel of the welding is located in the pipe.*

*The welding is located by:*

- *the height of welding counted with part of external surface (H\_SOUD), (reality, mm),*
- *the angle of welding (ANGL\_SOUD), (degrees),*
- *play of the welding characterized by the space located between the body and pipe (JEU\_SOUD), (reality, mm).*

*Finally the body of pricking is defined by:*

- *the thickness of body (E\_CORP), (reality, mm),*
- *the diameter external of body (DEXT\_CORP), (reality, mm),*
- *the maximum dimension of body (X\_MAX), (reality, mm).*

*If analyzed pricking comprises a crack, it is also necessary to define the characteristics of the crack:*

- *the type of the crack (long or short).*

*The long cracks correspond to long but not very deep cracks (1/8 or 1/4 thickness), the short cracks correspond to cracks of maximum depth equal to the half thickness pricking.*

- *depth of the crack (DEPTH), (reality, mm),*
- *the length of the crack (LENGTH), (reality, mm),*
- *the position of the center of the crack (AZIMUTH), (degrees),*
- *the position (right or tilted) according to the type of the welding (POSITION), [Figures 3.1-b] and [Figure 3.1-c],*
- *the position emerging in internal or external or non-opening skin (CRACK),*
- *the length of the interior ligament (crack not emerging) (LIGA\_INT), (reality, mm),*
- *the half angle of opening of crack (ANGL\_OUVERTURE), (degrees).*

*center pipe*

***E\_TUBU  
ANGL\_OUVERURE***

***H SOUD***

***E\_CORP***

***RIGHT  
INCLINE***

***JEU\_SOUD***

***center body  
Appear 3.1-b: Standard geometry pricking n°1  
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***center pipe***

***E\_TUBU***

**INCLINE**  
**ANGL\_OUVERURE**

**JEU\_SOUD**

**RIGHT**

**H SOUD**  
**E\_CORP**

*center body*

*Appear 3.1-c: Standard geometry pricking n°2*

*The boundary conditions, the loadings and the data material are indicated on the level of macro-order MACR\_ASPIC\_CALC [bib12], objectives of the following paragraphs. This macro-order has the aim of carrying out a preset calculation of healthy or fissured prickings, like associated postprocessings.*

**3.2**

**Boundary conditions and loadings**

*To carry out a calculation with the finite elements, modeling forces to define the conditions well in limits and the loadings applied which they are mechanical or thermal.*

*Symbolically a pricking is defined by the intersection of the right-hand side [R1, R2] representing the body and*

*half-line [O, B] representing the pipe. The point O represents the origin of pricking i.e. the intersection of the axes of the two tubes.*

*(R1: P1\_CORP, R2: P2\_CORP and b: P\_TUBU)*

**B**

**Z**

**Y**

**X**

**R1**  
**R2**  
**O**

**Appear 3.2-a: Notation symbolic of pricking**  
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**To ensure the balance (BALANCE) of the structure, one defines an embedding of the beam type in the one of the two ends of the body (R1 or R2). This choice depends the definition on the torque of the efforts with**

**to apply at the ends (R1 or R2 and B).**

**One indicates then the value of the pressure (PRES\_REP) which applies in internal skin (MPa), with taking into account of the basic effect on the faces associated at the end with the pipe B and one with two faces ends of the body (R1 or R2).**

**The torque of effort is applied at the ends B of the pipe and (R1 or R2) of body (TORS\_CORP, TORS\_TUBU).**

**One informs the 6 components of the torque of efforts:**

- force according to X FX (NR)**
- force according to Y FY (NR)**
- force according to Z FZ (NR)**
- moment according to X MX (N.mm)**
- moment according to Y MY (N.mm)**
- moment according to Z MZ (N.mm)**

*For thermal calculations (EXCHANGE), one indicates the value of the coefficient of exchange (W/mm<sup>2</sup>) on skin interns pipe and body, as well as the value of the temperature of the fluid (°C) inside pricking for various moments of the transient. One will see in chapter 4 how to build this torque of effort starting from the DAC (File of Analysis of Design).*

### **3.3 Materials**

*The definition of materials is done apart from macro-order MACR\_ASPIC\_CALC, but their assignment is done in the macro-order by key word AFFE\_MATERIAU. Data material either are taken at temperature given (ambient or average of the transient), or function of the temperature (case general). When these data depend on the temperature, they are stored for a list of temperatures. They come is: RCC-M [bib10], RSE-M [bib4] or of specific measurements.*

*The data necessary to the definition of material are:  
data of behaviour in traction*

- modulus Young E (MPa)*
- Poisson's ratio*
- dilation coefficient (°C<sup>-1</sup>)*
- thermal conductivity (W.mm<sup>-1</sup>°C<sup>-1</sup>)*
- density (kg.mm<sup>-3</sup>)*

*One also notes the importance of the definition of the temperature of reference for which there is not no thermal deformation.*

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## 4

***Calculation of line to the analysis of harmfulness of defect***

## 4.1

***Calculations of lines: general information***

***A calculation of line consists in determining torques of effort and displacements and checking them criteria of design defined in the RCC-M [bib5].***

***The rules of layout used by the manufacturer are such as pipings are primarily solicited in pressure and inflection whatever the loading. The criteria of design relate to constraints due to the pressure and on those generated by the torsion and bending moments, thus that by the basic effect.***

***In a general way, an auxiliary line and its pipings are represented by a telegraphic model or beam from isometric in the plan. The components are modelled according to their stiffness and their mass respective: self-supporting quality, valves, valves, prickings.***

***Within the framework of an analysis of harmfulness of defect in a component, one uses in data input torques resulting from the calculation of line. These torques known as “are signed” or “not signed”.***

***The torque is signed when it is defined perfectly by its direction, its sign and its amplitude.***

***Typically, they are the loadings of the weight type, pressure or thermal dilation. The torque is not signed when it is defined only by its maximum amplitude and its direction. It is the case of alternative loadings like a rupture of piping or a seism. For the mechanical analysis of pricking, the data of the DAC to be extracted are the torques calculated with the node of the line which represents***

***the intersection between two portions of line.***

## 4.2

***Definition of the loading ASPIC starting from the DAC***

***The space modeling of a line of piping using elements beams makes it possible to determine in each modelled node the mechanical torques which result from the whole of the situations from operation studied. These torques are available in the DAC, whose extract is given in [bib14].***

***The signed loadings are traditional mechanical efforts, they are practically balanced. By against the not signed loadings are not real efforts but only the terminals higher of each component. They are not balanced.***

***To define the mechanical efforts several stages are necessary, they are described in following paragraphs.***

***4.2.1 Stage 1: change of reference mark***

***In modeling space beam, pricking corresponds to a node of the grid which is the point commun run with three beams. Mechanical torques calculated in this node for each beam***

**allow to know the efforts to be applied at the ends R1, R2 and B of pricking. Like locate local related to each beam or the total reference mark “manufacturer” in whom mechanical torques**

*are calculated does not correspond to the reference mark of pricking, this first stage consists in carrying out one*

*change of adequate reference mark in order to determine the mechanical torques in the reference mark of pricking*

*(0, X, Y, Z). With the exit of this change of reference mark, the components of the mechanical torques are*

*noted:*

· *R1 end: (FR1, FR1, FR1, MR1, MR1, MR1*

*,*  
*1 X*  
*Y*

*,*  
*1*

*,*  
*1 Z*  
*1X*  
*Y*

*,*  
*1*

*,*  
*1 Z)*

· *R2 end: (FR2, FR2, FR2, MR2, MR2, MR2*

*,*  
*1 X*  
*Y*

*,*  
*1*

*,*  
*1 Z*  
*,*  
*1 X*  
*Y*

*,*  
*1*

*,*  
*1 Z)*

· *end b: (BFR, BFR, BFR, MB, MB, MB*

,  
1 X  
Y  
,  
1  
,  
1 Z  
,  
1 X  
Y  
,  
1  
,  
1 Z)

*This stage relates to as well the signed loadings as not signed.*

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#### **4.2.2 Stage 2: rebalancing of the torques**

***Because of precision of calculations related to the discretization of the line of piping, torques mechanics which one calculates is not rigorously balanced. Correction suggested here consist in rebalancing torques by average value.***

***To rebalance the torques by average value consists in modifying each component according to following formulas:***



**FR1**

**FR**

**1**

**1**

**FR1**

**FR2**

**BFR**

**2, I =**

**,**

**1 I - 3 (**

**,**

**1 I +**

**,**

**1 I +**

**,**

**1 I)**

**FR2**

**FR**

**1**

**2**

**FR1**

**FR2**

**BFR**

**éq**

**4.2.2-1**

**2, I =**

**,**

**1 I - 3 (**

**,**

**1 I +**

**,**

**1 I +**

**,**

**1 I)**

**BFR**

**BFR**

**1 FR1**

**FR2**

**BFR**

**2, I =**

,  
**1 I - 3 (**  
,  
**1 I +**  
,  
**1 I +**  
,  
**1 I)**  
**MR1**  
**MR.**  
**1**  
**1**  
**MR1**  
**MR2**  
**MB**  
**2, I =**  
,  
**1 I - 3 (**  
,  
**1 I +**  
,  
**1 I +**  
,  
**1 I)**

*and MR2*  
**MR.**  
**1**  
**2**  
**MR1**  
**MR2**  
**MB**  
**2, I =**  
,  
**1 I - 3 (**  
,  
**1 I +**  
,  
**1 I +**  
,  
**1 I)**

**MB**

**MB**

**1 MR1**

**MR2**

**MB**

**2, I =**

**,**

**1 I - 3 (**

**,**

**1 I +**

**,**

**1 I +**

**,**

**1 I)**

*with I = (X, Y, Z)*

*Thus the torques resulting from the calculation of line check the equilibrium equations:*

**1**

**FR**

**FR**

**BFR**

**1**

**MR.**

**MR.**

**MB**

**2, X +**

**22, X +**

**2, X =**

**.**

**0**

**2, X +**

**22, X +**

**2, X =**

**.**

**0**

**1**

**FR**  
**FR**  
**BFR**  
*and*  
**I**  
**MR.**  
**MR.**  
**MB**  
*éq*  
**4.2.2-2**  
**2, Y +**  
**22, Y +**  
**2, Y =**  
**.**  
**0**  
**2, Y +**  
**22, Y +**  
**2, Y =**  
**.**  
**0**

**I**  
**FR**  
**FR**  
**BFR**  
  
**I**  
**MR.**  
**MR.**  
**MB**  
**2, Z +**  
**22, Z +**  
**2, Z =**  
**.**  
**0**  
**2, Z +**  
**22, Z +**  
**2, Z =**  
**.**  
**0**

### 4.2.3 Stage 3: correction of the moments

The load application at the ends R1, R2 and B induced, for the sharp efforts, one moment additional that it is necessary to compensate by introducing a correction at the time rebalanced.

Finally the efforts which one applies at the R1 ends, R2 and B are defined by:

**FR1**

**FR1**

**MR1 = MR1**

**X =**

**2, X**

**X**

**2, X**

**FR1 = FR1**

**FR1**

**and MR1 = MR1 = MR1**

**FR1**

**D éq**

**4.2.3-1**

**Y**

**2, Y -**

**2, Z ×**

**Y =**

**2 Y**

**,**

**1**

**FR1**

**FR1**

**MR1 = MR1**

**FR1**

**D**

**Z**

**2, Z +**

**2, Y ×**

**Z =**  
**2, Z**

**1**

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***FR2***  
***FR2***  
***MR2 = MR2***  
***X =***

***2, X***

***X***  
***2, X***

***FR2 = FR2***  
***FR2***  
***and MR2 = MR2 = MR2***

***FR2***  
***D***  
***éq 4.2.3-2***

***Y***  
***2, Y +***  
***2, Z ×***  
***Y =***

**2 Y**

,

**1**

**FR2**

**FR2**

**MR2 = MR2**

**FR2**

**D**

**Z**

**2, Z -**

**2, Y ×**

**Z =**

**2, Z**

**1**

**BFR**

**BFR**

**MB = MB**

**BFR**

**D**

**X**

**2, X +**

**2, Y ×**

**X =**

**2, X**

**2**

**BFR = BFR**

**BFR**

**and MB = MB = MB**

**BFR**

**D**

**éq**

**4.2.3-3**

**Y**

**2, Y -**

**2, X ×**

**Y =**

**2 Y**

,

**2**

**BFR**

**BFR**

**MB = MB**

**Z =**

**2, Z**

**Z**

**2, Z**

*The equilibrium equations relating to pricking then are automatically checked:*

**1**

**FR**

**FR**

**BFR**

**X +**

**2 X +**

**X =**

.

**0**

**1**

**FR**

**FR**

**BFR**

**éq**

**4.2.3-4**

**Y +**

**2Y +**

**Y =**

.

**0**



*1*  
*FR*  
*FR*  
*BFR*  
*Y +*  
*2Y +*  
*Y =*  
*.*  
*0*  
*1*  
*MR. X +*  
*2*  
*MR. X + MBX - FBY × d2 =.*  
*0*

*and*  
*1*  
*MR.*  
*Y +*  
*2*  
*MR. Y + MBY + 1*  
*FR Z × d FR*  
*D*  
*BFR*  
*D*  
*1 -*  
*2Z × 1 +*  
*X × 2 =.*  
*0*

*1*  
*MR. Z +*  
*2*  
*MR. Z + MBZ - 1*  
*FR Y × d FR*  
*D*  
*1 +*  
*2Y × 1 =.*  
*0*

*Real efforts defined by the equations [éq 4.2.3-1] [éq 4.2.3-2] and [éq 4.2.3-3] can be applied directly at the ends R1, R2 and B of fissured pricking. In ASPIC one of ends of the RUN is embedded (R1 or R2). The torque of effort defines in the paragraph [§3.2] is [éq 4.2.3-3] for the end of the pipe and [éq 4.2.3-1] or [éq 4.2.3-2] for the end of the body.*

#### **4.2.4 Stage 4: obtaining the maximized loading**

*The ultimate stage consists in defining the maximized loading. The maximized loading is the loading corresponding to the combination of the signed loading and not signed such as the rate of refund of energy, noted local Gmax is maximum for a given crack.*

*Two methods of calculation of Gmax are available, analytical described in [bib13], the other numerical and established in Code\_Aster.*

*The analytical method relates to the loading not signed and consists in seeking that which maximizes the mode of opening I. the REX [bib15] shows that his implementation is tiresome, also one recommend the use of the numerical method. An example of the implementation of the method analytical is given in [bib8]. This example made it possible to validate the analytical method by comparison between the result and the numerical method of reference.*

*The numerical method established in Code\_Aster examines the three possible couples of constraints and the minimum of maximum retains reached (conservative solution compared to the exact solution).*

*In other words, one calculation three Gmax, the first starting from the torques defined at the end of the RUN (R1 and R2), the second starting from the torques defined in the one of the end of the RUN and the end of the BRANCH*

*(R1 and B), the last is the combination (R2 and B). An example of the implementation of the method numerical is given in [bib9].*

*It is possible to maximize the mechanical loading in its totality, in which case, it is enough to calculate*

*the amplitude of the total loading as being the sum of the amplitudes of the loading signed and of loading not signed. The result of [bib8] shows that this way of making is conservative by report/ratio with the case or only the loading not signed is maximized.*

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### **4.3 Application**

**The following table gives the elementary loadings to the center of pricking (raised in the DAC) participants in the situation of category 2. The signed loadings are cumulated linearly between them, the loadings not signed as for them are cumulated quadratically. These loadings must to be affected of a safety coefficient of 1.5.**

**In each category, the situations are obtained by the following combinations, for example in 2nd category: 1 17 18 19 max (14, 15, 16) 2 6 7 8 to 13**

**Heading number**

**Nature**

**Actual weight**

**1**

**Signed**

**Displacements be**

**17**

**Signed**

**Winter displacements**

**18**

**Signed**

**Creep 19**

**Signed**

**Maximum dilation CP5 GVI**

**Max (14,15 and 16)**

**Signed**

**Acceptable normal seism**

**2**

**Not Signed**

**Radial DDS SNA crossings Br**

**6**

**Not Signed**

**Tangential DDS SNA crossings Br**

**7**

**Not Signed**

**DDS SNA pricking Steam Generator**

**8 to 13**

**Not Signed**

*One gives an example of the implementation of the stages (1, 2 and 3) successive described Ci above for the case of loading  $n \cdot 1$  corresponding to the actual weight. The first table is the result of transformation of data resulting from the DAC (second table).*

*Number (ASPIC)*

*FR2x (daN) FR2y (daN) FR2z (daN)*

*MR2x*

*MR2y*

*MR2z*

*(daN.m)*

*(daN.m)*

*(daN.m)*

*I (actual weight)*

492,93

458,31

-951,23

731,76

-98,90

776,68

*Number (DAC)*

*Nx\_d (daN) Ty\_d (daN) Tz\_d (daN)*

*Cx\_d*

*My\_d*

*Mz\_d*

*(daN.m)*

*(daN.m)*

*(daN.m)*

*I (actual weight)*

21,597

13,021

-1422,562

544,156

1237,734

130,765

*An example of maximization of the mechanical loading is given in [bib8] and [bib9].*

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*Analyze harmfulness of defect on a pricking*

*The sizes which one uses in breaking process are the stress intensity factors for each mode of opening of the defect and the rate of refund of energy. The rate of refund of energy  $G$  is calculated whatever the mode of request (opening or closing) of the crack.*

## **5.1 Principle**

*Two methods can be implemented starting from the results of the execution the macro one order calculation. One, or one compares the rate of refund of elatoplastic energy  $G (= JEF)$  with the fissuring force  $J_{0,2}$  of material. If the  $J_{0,2} \text{ ratio}/JEF > 1$ , it does not have risk of brutal rupture there.*

*The other, or calculation is elastic, one then applies the analytical method of plastic correction. In the case of a mechanical loading combining and thermics it consists of a rule of office plurality between the method  $K_{cp}$  and  $J_{th}$ . In mechanics alone, the method codified in the RSE-M is the method*

*$K_{cp}$ .*

*The study of the correction of plasticity under mechanical loading only ( $1/Kr$ ) is considered to be too complex,*

*the geometry itself of prickings does not allow the  $Lr$  calculation (indicating of the level of plasticity in mechanics). Moreover one standard validation [bib10] would require many calculations finite elements in elastoplasticity.*

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## **5.2**

*Output data ASPIC*

*Postprocessings of calculation ASPIC must make it possible to implement analyses of harmfulness*

*of defect in accordance with the RSE-M such as:*

- transformation of stress fields into stress intensity factors by the method functions of influence*
- calculation of the correction of plasticity and checking of the field of validity.*

*For healthy prickings, the constraints of opening according to modes I, II and III are calculated. Via operand RCCM, one can carry out a postprocessing of type POST\_RCCM, precautions are with to take at the time to define the characteristics material [bib12].*

*The rate of refund of density of energy, noted G, is calculated according to the curvilinear X-coordinate on*

*bottom of crack and according to time. It is this value which is to compare with the fissuring force  $J_{0,2}$  material for evaluation of the factors of margin.*

### *5.3 Coding*

*The criteria to be applied for the specific studies of the defects are codified in the appendix 5.6 IV 2 of RSE-M [bib4] for the materials of level 2.*

*The fissuring force  $J_{0,2}$  of material to the starting of the tear corresponds conventionally to one ductile extension of 0,2 Misters For example for the base metal standard A48 or A42 and the welded joints,*

*these values are:*

- $J_{0,2} = 92 \text{ KJ/m}^2$  for a lower temperature or equalizes with  $100^\circ\text{C}$*
- $J_{0,2} = 55 \text{ KJ/m}^2$  for a higher temperature or equalizes with  $200^\circ\text{C}$*

*The values of  $J_{0,2}$  can be to interpolate linearly between  $100^\circ\text{C}$  and  $200^\circ\text{C}$*

### *5.4 Example of application*

*One finds examples of use in the documents [bib8], [bib9].*

*One summarizes in the table according to the results of the analysis of harmfulness of defect on pricking*

*ANG-ASG of stage CP0-BGY [bib9].*

*Pricking ANG-ASG*

*Interface right*

*has (mm)*

*3*

*c/a*

*17,3*

*Tmoy °C*

*186*

**JEF**

**E**

**(KJ/m<sup>2</sup>)**

4,87

**JEF (KJ/m<sup>2</sup>)**

3,32

**J0,2 (KJ/m<sup>2</sup>)**

60,2

**J0,2/JEF**

18,13

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**6**

**Application or conditions of use of the results**

**The plastic designs must be reserved for the mechanical analyses of type appraises because of associated computing time (see appendix). Preparation of the data input for the macro ones orders of ASPIC requires much rigour. A REX [bib15] of work practise with ASPIC showed that the preparation of the loadings and obtaining the maximized loading take 2 with 3 working days for an engineer. To obtain the maximized loading, one recommends to use numerical method of calculation of local Gmax.**

**For the calculation of the fissuring force, one recommends the use of the analytical method as in [bib8] and [bib9]. For that it should beforehand be checked that the applicability is included/ understood in**

**field of validity of the methods codified in the RSE-M [bib4].**

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### **Appendix 1 Example of data file ASPIC**

*The process control language describes Ci below corresponds to version 6 of Code\_Aster.*

**# AUTHOR NR. Ligneau**

**# Pricking ARE-ASG GRAVELINES 3**

**# FRA EER cd. 1470 C of the 15/12/99**

**#**

**# Piquage fissures**

**#**

**# ASTER-V6.04**

**#**

**# units: NR, mm, MPa**

**BEGINNING (CODE=\_F (NAME = "ARE-ASG"))**

**MA = MACR\_ASPIC\_MAIL (**

**EXEC\_MALLAGE=\_F (SOFTWARE = "GIBI2000"),**

**PIPE =\_F (E\_BASE = 21.4,**

**DEXT\_BASE = 140.0,**

**L\_BASE = 41.0,**

**L\_CHANF = 40.8,**

**E\_TUBU = 8.0,**

**DEXT\_TUBU = 114.3,**

**Z\_MAX = 490.49,**

**TYPE = "TYPE\_2"),**

**RAFF\_MAIL = "LARGE",**

**WELDING =\_F (H\_SOUD = 15.0,**

**ANGL\_SOUD = 30.0,**  
**JEU\_SOUD = 2.5),**  
**BODY =\_F (E\_CORP = 30.9,**  
**DEXT\_CORP = 406.4,**  
**X\_MAX = 764.47),**

**# fissures has = 3 mm**

**FISS\_SOUDURE =\_F (STANDARD = “LONG”,**  
**DEPTH = 3.0,**  
**LENGTH = 104.0,**  
**AZIMUTH = 0.0,**  
**POSITION = “RIGHT”,**  
**FISSURE = “DEB\_INT”)**  
**)**

**# Tu42C**

**TU42C=DEFI\_MATERIAU (ELAS=\_F (E = 1.99100E5,**  
**NAKED = 0.3,**  
**ALPHA = 1.845E-05,)**  
**RCCM=\_F (SM = 103.0,)**  
**THER=\_F (LAMBDA = 0.0514,**  
**RHO\_CP = 3.8394E-3,))**

**# Given of the coefficient of exchange on the internal skin**

**COEFHCOR=DEFI\_CONSTANTE (VALE=1.85E-3,)**  
**COEFHTUB=DEFI\_CONSTANTE (VALE=0.01775,)**

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**:**

**U2.09.01-A Page****: 16/20****# Description of the variation of the loadings in the course of time**

**VARTEMP=DEFI\_FONCTION (NOM\_PARA=' INST',  
VALE= (0.0, 220.0,  
1.0, 220.0,  
2.0, 7.0),  
PROL\_DROITE=' CONSTANT')**

**VARP=DEFI\_FONCTION (NOM\_PARA=' INST',  
VALE= (0.0, 0.0,  
1.0, 1.0),  
PROL\_DROITE=' CONSTANT')**

**VARFOR=DEFI\_FONCTION (NOM\_PARA=' INST',  
VALE= (0.0, 0.0,  
1.0, 1.0),  
PROL\_DROITE=' CONSTANT')**

**LIST=DEFI\_LIST\_REEL (DEBUT=0.0,  
INTERVALLE= (\_F (JUSQU\_A = 1.0,  
= 1 NUMBERS),  
\_F (JUSQU\_A = 2.0,  
NUMBERS = 10),  
\_F (JUSQU\_A = 6.0,  
NUMBERS = 8),  
\_F (JUSQU\_A = 10.0,  
NUMBERS = 4))))**

**RESU<sub>Ther</sub> = MACR\_ASPIC\_CALC (  
TYPE\_MALLAGE = “FISS\_LONG\_DEB”,  
PIPE =\_F (STANDARD = “TYPE\_2”),  
MODEL = CO (“MOD”),  
GRID =MA,  
RESU\_THER =CO (“RESUTH”),  
AFFE\_MATERIAU=\_F (ALL = “YES”,  
RCCM = “YES”,  
MATER = TU42C,  
TEMP\_REF = 220.0),  
ECHANGE=\_F (COEF\_H\_TUBU = COEFHTUB,  
COEF\_H\_CORP = COEFHCOR,**

```
TEMP_EXT = VARTEMP),  
EQUILIBRE=_F (NODE = "P2_CORP"),  
PRES_REP =_F (CLOSE = 0.0,  
NODE = "P1_CORP",  
EFFE_FOND = "YES",  
FONC_MULT = VARP),  
COMP_ELAS=_F (RELATION = "ELAS"),  
INCREMENT=_F (LIST_INST = LIST),  
NEWTON =_F (REAC_INCR = 50,  
STAMP = "TANGENT",  
REAC_ITER = 10),  
THETA_3D = (_F (R_INF=0.1,  
R_SUP=1.0),  
_F (R_INF=0.5,  
R_SUP=1.0),  
_F (R_INF=0.25,  
R_SUP=2.0),  
_F (R_INF=0.5,  
R_SUP=2.5))
```

END ()

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*Computing time on Origin 2000, (one can divide by three to have an estimate on Alphaserwer).*

***Nb ddl***

***Memory capacity***

***Tps of total calculation (S CPU)***

***(Mo)***

***100 000***

***1500***

***CALCULATION THERMO\_ELASTIQUE***

***grid without defect***

***Solveur THER\_LINE: 10 S CPU/pas of tps***

***“FINE” refinement***

***Solveur STAT\_NON\_LINE and CALC\_ELEM: 1000 S CPU for***

***the 1st increment, 55 S CPU for the following***

***Examination in temperature: 6 S CPU/pas of tps***

***Examination in constraint: 100 S CPU/pas of tps***

***102 000***

***2500***

***CALCULATION THERMO\_PLASTIQUE***

***grid with crack***

***Solveur THER\_LINE: 21 S CPU/pas of tps***

***long***

***Solveur STAT\_NON\_LINE and CALC\_ELEM: 12.000 S CPU/pas***

***“LARGE” refinement***

***of tps on average (3 to 4 iterations per step of calculation) that is to say***

***a total of 76h CPU of calculation for 23 step of time.***

***Examination in temperature: negligible time***

***Examination in Gthéta: 10s CPU/pas of tps***

***The plastic designs must be reserved for the mechanical analyses of type appraises because of the time of***

***associated calculation.***

***The computing times to determine G local maximum are important. They are specified in the table below:***

***Total time CPU (in S)***

***Memory requested (Mo)***

***Right defect***

***70752***

***1100***

***Tilted defect***

***64466***

***1100***

### **Healthy grid**

*For the thermal transients, it is necessary to use a refinement says "FINE" grid. To strip the elementary stress fields under loading, it is necessary to strip in plans spaced to the maximum of 15°. That is to say 24 plans on the whole for ASPIC.*

### **Geometry of the welding**

*The geometry of the welding has an influence: the covered total angle and the external extra thickness. For the angle, them two interfaces welding body and welding pipe constitutes extreme positions and also give results which wrap all the intermediate plans. As for the extra thickness, one cannot conclude from way reliable only starting from the results presented here. One will conclude in a very total way by saying that more this extra thickness is small, less there is matter and thus more one places oneself in a geometrical configuration penalizing.*

### **Elastic design**

*The macro ordering of calculation ASPIC calls upon solvor STAT\_NON\_LINE. Default options of it solvor implies an actualization of the matrix of rigidity to each increment, which is expensive in times of calculation (1000s with each resolution) if one must calculate several steps of loading (case of a transient thermics) and useless for an elastic analysis. Consequently, it is absolutely necessary to indicate in the macro one order calculation ASPIC the option:*

*SOLVEUR = \_F (  
REAC\_INCR = N,*

*N > a number of total increment of calculation*

*STAMP = "TANGENT",*

*REAC\_ITER = 0),*

### **Elastoplastic calculation**

*These calculations are very long and very expensive. Various options were used under the key word NEWTON:*

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***OPTION 1:***

*NEWTON =\_F (MATRIX = "ELASTIC"),*

*· Calculation converges very slowly (more than 10 iterations for an increment), much more slowly than with a TANGENT matrix.*

***OPTION 2:***

*NEWTON =\_F (REAC\_INCR = 1,*

*STAMP*

*=*

*"TANGENT",*

*REAC\_ITER = 1),*

*RECH\_LINEAIRE =\_F (RESI\_LINE\_RELA = 1.0E-3,*

*ITER\_LINE\_MAXI = 3),*

*· So that calculation converges with a reasonable iteration count (3 to 4 iterations by increment of time) it is necessary to bring up to date the tangent matrix with each increment.*

*· The use of the linear option of research does not seem to modify much computing time. The linear coefficient of research is very close to 1.*

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### ***Methodological appendix 3 Reference frame***

***The syntheses of the notes constituting the methodological reference frame are restored Ci below.***

***Study of validation ASPIC: Pricking ARE-ASG under mechanical and thermal loading. NR.***

***LIGNEAU -***

***SEPTEN E-N-T-MS/00-01631 A***

***This note allowed:***

- to validate the analytical method of maximization of the loading not signed by comparison with one method of reference [bib12]***
- to validate the use of the tool trade ASPIC to implement an analysis of harmfulness by comparison with a calculation carried out by FRAMATOME***
- to validate ASPIC for the linear thermomechanical analyses.***

***Analytical method of plastic correction for prickings under thermal loading and***

***thermomechanics J.P. SERMAGE SEPTEN E-N-ES-MS/02-01069 A***

***This note, via the general step of analysis of harmfulness of defect being based on the codified methods***

***in the RSE-M and on the basis of study [bib5], allowed to validate:***

- the use of the Jth method, for the thermal loadings only***
- combination of the methods Kcp and Jth in the case of mechanical combined loadings and thermics.***

***Tool-trade ASPIC Validation of the grids for the calculation of thermal transients S. MUSI,***

***A. BENAZIZA SEPTEN E-N-T-MS/00-01108 A***

***This note allowed:***

- to validate grids of pricking healthy and fissured in linear elasticity***



· *to contribute to the validation of the grids of prickings fissured in elastoplasticity by a comparison qualitative with a study FRAMATOME, whose reference is given Ci below:*

*Pricking ARE/ASG of GRAVELINES 3 elastoplastic Calculations 3D of pricking comprising a defect circumferential in situations of 2nd, 3rd and 4th categories Notes FRA EER/DC/1470 index C, N° FDU: 00A04082*

*Analyze harmfulness of defect in a pricking: validation of the simplified method of the functions of influence. NR. LIGNEAU SEPTEN E-N-T-MS/00-00828 A*  
*This note allowed:*

· *to validate the use of the analytical method of the functions of influence codified in the RSE-M for calculation of the rate of elastic refund of energy*  
· *to show the feasibility of a study of harmfulness of defect with ASPIC*

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*C. CHEDEAU: Specification for the continuation of the development under quality assurance of ASPIC - UTO D4507-SIS-CDE/CDE-98/1916*

*[3]*

*J.P. SERMAGE: Quality Detailed plan of the batch “tool-trade ASPIC” of the project “Service*

***for the UTO” - SEPTEN E-N-ES-MS/01-01051 A***

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***C. JEAN: Card-index of introduction of the software Code\_Aster version 5.7. Note E-N-ES-MS/02-00733.A***

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***NR. LIGNEAU: Study of validation ASPIC: Pricking ARE-ASG under mechanical loading and thermics - SEPTEN E-N-T-MS/00-01631 A***

***[7]***

***S. MUSI, A. BENAZIZA: Tool-trade ASPIC Validation of the grids for the calculation of thermal transients - SEPTEN E-N-T-MS/00-01108 A***

***[8]***

***NR. LIGNEAU: Analyze harmfulness of defect in a pricking: validation of the method simplified functions of influence - SEPTEN E-N-T-MS/00-00828 A***

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***J.P. SERMAGE: Analytical method of plastic correction for prickings under thermal loading and thermomechanics - SEPTEN E-N-ES-MS/02-01069 A***

***[10]***

***M.H. LACIRE: Tubes with circumferential defects: validation of the simplified method of calculation of J under mechanical loading - Report ECA SEMT/LISN/RT/99-036/A***

***[11]***

***RCC-M Volume I Volumes B-C-D: material of levels 1,2 and 3 AFCEN edition 2000.***

***[12] Documentation***

***use of macro-orders MACR\_ASPIC\_MAIL and MACR\_ASPIC\_CALC***

***[13]***

***Y. MEZIERE: Methodology of analysis of harmfulness of defects in pricking in elasticity linear - SEPTEN E-N-T-MS/98-00268 A***

***[14]***

***Data and assumptions for the validation of the analytical method of plastic correction for prickings ASPIC. Courier UTO D4507-SIS-BUI n°01/0677***

***[15]***

***Tool-trade ASPIC Experience feedback UTO. CR of evaluation E-N-T-MS/01-00100-A***

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***Titrate:***

***Realization of the calculation of an assembly pin-attaches***

**Date:**  
**26/09/05**  
**Author (S):**  
**J. Key ANGLES**  
**:**  
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**Organization (S): EDF-R & D /AMA**

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**Realization of the calculation of an assembly pin-attaches**

## **1 Goal**

**This note concerns, the realization of the grid and of the total calculation of an assembly pin-attaches with**

**Code\_Aster.**

**Calculations themselves as well as the macro-orders evoked in this document are available in the command files of cast-test ZZZZ120A and ZZZZ120B.**

*The production of the grid requires the use of the function MACR\_GOUJ2E\_MAIL which must be defined in the beginning of the command file. On the other hand, calculation is carried out only with orders of Code\_Aster. Macro-order POST\_GOUJ allows the presentation of the results in a format which facilitates their reading. Like function MACR\_GOUJ2E\_MAIL, this macro order must be defined in the beginning of the command file. Calculation also requires the use of the data base containing the geometrical and mechanical characteristics assemblies.*

*We give the contents of the base in its version 1.00 of the 16/09/1999 which was produced by Department MMN starting from the old base (“gouj2ech.base\_v1\_11” version 1.09 of the 9/6/1997) qualified by the UTO, and we briefly point out the manner of feeding this new base of data.*

*This base is conceived so that the contribution of new data, characterizing new situations local, can be carried out easily.*

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***Count***

***matters***

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## **2 Introduction**

*This note concerns, the use of the function `macr_gouj2e_mail` and the macro-order `POST_GOUJ` which allows, respectively, to carry out the grid of an assembly pin-attaches and post-to treat the results of a mechanical calculation carried out with the traditional orders of `Code_Aster`. Calculation also requires the use of the data base containing them geometrical characteristics and mechanics of the assemblies.*

*Initially we describe the function `macr_gouj2e_mail` and the macro-order `POST_GOUJ`. The text of these macro-orders as their catalogues are available in command files of case-tests `ZZZZ120A` and `ZZZZ120B`.*

*In the second part we detail the contents of the profile of study and the command file. Us let us continue by specifying the manner of using the function `macr_gouj2e_mail`, the macro-order `Traditional POST_GOUJ` and orders to carry out the grid and the total calculation of an assembly pin-attach. To finish, we describe the contents of the file of results (`.resu`) before approaching quickly contents of the file of message (`.mess`).*

*The last part is devoted to the data base of the geometrical characteristics and mechanics of the pins. We follow the curves of behavior of the nets like the organization of the various data. We give the contents of the base in its version 1.00 of 16/09/1999 which was produced by Department MMN. Lastly, we briefly point out the manner to feed this data base.*

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**3**

***Description of the function macr\_gouj2e\_mail***

**3.1 Drank**

**of**

***macr\_gouj2e\_mail***

*To create the command files GIBI in units UNITD and UNITP.*

**3.2 Syntax**

***Macr\_gouj2e\_mail***

(

**TYPE**

=

/

**“M33”,**

**[TXM]**

/

**“M64”,**

/

**“M90”,**

/  
“M115”,  
/  
“M155”,  
/  
“M180”,  
/  
“M186”,

**ALTERNATIVE**

=  
/  
“A”,  
[TXM]  
/  
“B”,  
/  
“It,  
/  
“Of,  
/  
“E”,  
/  
“F”,  
/  
“G”,  
/  
“H”,  
/  
“I”,  
/  
“I,  
/  
“K”,  
/  
“It,  
/  
“Me,  
/  
“,  
/



**“O”**,  
/  
**“P”**,  
/  
**“Q”**,  
/  
**“R”**,  
/  
**“**,  
/  
**“You**,  
/  
**“U”**,  
/  
**“V”**,  
/  
**“W”**,  
/  
**“X”**,  
/  
**“Y”**,  
/  
**“Z”**,

***NB\_FILET = Nf,***  
***[I]***

***H\_CORP\_BRID = H\_corps\_bride***  
***,***  
***[R]***

***R\_EXT\_BRID = Reb***  
***,***  
***[R]***

***H\_HAUT\_BRID***  
***=***  
***,***  
***H\_haut\_bride,***  
***[R]***  
***,***

***0.0D0,***  
***[DEFECT]***

***H\_BAS\_BRID =/  
H\_bas\_bride***

***,  
[R]***

***/  
0.0D0,  
[DEFECT]***

***FILET\_ABST = Numero\_filet,  
[L\_I]***

***UNITD = 70,  
[I]***

***UNITP = 71,  
[I]***

***)***

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### **3.3**

#### ***Geometrical definition of the assembly pin-attaches***

*The assemblies pin-supports which are concerned here are those which maintain the lid of ferment or plates it closed inspection pit.*

*Ray interns support*

*High of Support*

*H\_HAUT\_BRID Height top of support*

*net 1*

*y*

*X*

**PIN**

*Body of Support*

*H\_CORP\_BRID Height of the body of support*

*Not or height*

*of a net*

**ATTACH**

*net N*

*Low of Support*

*H\_BAS\_BRID Height of the bottom of support*

**NETS**

*External R\_EXT\_BRID Ray of the support*

***Appear 3.3-a: description of the various geometrical parameters assembly pin-attaches***

*The ray interns support, the external ray of the pin as well as the step or the height of a net is*

sizes characteristic of a given assembly. These three last sizes are not thus not accessible to the user.

All dimensions (lengths) must be given in **millimetres**. If the user gives values with the heights top of support and the bottom of support, those cannot be lower than one millimetre.

### **3.4 Operands**

#### **3.4.1 Operand**

##### **TYPE**

##### **TYPE**

=

/

“M33”,

[TXM]

/

“M64”,

/

“M90”,

/

“M115”,

/

“M155”,

/

“M180”,

/

“M186”,

*This operand makes it possible to indicate the type of characteristics which one wants to include, for example it*

*type “M186” corresponds to the pin of lid of tank of the N4 stage.*

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### ***3.4.2 Operand***

#### ***ALTERNATIVE***

#### ***ALTERNATIVE***

***= /***

***“A”,***

***[TXM]***

***/***

***“B”,***

***/***

***“It,***

***/***

***“Of,***

***/***

***“E”,***

***/***

***“F”,***

***/***

***“G”,***

***/***

***“H”,***

***/***

***“I”,***

***/***

***“I,***

***/***

***“K”,***

***/***

***“It,***

***/***

***“Me,***

/  
“  
/  
“O”,  
/  
“P”,  
/  
“Q”,  
/  
“R”,  
/  
“  
/  
“You,  
/  
“U”,  
/  
“V”,  
/  
“W”,  
/  
“X”,  
/  
“Y”,  
/  
“Z”,

*This operand makes it possible to specify the alternative in the type of characteristic which one wants to include.*

### **3.4.3 Operand**

**NB\_FILET**

**NB\_FILET**

=  
**Nf**  
**[I]**

*Numbers total theoretical nets of an assembly pin-attaches.*

### **3.4.4 Operand**

**H\_CORP\_BRID**

### ***H\_CORP\_BRID***

=

***H\_corps\_bride***

**[R]**

***Height of the body of support in millimetres. The body of support is the part of the support which is in catch with the nets.***

### ***3.4.5 Operand***

***R\_EXT\_BRID***

***R\_EXT\_BRID =***

***Reb***

**[R]**

***Value of the ray external of the support in millimetres.***

### ***3.4.6 Operand***

***H\_HAUT\_BRID***

***H\_HAUT\_BRID***

=

***H\_haut\_bride***

**[R]**

***Height top of support in millimetres.***

### ***3.4.7 Operand***

***H\_BAS\_BRID***

***H\_BAS\_BRID =***

***H\_bas\_bride***

**[R]**

***Height of the bottom of support in millimetres.***

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***3.4.8 Operand***

***FILET\_ABST***

***FILET\_ABST =***

***Numero\_filet***

***[L\_I]***

***This key word makes it possible to indicate the list of the nets absent, if it is necessary (see [Figure 3.3-a]).***

***3.4.9 Operand***

***UNITD***

***UNITD***

***=***

***70***

***[I]***

***Number of the logical unit which contains the parameters user and the beginning of the file containing them instructions of grid (gouj1.datg).***

***3.4.10 Operand UNITP***

***UNITP***

***=***

***71***

***[I]***

***Number of the logical unit which contains the instructions of elimination of the possible nets absent***



*and  
end of the file containing the instructions of grid (gouj2.datg).*

**Note:**

*The files fort.70 (UNITD = 70) and fort.71 (UNITP = 71) are carried out in manner connected by GIBI by the means of instruction GIBI: “OPTI DONN “. /fort.71”; ” which find at the end of the file gouj1.datg, therefore file fort.70. Two key words UNITD and UNITP are indicated at the time of the definition of the function macr\_gouj2e\_mail.*

**3.5 Example**

*INCLUDE (UNIT = 38,)*

*TYPE = “M155”*

*ALTERNATIVE = “A”*

*NB\_FILET = 56*

*H\_CORP\_BRID = 225.0*

*R\_EXT\_BRID = 140.0*

*H\_HAUT\_BRID = 200.0*

*H\_BAS\_BRID = 0.0*

*FILET\_ABST = (3, 4,)*

*macr\_gouj2e\_mail (STANDARD, ALTERNATIVE, NB\_FILET, H\_CORP\_BRID, R\_EXT\_BRID, H\_HAUT\_BRID, H\_BAS\_BRID, FILET\_ABST,)*

*loc\_outils=aster.repout ()*

*EXEC\_LOGICIEL (LOGICIEL=loc\_outils+' gibi',*

*ARGUMENT= (\_F (NOM\_PARA=' fort.70'),*

*\_F (NOM\_PARA=' fort.19')),);*

*PRE\_GIBI ()*

*MAIL=LIRE\_MAILLAGE ()*

*MAIL=DEFI\_GROUP (reuse = EMAIL,*

*MAILLAGE=MAIL,*

*CREA\_GROUP\_NO= (\_F (NOM=' NDFILETS',*

*GROUP\_MA=' CORPSGOU',*

*CRIT\_NOEUD=' TOUS')),)*

*IMPR\_RESU (FORMAT=' CASTEM', UNITE=53, RESU=\_F (MAILLAGE=MAIL,))*

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**Note:**

**Order INCLUDE makes it possible to include the orders which define all the assemblies pin-attach. The data necessary to construction of the grid are recovered by function macr\_gouj2e\_mail starting from the information indicated in the operands: TYPE and ALTERNATIVE.**

**Operands UNITD and UNITP are not indicated during the use of the function macr\_gouj2e\_mail because they are it at the time of the definition of the latter. In order EXEC\_LOGICIEL, “gibi” and “gibi2000” correspond to version 2000 of Gibi on the machine Aster (Alpha Waiter).**

**4**

**Description of macro order POST\_GOUJ**

**4.1 Drank**

**of**

**POST\_GOUJ**

**To carry out the post treatment in a specific format.**

**To transform a table created by POST\_RELEVE\_T into a table of a specific format of type table\_sdaster. The table of the table\_sdaster type contains parameters “NUME\_FILET”,**

**“NODES”** (number of node corresponding to the number of net), **“NUME\_ORDRE”** (correspondent with the increment of load), **“REACTION”** (reaction of the nets) and **“REACTION\_CUM”** (reaction cumulated of nets in %).

*Product a structure of data of the table\_sdaster type.*

## 4.2 Syntax

**ntab [table\_sdaster]**

=

**POST\_GOUJ**

(

**COUNT =**

**tabl\_post\_rele**

,

**[TXM]**

)

## 4.3 Operand

### 4.3.1 Operand

**COUNT**

**COUNT**

= **[TXM]**

*This operand makes it possible to indicate the name of the table of the tabl\_post\_rele type which one wants to modify.*

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#### **4.4 Example**

```
TFORC = POST_RELEVE_T (  
  ACTION = _F (  
    ENTITLE = "RESU_TI",  
    GROUP_NO = "NDFILETS",  
    RESULT = CALC,  
    NOM_CHAM = "FORC_NODA",  
    TOUT_ORDRE = "YES",  
    NOM_CMP = "DY",  
    OPERATION = "EXTRACTION"  
  )  
)
```

```
NTFORC = POST_GOUJ (  
  COUNT = TFORC,  
)
```

```
IMPR_TABLE (TABLE = NTFORC,  
  NOM_PARA = ("NUME_FILET", "NODES"),  
  FILTER = _F (  
    NOM_PARA = "NODES",  
    CRIT_COMP = "NON_VIDE"  
  ),  
  FORMAT = "AGRAF"  
)
```

```
IMPR_TABLE (TABLE = NTFORC,  
  NOM_PARA = (  
    "NUME_ORDRE", "NUME_FILET",  
    "REACTION", "REACTION_CUMU"  
  )
```

```
),  
FILTER =_F (  
NOM_PARA = “NUME_ORDRE”,  
CRIT_COMP = “EQ”,  
VALE_I = 1  
)  
FORMAT = “AGRAF”  
)
```

5

## ***Realization of the calculation of an assembly pin-attaches***

***In this part one indicates the manner of using the function `macr_gouj2e_mail`, the macro one order `POST_GOUJ` and the orders of `Code_Aster` to make a total calculation of an assembly pin-attach. One will start by describing the profile of study (file `.astk`), one will continue while clarifying***

***contents of the message and result, command files (file `.com m`) (file `.resu`) (file `.mess`). The contents of the data base (logical unit 38 free format) are described in [§6].***

5.1

### ***Profile of study***

***In the profile of study, only two files are obligatory in data: the command file (file `.com m`) and the file containing the data base (logical unit 38 free format). The file containing the grid (file `.mail`) is automatically produced and is not visible by the user. Nevertheless, this last can visualize the grid produces by putting in result the file “grid Gibi, (`mgib`)” corresponding to the logical unit 53, and while using in the command file order `IMPR_RESU` as indicated in the paragraph [§ 5.2.2].***

***The file of results (file `.resu`) makes it possible to exploit the results.***

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**The command file (file .com m) must obligatorily contain the front following lines the order BEGINNING ():**

**importation aster****importation bone**

#####

**# Generation of the name of the file for L unit logical unit****def name\_file (unit):****to cur\_dir = os.getcwd ()****nomFichier = cur\_dir+'/extremely. '+str (unit)****return nomFichier**

#####

#####

**# creation of the command files GIBI in units UNITD and UNITP****def macr\_gouj2e\_mail (STANDARD, ALTERNATIVE, NB\_FILET, H\_CORP\_BRID, R\_EXT\_BRID,****H\_HAUT\_BRID, H\_BAS\_BRID, FILET\_ABST,****UNITD=70, UNITP=71):****text = “\*\*\*\*\* |****text = text + “\* |****text = text + “\* CREATION OF the GRID OF PIN, NETS AND ATTACHES 2D AXIS |****text = text + “\* ----- |****text = text + “\*\*\*\*\* |****text = text + “\* VERSION 1.0 \* |****text = text + “\* VERSION OF the 15/07/1999 \* |****text = text + “\*\*\*\*\* |****text = text + “\* |****text = text + “OPTI NIVE 10; |****text = text + “OPTI ECHO 0; |****text = text + “\*\*\*\*\* |**

```

text = text + "***** MAIN PROGRAM ***** |
text = text + "***** |
text = text + "* |
text = text + "OPTION DIME 2 ELEM QUA4 ECHO 0; |
text = text + "* BEGINNING PARAMETERS USER |
text = text + "* |
text = text + "* GENERAL PARAMETERS |
text = text + "* |
text = text + 'RI_BRI = "+str (eval ("RIB'+TYPE+VARIANTE)) +"; "+ |
text = text + 'RE_GOUJ = "+str (eval ("REG'+TYPE+VARIANTE)) +"; "+ |
text = text + "NOT = "+str (eval ("HF" +TYPE+VARIANTE)) +"; "+ |
text = text + "RE_BRI = "+str (R_EXT_BRID) +"; |
text = text + "HTE_BRI = "+str (H_CORP_BRID) +"; |
text = text + "NFIL = "+str (NB_FILET) +"; |
text = text + "H_MINFI = "+str (H_BAS_BRID) +"; |
text = text + "H_HTBRI = "+str (H_HAUT_BRID) +"; |
text = text + "* FINE PARAMETERS USER |
textp = ''
yew FILET_ABST! =None:
for num in FILET_ABST:
textp = textp + "NETS = DIFF NETS FIL00'+str (num) +"; |
loc_datg = aster.repdex ()
textp = textp + """" OPTI DONN """" +loc_datg+ """" gouj2.datg"""; | N """"
text = text + """" OPTI DONN """" +loc_datg+ """" gouj1.datg"""; | N """"

# Name of the command file for GIBI
nomFichierDATG = name_file (UNITD)
nomFichierDATP = name_file (UNITP)

# Opening of the file D entered of orders gibi
fdgib=open (nomFichierDATG, "W")
fdgip=open (nomFichierDATP, "W")
fdgib.write (text)
fdgip.write (textp)

```

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**fdgib.close ()**  
**fdgip.close ()**

**return**  
#####  
#####  
**# macro orders postprocessing (ex POST\_GOUJ2E)**  
**# calculation of the reactions cumulees according to the nets**

**def POST\_GOUJ\_ops (coil, TABLE):**  
**ier=0**  
**### One imports the definitions of the orders has to use in the macro one**  
**CREA\_TABLE =SELF.GET\_CMD (“CREA\_TABLE”)**

**aa1=TABLE.EXTR\_TABLE ()**  
**aaa=aa1.values ()**

**v\_DY=aaa [“DY”]**  
**v\_NU=aaa [“NUME\_ORDRE”]**  
**NBVAL=len (v\_DY)**  
**nbv=0**  
**for num in v\_NU:**  
**yew num==v\_NU [0]: nbv=nbv+1**  
**yew nbv>0: ninch=NbVAL/nbv**  
**else: print “error”**

**v\_F1= [v\_DY [i\*nbv: (i+1) \*nbv] for I in arranges (ninch)]**  
**v\_FO= []**  
**v\_CU= []**  
**def add (X, y): return x+y**  
**for list in v\_F1:**  
**liste.reverse ()**  
**v\_FO.append (list)**  
**ftot=reduce (add, list)**



*v\_CU.append ([reduce (add, list [: i+1]) \*100. /ftot for I in arranges (len (list))])*

*v\_NF= []*

*for I in arranges (ninch): v\_NF=v\_NF+range (1, nbv+1)*

*v\_RE= []*

*for list in v\_FO: v\_RE=v\_RE+list*

*v\_RC= []*

*for list in v\_CU: v\_RC=v\_RC+list*

*self.DeclareOut ("tab3", self.sd)*

*tab3=CREA\_TABLE (LISTE= (\_F (PARA = "NUME\_ORDRE",*

*LISTE\_I = v\_NU),*

*\_F (PARA = "NUME\_FILET",*

*LISTE\_I = v\_NF),*

*\_F (PARA = "REACTION",*

*LISTE\_R = v\_RE),*

*\_F (PARA = "REACTION\_CUMU",*

*LISTE\_R = v\_RC),*

*))*

*return 0*

*POST\_GOUJ=MACRO (nom= " POST\_GOUJ ", op=POST\_GOUJ\_ops, sd\_prod=table\_sdaster, reentrant='*

*, fr= "",*

*TABLE=SIMP (statut=' o', typ=tabl\_post\_rele),)*

*#####*

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**Note:**

*The preceding lines are present in the cases tests ZZZZ120A and ZZZZ120B, it will thus be necessary to recopy at the beginning of all new command file.*

*Then the command file will have to contain the orders and the sets of orders in the order indicated below:*

- 1) **BEGINNING ()**
- 2) **INCLUDE ()**
- 3) *email = {Together of orders which produce the grid. }*
- 4) *calc = {Together of orders which carry out calculation. }*
- 5) **END ()**

**5.2.1 Detail of order INCLUDE**

*The syntax of order INCLUDE is as follows:*

**INCLUDE (UNIT = 38,)**

*The Logical number of Unit (38) corresponds to the file containing the data base, cf [§5.1].*

**5.2.2 Production of the grid**

*The function macr\_gouj2e\_mail, cf [[§3] and the whole of orders described low ensure production of the grid of an assembly pin-attaches such as that which is presented on [Figure 3.3-a]. Except order IMPR\_RESU, They all are necessary.*

- 1)  
*function*  
**macr\_gouj2e\_mail;**
- 2)  
*line*  
**loc\_outils=aster.repout ();**
- 3)  
*order*  
**EXEC\_LOGICIEL;**
- 4)  
*order*  
**PRE\_GIBI;**
- 5)

**order**

**MAIL=LIRE\_MAILLAGE;**

**6)**

**order**

**MAIL=DEFI\_GROUP;**

**7) optional order IMPR\_RESU.**

**Order EXEC\_LOGICIEL launches the Gibi software which generates the file of grid to the format Gibi (file .mgib) starting from the data files Gibi (file .datg) to which the user does not have access.**

**The function macr\_gouj2e\_mail is used to recover in the data base the ray interns attach, the external ray of the pin and the step of the nets of the pin characterized by its type and its alternative,**

**cf [§3]. Moreover this function prepares the data files Gibi (.datg). Characteristics geometrical of the support and the nets are specified by the means of operands H\_CORP\_BRID (Height of the Body of Support, part of the support in catch with the nets) and R\_EXT\_BRID (Ray Outside of the Support) which is obligatory. Operands H\_HAUT\_BRID (Height Top of Support) and H\_BAS\_BRID (Height of the Bottom of Support) are optional, they are worth zero per defect. All them**

**dimensions must be given in millimetres. If the user gives values to the heights of high of support and the bottom of support, those cannot be lower than 1 millimetre. The ray intern of the support, the external ray of the pin as well as the step or the height of a net is sizes characteristic of a given assembly which are stored in the base; they are not, consequently, to inform by the user.**

**One indicates the total and theoretical number of nets with single-ended spanner word obligatory NB\_FILET. If**

**some of the nets miss or missing, single-ended spanner word FILET\_ABST makes it possible to indicate some**

**list. The nets absent are not with a grid.**

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**Notice 5.2.2-1:**

*The name of the concept grid (here email) must be different from the names of concepts defined in base data, which one presents the list in [Table 5.2.2-1]. In [Table 5.2.2-1], prefixes SGM, REGM, etc are reserved for concepts of the data base (which can be enriched later), the symbol “xx” can be equal to 33, 64, 90, 115, 155, 180 or 186. symbol “there” can be equal to the one of the twenty six letters of the alphabet.*

**Name concept Definition**

*SGM<sub>xx</sub>y*

*section of the pin*

*REGM<sub>xx</sub>y*

*ray external of the pin*

*HFM<sub>xx</sub>y*

*height or not of the net*

*RIBM<sub>xx</sub>y*

*interior ray of the support*

*CFM<sub>xx</sub>y*

*configuration net*

*HBM<sub>xx</sub>y*

*high of support*

*COM<sub>xx</sub>y*

*mechanical behavior*

*MABM<sub>xx</sub>y*

*name of material of the support*

*MAGM<sub>xx</sub>y*

*name of material of the pin*

*PFM<sub>xx</sub>y*

*behavior of the first net (traction diagram)*

*DFM<sub>xx</sub>y*

*behavior of the second net (traction diagram)*

*FCM<sub>xx</sub>y*

*behavior of the current nets (traction diagram)*

*MGM<sub>xx</sub>y*

*definition of material of the pin (E and NAKED)*

*MBM<sub>xx</sub>y*

*definition of material of the support (E and NAKED)*

*FTM<sub>xy</sub>**behavior of a truncated net (traction diagram)**FTAM<sub>xy</sub>**behavior of a truncated net of type A (traction diagram)**FTBM<sub>xy</sub>**behavior of a truncated net of type B (traction diagram)**JHTM<sub>xy</sub>**behavior of a net whose play is except tolerance (traction diagram)**HTAM<sub>xy</sub>**behavior of a net whose play is except tolerance of the type A (curve of traction)**HTBM<sub>xy</sub>**behavior of a net whose play is except tolerance of the type B (curve of traction)****Table 5.2.2-1: List names of concepts which are prohibited with the user***

*Below we indicate a typical example of command file allowing to produce it grid of an assembly pin-attaches.*

*# user datum**# it is necessary to satisfy the constraints:**#**# height of support lower than the number of nets by the step:**# NB\_FILET \* HFM155A < H\_CORP\_BRID**#**# interior ray of support lower than the external ray:**# RIBM155A < R\_EXT\_BRID**#**# ray external of the pin lower than the interior ray of support:**# REGM155A < RIBM155A**#**TYPE = "M155"**ALTERNATIVE = "A"**NB\_FILET = 56**H\_CORP\_BRID = 225.0**R\_EXT\_BRID = 140.0**H\_HAUT\_BRID = 200.0**H\_BAS\_BRID = 0.0**FILET\_ABST = (3,4,)**macr\_gouj2e\_mail (STANDARD, ALTERNATIVE, NB\_FILET, H\_CORP\_BRID, R\_EXT\_BRID, H\_HAUT\_BRID, H\_BAS\_BRID, FILET\_ABST,)**loc\_outils=aster.repout ()*

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```
EXEC_LOGICIEL (LOGICIEL=loc_outils+' gibi',  
ARGUMENT= (_F (NOM_PARA=' fort.70'),  
_F (NOM_PARA=' fort.19')),);
```

```
PRE_GIBI ()
```

```
MAIL=LIRE_MAILLAGE ()
```

```
MAIL=DEFI_GROUP (reuse = EMAIL,  
MAILLAGE=MAIL,  
CREA_GROUP_NO= (_F (NOM=' NDFILETS',  
GROUP_MA=' CORPSGOU',  
CRIT_NOEUD=' TOUS')),)
```

*The following line is optional, it makes it possible to print the grid with the format Gibi (mgib) in a file which,*

*in the profile of study, must correspond to unit 53 in this example.*

```
IMPR_RESU (FORMAT=' CASTEM', UNITE=53, RESU=_F (MAILLAGE=MAIL,))
```

*Lastly, all the entities of the grid which can be affected of a particular behavior or one loading are named:*

**THE PILE NUMBER 1 CONTAINS 73 OBJECT (S) GRID**

*IT A 66 OBJECT (S) NAMES THERE (S):  
CORPSGOU 5 HAUTGOUJ 6 PIN 7 FIL001 8 NETS 9  
FIL002 10 FIL005 11 FIL006 12 FIL007 13 FIL008 14  
FIL009 15 FIL010 16 FIL011 17 FIL012 18 FIL013 19  
FIL014 20 FIL015 21 FIL016 22 FIL017 23 FIL018 24  
FIL019 25 FIL020 26 FIL021 27 FIL022 28 FIL023 29  
FIL024 30 FIL025 31 FIL026 32 FIL027 33 FIL028 34  
FIL029 35 FIL030 36 FIL031 37 FIL032 38 FIL033 39  
FIL034 40 FIL035 41 FIL036 42 FIL037 43 FIL038 44  
FIL039 45 FIL040 46 FIL041 47 FIL042 48 FIL043 49  
FIL044 50 FIL045 51 FIL046 52 FIL047 53 FIL048 54  
FIL049 55 FIL050 56 FIL051 57 FIL052 58 FIL053 59  
FIL054 60 FIL055 61 FIL056 62 BASGBRID 63 GBRIDE 64  
ATTACH 65 HBRIDE 68 BBRIDE 69 DBRIDE 70 EMAIL 1  
SHBRI 71*

*THE PILE NUMBER 32 CONTAINS 2453 OBJECT (S) NOT  
IT A 8 OBJECT (S) NAMES THERE (S):  
PBFIL 2397 PHFIL 2452 PHGOUJ 2453 PBGBRID 262 PBGFBRID 361  
PHGFBRID 636 PCFIL 2397 PCBRID 361*

### ***5.2.3 Realization of calculation***

*Before writing the part “calculation” of the command file, it is advised to consult the base data in order to know the types of nets, materials and the diagrams traction which are associated a type of assembly pin-attaches given.*

*The realization of calculation requires the sequence of the following orders of Code\_Aster:*

- 1)  
order  
DEFI\_GROUP which enriches the grid by creating groups by nodes;*
- 2)  
order  
AFFE\_MODELE which assigns the mechanical phenomena to the various groups meshes;*
- 3)  
order  
AFFE\_CARA\_ELEM which makes it possible to define the section of the beam which models it pin and the characteristics of discrete which model the nets;*
- 4)  
order  
DEFI\_MATERIAU which makes it possible to define materials of the nets of the pin;*
- 5)*

**order**  
**AFFE\_MATERIAU** which affects materials defined in the groups of meshes  
adequate;

6)

**order**  
**AFFE\_CHAR\_MECA** which affects the boundary conditions and the loading;  
7) the order **DEFI\_FONCTION** which defines the multiplying function to apply to  
loading;

8)

**order**  
**DEFI\_LIST\_REEL** which defines the list of moments;

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9)

*order*

*STAT\_NON\_LINE which carries out calculation;*

*10) the order CALC\_NO which calculates the nodal forces;*

*11) the order POST\_RELEVE\_T which recovers the relevant results;*

*12) the macro-order POST\_GOUJ which reorganizes the results in the adapted format;*

*the 13) order IMPR\_TABLE which makes it possible to print the results.*

*Concretely that results in the following orders:*

```
MAIL=DEFI_GROUP (reuse =MAIL,  
MAILLAGE=MAIL,  
CREA_GROUP_NO= (_F (GROUP_MA=' GOUJON',  
NOM=' GOUJ_NO',  
CRIT_NOEUD=' TOUS',),  
_F (GROUP_MA=' FILETS',  
NOM=' FILET_NO',  
CRIT_NOEUD=' TOUS',),  
_F (GROUP_MA=' BRIDE',  
NOM=' BRIDE_NO',  
CRIT_NOEUD=' TOUS',),),),);
```

```
modele=AFFE_MODELE (MAILLAGE=MAIL,  
AFFE= (_F (GROUP_MA=' GOUJON',  
PHENOMENE=' MECANIQUE',  
MODELISATION=' POU_D_E',),  
_F (GROUP_MA=' FILETS',  
PHENOMENE=' MECANIQUE',
```

```
MODELISATION='2D_DIS_T'),  
_F (GROUP_MA=' BRIDE',  
PHENOMENE=' MECANIQUE',  
MODELISATION=' AXIS',),),);
```

*REGM155A is the ray external of the pin of the type M155 alternative A.*

```
carael=AFFE_CARA_ELEM (MODELE=modele,  
POUTRE=_F (GROUP_MA=' GOUJON',  
SECTION=' CERCLE',  
CARA=' R',  
VALE=REGM155A,),  
DISCRET_2D=_F (GROUP_MA=' FILETS',  
CARA=' K_T_D_L',  
VALE= (10000000.0, 10000000.0,),),);
```

*One can apply to the ordinary nets three behaviors, to see it [Table 5.2.2-1]:*

- 1) behavior of the first net (traction diagram);*
- 2) behavior of the second net (traction diagram);*
- 3) behavior of the current nets (traction diagram).*

*One can apply to the nets six particular behaviors, to see it [Table 5.2.2-1]:*

- 1) behavior of a truncated current net, (traction diagram), cf [§6.1] Remark 6.1-1;*
- 2) behavior of a truncated net of type A, (traction diagram);*
- 3) behavior of a truncated net of type B, (traction diagram);*
- 4) behavior of a current net whose play is except tolerance, (traction diagram);*
- 5) behavior of the first net whose play is except tolerance of the type A (traction diagram);*
- 6) behavior of the second net whose play is except tolerance of the type B (traction diagram).*

***The user will have to check in the data base, that the behaviors which it counts to use are well defined, cf [§6].***

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*For example, for the M155 assembly there are no traction diagrams for truncated nets or having a play except tolerance, contrary to the M90 assembly.*

*PFM155A is the traction diagram of the First net of the pin of the type M155 alternative A.*

*MF\_1=DEFI\_MATERIAU (TRACTION=\_F (SIGM=PFM155A,));*

*DFM155A is the traction diagram of the Second net of the pin of the type M155 alternative A.*

*MF\_2=DEFI\_MATERIAU (TRACTION=\_F (SIGM=DFM155A,));*

*FCM155A is the traction diagram of the current nets (other nets) of the pin of the type M155 alternative A.*

*MF\_C=DEFI\_MATERIAU (TRACTION=\_F (SIGM=FCM155A,));*

*One affects in the last materials particular to the nets which have a particular behavior.*

*chmat=AFPE\_MATERIAU (MAILLAGE=MAIL,*

*AFPE= (\_F (GROUP\_MA=' GOUJON',*

*MATER=MGM155A,)*

*\_F (GROUP\_MA=' FILETS',*

*MATER=MF\_C,)*

*\_F (GROUP\_MA=' BRIDE',*

*MATER=MBM155A,)*

*\_F (GROUP\_MA=' FIL001',*

*MATER=MF\_1,)*

*\_F (GROUP\_MA=' FIL002',*

*MATER=MF\_2,)),);*

*There are three types of boundary conditions on the support:*

*1) with dimensions side outside of the support blocked following y;*

*2) with dimensions side outside and bases support blocked following y;*

*3) bases support blocked according to Y.*

*One also specifies the value, in **Newton**, of the force of traction applied at the head of the pin.*

*F*

*F*

*F*

***PIN***

***ATTACH***

***PIN***

***ATTACH***

***PIN***

***ATTACH***

***NETS***

***NETS***

***NETS***

*Boundary conditions 1*

*Boundary conditions 2*

*Boundary conditions 3*

*charme=AFFE\_CHAR\_MECA (MODELE=modele,  
DDL\_IMPO=\_F (GROUP\_NO= ("GOUJ\_NO", "FILET\_NO", "BRIDE\_NO"),  
DX=0.0,),  
FACE\_IMPO= (\_F (GROUP\_MA= ("DBRIDE", "BBRIDE"),  
DY=0.0,),  
\_F (GROUP\_MA=' GOUJON',  
DZ=0.0,  
DRY=0.0,)),),  
FORCE\_NODALE=\_F (GROUP\_NO=' PHGOUJ',  
FY=1.0,)),);*

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The *FORCE\_NODALE* will be multiplied by the following function during calculation (order *STAT\_NON\_LINE*, key word *EXCIT*):

```
fonc=DEFI_FONCTION (NOM_PARA=' INST',
NOM_RESU=' TOUTRESU',
VALE= (0.0, 0.0, 5.0, 5000000.0,));
```

Order *DEFI\_LIST\_REEL* is used to define the list of moments necessary to incremental calculation (order *STAT\_NON\_LINE*, key word *COMP\_INCR*).

```
list=DEFI_LIST_REEL (DEBUT=0.0,
INTERVALLE= (_F (JUSQU_A=1.0,
NOMBRE=1,),
_F (JUSQU_A=2.0,
NOMBRE=1,),
_F (JUSQU_A=3.0,
NOMBRE=1,),
_F (JUSQU_A=4.0,
NOMBRE=1,),
_F (JUSQU_A=5.0,
NOMBRE=1,)),);
```

Two types of calculation can be selected:

.  
**ELASTOPLASTIC**, one uses the **behavior of the nets** given in the form of curve of traction in the base, one uses the incremental behavior then:

```
_F (RELATION=' DIS_GOUJ2E_PLAS',
DEFORMATION=' PETIT',
GROUP_MA=' FILETS',),),
```

.  
**RUBBER BAND**, that amounts plotting a straight line with the origin and the first point of the curve of traction **of the nets**, which makes it possible to make a linear elastic design, one uses it incremental behavior:

```
_F (RELATION=' DIS_GOUJ2E_ELAS',
DEFORMATION=' PETIT',
GROUP_MA=' FILETS',),),
```

In the example below we carry out an **ELASTOPLASTIC** calculation.

```
CALC=STAT_NON_LINE (MODELE=model,
```

*CHAM\_MATER=chmat,*  
*CARA\_ELEM=carael,*  
*EXCIT=\_F (CHARGE=charme,*  
*FONC\_MULT=fonc,*  
*TYPE\_CHARGE='FIXE\_CSTE'),*  
*COMP\_INCR= (\_F (RELATION='ELAS',*  
*DEFORMATION='PETIT',*  
*GROUP\_MA='GOUJON'),*  
*\_F (RELATION='ELAS',*  
*DEFORMATION='PETIT',*  
*GROUP\_MA='BRIDE'),*  
*\_F (RELATION='DIS\_GOUJ2E\_PLAS',*  
*DEFORMATION='PETIT',*  
*GROUP\_MA='FILETS'),),*  
*INCREMENT=\_F (LIST\_INST=list,)*  
*NEWTON=\_F (REAC\_ITER=3,)*  
*CONVERGENCE=\_F (ITER\_GLOB\_MAXI=20,));*

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*Order CALC\_NO calculates the nodal forces exerted on the nets.*

*CALC=CALC\_NO (reuse =CALC,*

*RESULTAT=CALC,*

*PRECISION=0.001,*

*CRITERE='RELATIF',*

*OPTION='FORC\_NODA',*

*GROUP\_MA=' FILETS',);*

*The key word factor IMPRESSION is used to choose the format of presentation of the results.*

*tab1=POST\_RELEVE\_T (ACTION=\_F (INTITULE=' RESU\_T1',  
GROUP\_NO=' NDFILETS',  
FORMAT\_C=' MODULE',  
RESULTAT=CALC,  
NOM\_CHAM=' FORC\_NODA',  
TOUT\_ORDRE=' OUI',  
PRECISION=1e-06,  
CRITERE=' RELATIF',  
NOM\_CMP=' DY',  
REPERE=' GLOBAL',  
MOYE\_NOEUD=' OUI',  
OPERATION=' EXTRACTION',),),);*

*In addition to the traditional formats of impression of Code\_Aster there is the format COUNTS specific to calculation*

*total of an assembly pin-attaches, cf [§3.3].*

*tab2=POST\_GOUJ (TABLE=tab1,);*

*IMPR\_TABLE (  
TABLE=tab2,  
UNITE=8,  
FORMAT=' AGRAF',  
FILTRE=\_F (NOM\_PARA=' NUME\_ORDRE',  
VALE\_I=1,),  
NOM\_PARA= ("NUME\_ORDRE", "NUME\_FILET", "REACTION", "REACTION\_CUMU",),),);*

### **Notice 5.2.3-1:**

*Cf Notice 5.2.2-1.*

## **5.3**

### **The file of results**

*In this part one presents only the format COUNTS dedicated to the total calculation of an assembly pin-attach. In this last case the results are presented in two parts. The first gives correspondence number of net-number of node. The second part is organized in the form of a table having four columns. First relates to the increment or sequence number, second indicates the number of the nets, the third the reaction in **Newton** of the nets and the fourth cumulated reaction of the nets expressed in %. The format TABLE simply makes it possible to trace them*

*curves: reaction of the nets according to their number and cumulated reaction of the nets according to their number, using the software of layout of curves xmgrace.*

*One gives an outline of the format below COUNTS.*

***Part giving the correspondence number of net-number of node:***

*NUME\_FILET NODES*

*1 \ N1954*

*2 \ N1953*

*3 \ N1952*

*4 \ N1951*

*5 \ N1950*

*..*

*..*

*..*

*..*

*..*

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*52 \ N1903*

*53 \ N1902*

*54 \ N1901*

*55 \ N1900*

*56 \ N1899*



**Part giving the sequence number, the number of net, the reaction (in NR) and the cumulated reaction (in % of the total), example for the sequence number five:**

*NUME\_ORDRE NUME\_FILET REACTION REACTION\_CUMU*

*5 1 3.75966E+05 7.51932E+00*

*5 2 3.63799E+05 1.47953E+01*

*5 3 0.00000E+00 1.47953E+01*

*5 4 0.00000E+00 1.47953E+01*

*5 5 3.09596E+05 2.09872E+01*

*5 6 2.84261E+05 2.66724E+01*

*.  
. .  
. .*

*5 52 3.35943E+04 9.66590E+01*

*5 53 3.59525E+04 9.73780E+01*

*5 54 3.90373E+04 9.81588E+01*

*5 55 4.31747E+04 9.90223E+01*

*5 56 4.88871E+04 1.00000E+02*

**Notice 5.3-1:**

*The sequence number corresponds to the increment of load.*

**5.4**

***The file of messages***

*This file contains the whole of the Code\_Aster orders, whole and the data base of orders produced by the macro-orders. We do not give here an outline of the file of messages (.mess), the eager reader of more than details will be able to consult the files of messages cases tests ZZZZ120A and ZZZZ120B.*

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## **6** **Presentation and use of the data base**

### **6.1 General**

*A threaded assembly leads to a modeling beam for the pin (element of beam) and 2D for the nets (discrete elements with two nodes) and attaches it (axisymmetric elements 2D). Three elements of an assembly are schematized on [Figure 6.1-a].*

*Ray interns support*

*High of Support*

*net 1*

*y*

*X*

*PIN*

*Body of Support*

*BR I D E*

*U (y)*

*v (y)*

*net N*

*Low of Support*

*NETS*

*External ray of the support*

*Appear 6.1-a: Schematized representation of an assembly*

*The pin and the support have a linear elastic behavior. The nonlinear behavior is located in the nets. It applies to the discrete elements and is given in an independent way by a local calculation axisymmetric 2D whose one exploited the results. This behavior appears under the form of a relation, indexed by the position of the net in the structure, between a difference of displacement  $U - v$  and force it shearing  $= Q = F (U - v)$  which is associated for him. Knowing it behavior of the elements constituting an assembly, one solves the total problem of which them displacements of the pin ( $U (y)$ ) and of support  $v (y)$  are solutions.*

*These are the various relations which are described, in the form of functions given point by point, in the base presented in this note. These curves were obtained for exerted tractions at the head pin and not of compressions.*

*Within the framework of the summary above, certain parameters characteristic of a given assembly intervene only during the integration of the total problem.*

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*It is the case, for example, of the number of nets, the total effort exerted at the head pin, conditions of blocking of the support (side surface and/or bases blocked (S)). These parameters do not appear*

*thus not in the specifications of a curve characteristic of a net.*

*The parameters which, on the other hand, determine the behavior of the nets are listed below:*

*.*

*Designation of the standardized form of the geometry of the pin, example: M33, M155;*

*.*

*Type of the assembly pin-attaches, example: NOMINAL or HELICOIL;*

*.*

*Stiffener top of support, example: WITH or WITHOUT;*

*.*

*Geometrical characteristics of play, example: MINIS or MAXIMUM;*

*.*

*Behavior of the nets and condition of contact pin/tapping, example: RUBBER BAND (linear rubber band) or ELASTOPLASTIC nonlinear traction diagram).*

*Each combination of these various parameters thus leads a priori to a specific relation shearing-jump of displacement. One locates each one of these combinations by a letter, by example: for the standardized form of the geometry of the M33 pin, if the assembly pin-attaches is NOMINAL, the stiffener top of support present (WITH), maximum clearance and the behavior of the nets*

*ELASTOPLASTIC one will speak about the M33 pin of alternative A, noted: M33\_A, cf [Table 6.2-3] Association forms standardized geometry of the pin (M33) and alternative (A) identifies in manner single the card of an assembly gathering the whole of the data relating to it (geometry of the assembly, characteristic of the assembly, curves behavior of the nets =  $Q = F(U - v)$ , definition of materials of the support and the pin) in the base, cf [Table 6.3-1] and [Table 6.3-2].*

#### **Remarks 6.1-1:**

*All configurations other than those with thread inserts (HELICOIL), cf [bib3], [bib4], were calculated in plasticity. If it is wanted nevertheless that the nets have a behavior linear rubber band it will be necessary to use RELATION=' DIS\_GOUJ2E\_ELAS' of key word COMP\_INCR order STAT\_NON\_LINE, cf [§ 5.2.3].*

*The curves representative of anomalies are they also specific place of the nets carriers of these anomalies, A and B respectively locating in the card of an assembly that of the first and second net.*

*The user will have to make sure that the types of behavior of the nets which it chose correspond or not to a configuration calculated in the base.*

## **6.2**

### **Presentation of the curves introduced into the data base**

*One presents, here version 1.0 of the data base at the date of the 16/09/1999.*

*The complete base can be obtained from EDF/BPI/UTO.*

*[Table 6.2-1] gathers the geometries available with their characteristics of assembly.*

#### **Geometry**

*Section of the pin*

*Ray external of*

*Thickness of*

*Interior ray of*

*(in mm<sup>2</sup>)*

*pin (in mm)*

*net*

*the support (in mm)*

*(in mm)*

*M33 6.45E+02*

*14.3286E+00 3.5*

*16.5*

*M64 2.715E+03 29.3975E+00 6.0*

*34.0*

*M90 5.845E+03 43.1338E+00 3.0*

*45.0*

*M115 9.724E+03 55.6349E+00 3.0*

*57.5*

*M155 1.704E+04 73.6478E+00 4.0*

*80.0*

*M180 2.337E+04 86.2491E+00 4.0*

*90.0*

*M186 2.487E+04 88.9740E+00 6.0*

*93.0*

*Table 6.2-1: List geometries of assemblies threaded available in the data base*

*[Table 6.2-2] presents materials available as well for the support as the pin. Some of these materials are not used that for the support or that for the pin, cf [Table 6.2-3].*

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*Material*

***YOUNG modulus***  
***YOUNG modulus***  
***Coefficient***  
***for the pin***  
***for the support (in MPa)***  
***of Poisson***  
***(in MPa)***  
***16MND5 1.90000E+05***  
***11.93800E+05***  
***0.3***  
***40NCDV 1.91139E+05***  
***12.00962E+05***  
***0.3***  
***Z3CN\_20\_09\_M (300\_C) 1.76500E+05***  
***11.08982E+05***  
***0.3***  
***40NCD (300\_C) 1.85000E+05***  
***11.62389E+05***  
***0.3***  
***20MND5 (316\_C) 1.95000E+05***  
***12.25200E+05***  
***0.3***  
***42CDV4 (316\_p3) 1.90220E+05***  
***11.95188E+05***  
***0.3***  
***16MND5 (343\_C) 1.90000E+05***  
***11.93800E+05***  
***0.3***  
***40NCDV (343\_C) 1.90000E+05***  
***11.93800E+05***  
***0.3***

***Table 6.2-2: List materials available in the data base.***

***In [Table 6.2-3] was gathered the list of the configurations of assemblies threaded in base data of the nets.***

***Notice 6.2-1:***

***The Young modulus of the support is multiplied by 2 bus it is treated in axisymmetric 2D, whereas the pin is in beam.***

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**WITH or**

**Type of**

**WITHOUT**

**Play**

**pin and**

**high of**

**MINIS**

**Configured**

**Material**

**Material**

**Alternative**

**attach**

**MAXIMUM**

**tion of the net**

**attach**

**pin**

**Behavior**

**20MND5**  
**42CDV4**  
**ELASTOPLASTIC**  
**M33\_A**  
**WITH**  
**MAXIMUM**  
**NOMINAL**  
**(316\_C)**  
**(316\_p3)**

**20MND5**  
**42CDV4**  
**ELASTOPLASTIC**  
**M33\_B**  
**WITHOUT**  
**MAXIMUM**  
**NOMINAL**  
**(316\_C)**  
**(316\_p3)**

**20MND5**  
**42CDV4**  
**ELASTOPLASTIC**  
**M33\_C**  
**WITH**  
**MINIS**  
**NOMINAL**  
**(316\_C)**  
**(316\_p3)**

**20MND5**  
**42CDV4**  
**ELASTOPLASTIC**



**M33\_D**  
**WITHOUT**  
**MINIS**  
**NOMINAL**  
**(316\_C)**  
**(316\_p3)**

**20MND5**  
**42CDV4**  
**ELASTOPLASTIC**  
**M33\_E**  
**WITH**  
**MAXIMUM**  
**NOMINAL**  
**(316\_C)**  
**(316\_p3)**

**ELASTOPLASTIC**  
**M64\_A**  
**WITH**  
**MAXIMUM**  
**NOMINAL**  
**16MND5**  
**40NCDV**

**M90\_A**  
**WITH**  
**MAXIMUM**  
**NOMINAL**  
**Z3CN\_20\_09\_M**  
**40NCD**  
**ELASTOPLASTIC**

**(300\_C)**

**(300\_C)**

**M90\_B**  
**WITH**  
**MINIS**  
**NOMINAL**  
**Z3CN\_20\_09\_M**  
**40NCD**  
**ELASTOPLASTIC**  
**(300\_C)**  
**(300\_C)**

**M115\_A**  
**WITH**  
**MAXIMUM**  
**NOMINAL**  
**Z3CN\_20\_09\_M**  
**40NCD**  
**ELASTOPLASTIC**  
**(300\_C)**  
**(300\_C)**

**M115\_B**  
**WITHOUT**  
**MAXIMUM**  
**NOMINAL**  
**Z3CN\_20\_09\_M**  
**40NCD**

***ELASTOPLASTIC***

***(300\_C)***

***(300\_C)***

***M115\_C***

***WITHOUT***

***MINIS***

***NOMINAL***

***Z3CN\_20\_09\_M***

***40NCD***

***ELASTOPLASTIC***

***(300\_C)***

***(300\_C)***

***M115\_D***

***WITH***

***MAXIMUM***

***NOMINAL***

***Z3CN\_20\_09\_M***

***40NCD***

***ELASTOPLASTIC***

***(300\_C)***

***(300\_C)***

***M115\_E***

***WITH***

***MAXIMUM***

***NOMINAL***

***Z3CN\_20\_09\_M***

**40NCD**  
**ELASTOPLASTIC**  
**(300\_C)**  
**(300\_C)**

**ELASTOPLASTIC**  
**M155\_A**  
**WITH**  
**MAXIMUM**  
**NOMINAL**  
**16MND5**  
**40NCDV**

**ELASTOPLASTIC**  
**M155\_B**  
**WITHOUT**  
**MAXIMUM**  
**NOMINAL**  
**16MND5**  
**40NCDV**

**ELASTOPLASTIC**  
**M155\_C**  
**WITH**  
**MINIS**  
**NOMINAL**  
**16MND5**  
**40NCDV**

***ELASTOPLASTIC  
M155\_D  
WITHOUT  
MAXIMUM  
HELICOIL  
16MND5  
40NCDV***

***ELASTOPLASTIC  
M180\_A  
WITH  
MAXIMUM  
NOMINAL  
16MND5  
40NCDV***

***ELASTOPLASTIC  
M180\_B  
WITHOUT  
MAXIMUM  
NOMINAL  
16MND5  
40NCDV***

***ELASTOPLASTIC  
M180\_C  
WITH  
MINIS  
NOMINAL***

**16MND5**  
**40NCDV**

**16MND5**  
**40NCDV**  
**ELASTOPLASTIC**  
**M186\_A**  
**WITH**  
**MAXIMUM**  
**NOMINAL**  
**(343\_C)**  
**(343\_C)**

**16MND5**  
**40NCDV**  
**ELASTOPLASTIC**  
**M186\_B**  
**WITH**  
**MINIS**  
**NOMINAL**  
**(343\_C)**  
**(343\_C)**

**Table 6.2-3: List configurations of assemblies threaded available in the data base version 1.00 of the 16/09/1999**

**The curves of behavior (force of shearing - play) which are in the data base are of the form presented in [Table 6.2-4]. The sizes  $U - v$  and  $Q$  are respectively expressed in mm and Newton.**

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**U - v**

**Q**

**1.4454D-03**

**5960.40**

**7.8791D-03**

**32289.00**

**1.4830D-02**

**57528.00**

**2.4101D-02**

**75876.00**

**3.1714D-02**

**82719.00**

**3.9722D-02**

**88368.00**

**4.7951D-02**

**93345.00**

**5.6338D-02**

**97836.00**

**6.4836D-02**

**102012.00**

**10.8080D-02**

**120678.00**

**15.1800D-02**

**136881.00**

**19.5490D-02**

**151413.00**

**23.8870D-02**

**164658.00**

**28.1710D-02**

**176835.00**

**32.3800D-02**

**188022.00**

**36.4850D-02**

**198210.00**

**40.4850D-02**

**207417.00**

**Table 6.2-4: Pin M115 alternative A**

### **6.3**

#### ***Presentation of the data base***

***The data base is the subject of a specific data-processing treatment; certain rules are essential to observe in order to supplement it in a rigorous way.***

***The file of the base is divided into three parts: the references dates and version, the framework heading, them cards of the assemblies. These three parts are mentioned and detailed below:***

***1) The first line contains the date and the number of version of the base. This line is considered as being a comment.***

***2) The framework of the heading makes it possible to note the successive evolutions of the base: author (S), date version and object.***

***3) The third part contains the cards of the assemblies. Those are consisted of the manner following: the type of the pin as well as the alternative has.***

***B Geometry of the assembly, left in which one finds: the section of the pin, it ray external of the pin, the height or the step of the net and the interior ray of the support.***

***C The characteristics of the assembly, one finds there: the configuration net, the characteristic high of support, the type of play, the mechanical behavior, the material attaches and the material pin.***

***D Curves describing the behavior of the nets (FIRST NET, SECOND NET, NET RUNNING,...).***

***E Materials of the support and the pin: the Young modulus and the Poisson's ratio.***

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*Each data is located by a **single name**, for example for the pin of the M33 type and of alternative A one a:*

**Name**

**Definition**

**SGM33A**

*section of the pin*

**REGM33A**

*ray external of the pin*

**HFM33A**

*height or not of the net*

**RIBM33A**

*interior ray of the support*

**CFM33A**

*configuration net*

**HBM33A**

*high of support*

**COM33A**

*mechanical behavior*

**MABM33A**

*name of material of the support*

**MAGM33A**

*name of material of the pin*

**PFM33A**

*behavior of the first net*

**DFM33A**

*behavior of the second net*

*FCM33A*

*behavior of the current nets*

*MGM33A*

*definition of material of the pin (E and NAKED)*

*MBM33A*

*definition of material of the support (E and NAKED)*

**Table 6.3-1: Definitions of the names**

*Each name must have with more the eight alphanumeric.*

*In addition, there exists for certain types of pin of the particular nets, for example for the pin of M180 type and alternative a:*

**Name**

**Definition**

*FTM180A*

*behavior of a truncated net*

*FTAM180A*

*behavior of a truncated net of type A*

*FTBM180A*

*behavior of a truncated net of type B*

*JHTM180A*

*behavior of a net whose play is except tolerance*

*HTAM180A*

*behavior of a net whose play is except tolerance of the type A*

*HTBM180A*

*behavior of a net whose play is except tolerance of the type B*

**Table 6.3-2: Definitions of the names of the particular nets**

**6.4 Food of the data base in curves of behavior nets**

*A local calculation is necessary each time a new combination of parameters must be studied. These calculations are carried out by finite elements, and it is a specific postprocessing which provides*

*with each step of load, the difference  $U - v$  and the value of the axial load corresponding. That was described in former publications [bib4], [bib5] and [bib6]. The evolution of the data base is with the initiative of the U.T.O.*

**6.5**

**Version 1.00 of the data base**

*Hereafter an extract of the data base concerning the behavior of the threaded assemblies is*

*presented in its version 1.00 the 16/09/1999:*  
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# DATES: 16/09/1999 VERSION: 1.00

#

# MODIFICATION

# AUTHOR: J. ANGLES

# DATES: 16/09/1999

# VERSION: 1.00

# SUBJECT: CUTTING TO SIZE ASTER

# OF THE OLD DATA BASE

#

#-----

# M33\_REF\_A.NOMI |

#-----

# DEPARTMENT: EPN

# DATES: 15/11/1995

#-----

# GEOMETRY OF THE ASSEMBLY |

#-----

#-----

# SECTION OF THE PIN (IN MM)

#

SGM33A = 6.45E+02

#  
# *RAY EXTERNAL OF THE PIN (IN MM)*  
#  
*REGM33A = 14.328638337E+00*

#  
# *HEIGHT OR NOT OF THE NET (IN MM)*  
#  
*HFM33A = 3.5*

#  
# *INTERIOR RAY OF THE SUPPORT (IN MM)*  
#  
*RIBM33A = 16.5*

#-----  
# *CHARACTERISTIC OF THE ASSEMBLY |*  
#-----  
#-----  
# *CONFIGURATION NET*  
#  
*CFM33A = "NOMINAL"*

#  
# *HIGH OF SUPPORT*  
#  
*HBM33A = "WITH"*

#  
# *PLAY*  
#  
*JEM33A = "MAXIMUM"*

#  
# *BEHAVIOR*  
#  
*COM33A = "ELASTOPLASTIC"*

#  
# *MATERIAL ATTACHES*  
#  
*MABM33A = "20MND5-316\_C"*

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#  
# MATERIAL PIN  
#  
MAGM33A = "42CDV4-316\_P3"

#  
#-----  
# GIVEN OF CURVES Of an ASSEMBLY  $Q=F(UV)$  /  
# OR UV EAST IN MISTERS AND Q IN NEWTON /  
#-----

#-----  
# FIRST NET CURVES OF 17 POINTS

PFM33A=DEFI\_FONCTION (  
NOM\_PARA=' EPSI',  
PROL\_DROITE=' LINEAIRE',  
PROL\_GAUCHE=' EXCLU',  
VALE= (

1.3213E-02, 24288.25,  
2.3137E-02, 42441.00,  
3.3313E-02, 59633.00,  
4.3544E-02, 69713.00,  
5.8073E-02, 77787.50,  
9.8094E-02, 85445.50,  
14.1580E-02, 90562.50,  
18.6320E-02, 94640.00,

27.7720E-02, 101346.00,  
46.3750E-02, 112297.50,  
65.1530E-02, 121698.50,  
83.9720E-02, 130354.00,  
103.8600E-02, 138873.00,  
118.9700E-02, 144711.00,  
145.2500E-02, 152999.00,  
174.0400E-02, 160786.50,  
204.2200E-02, 168563.50,  
)  
)

#  
# SECOND NET CURVES OF 17 POINTS  
DFM33A=DEFI\_FONCTION (  
NOM\_PARA=' EPSI',  
PROL\_DROITE=' LINEAIRE',  
PROL\_GAUCHE=' EXCLU',  
VALE= (  
1.1883E-02, 20395.20,  
2.0810E-02, 35716.71,  
2.9999E-02, 51450.00,  
3.9536E-02, 66048.50,  
5.3593E-02, 75936.00,  
9.3111E-02, 84672.00,  
13.6240E-02, 89845.00,  
18.0690E-02, 93961.00,  
27.1580E-02, 100555.00,  
45.6670E-02, 110901.00,  
64.3630E-02, 119444.50,  
83.0960E-02, 127176.00,  
102.8600E-02, 134708.00,  
117.5800E-02, 139947.50,  
141.6300E-02, 147542.50,  
167.2300E-02, 154434.00,  
193.7600E-02, 161066.50,  
)  
)

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#

# NET RUNNING CURVE OF 17 POINTS

FCM33A=DEFI\_FONCTION (

NOM\_PARA=' EPSI',

PROL\_DROITE=' LINEAIRE',

PROL\_GAUCHE=' EXCLU',

VALE= (

1.1879E-02, 21325.50,

2.0832E-02, 37397.96,

3.0330E-02, 54448.83,

4.0820E-02, 68953.50,

5.6362E-02, 78085.00,

9.7438E-02, 85711.50,

14.1160E-02, 90723.50,

18.6090E-02, 94713.50,

27.7600E-02, 101206.00,

46.3570E-02, 111513.50,

65.1280E-02, 120081.50,

83.7930E-02, 127792.00,

102.4000E-02, 134904.00,

116.9600E-02, 140143.50,

140.8600E-02, 147742.00,

166.2800E-02, 154665.00,

192.5700E-02, 161336.00,

)

)

#

*# DEFINITION OF MATERIAL OF THE PIN (E AND NAKED)*

*MGM33A=DEFI\_MATERIAU (*

*ELAS=\_F (E = 1.9022E+5,*

*NAKED = 0.3E0)*

*)*

*#*

*# DEFINITION OF MATERIAL OF THE SUPPORT (E AND NAKED)*

*# the VALUE OF the MODULUS YOUNG EAST OF 1.95E+05 MPA.*

*# FOR REASONS SPECIFIC TO THE CODE\_ASTER IT EAST*

*# NECESSARY TO MULTIPLY THIS VALUE BY 2\*PI,*

*# WHAT GIVES IN the EVENT: 12.252E+5 MPA.*

*MBM33A=DEFI\_MATERIAU (*

*ELAS=\_F (E = 12.252E+5,*

*NAKED = 0.3E0)*

*)*

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*22/02/06*

*Author (S):*

***E. GALENNE, J.M. PROIX, Mr. Key ABBAS***

*:*

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*Organization (S): EDF-R & D /AMA*



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Document: U2.09.03***

***Note of use of calculation and postprocessing  
of a mechanical study according to the RCCM***

***Summary:***

***This document is a help with the use of postprocessing according to RCCM'S.***

***Chapter 1 described the postprocessing of tiredness according to the RCCM B3600, i.e. on an analysis of the type beam of pipings (TYPE\_RESU\_MECA=' TUYAUTERIE').***

***Chapters 2 and 3 refer to the postprocessing of tiredness according to the RCCM B3200, following a calculation 2D or massive 3D of a component or a particular zone. Chapter 2 relates to the analysis subjected to unspecified, mechanical transients or thermics in small number (TYPE\_RESU\_MECA=' EVOLUTION').***

***Chapter 3 relates to the analysis of a zone of piping subjected to many loadings, resulting from same situations as the lines of piping of chapter 1 (TYPE\_RESU\_MECA=' UNITAIRE').***

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# ***1***

## ***Lawful analysis of a line of piping using POST\_RCCM option FATIGUE\_B3600***

***The goal of this chapter is to provide the indication to carry out of A to Z a calculation of a line of piping subjected to the whole of the loadings envisaged to its design, and its analysis lawful compared to the damage of tiredness according to the RCC-M B3600.***

***We will take for example line VVP studied in [bib1]. This one been the subject of test RCCM02 [V3.01.113] with regard to the analysis with tiredness according to RCC-M B3600. This order is described in the documentation of use [U4.83.11]. The detail of the equations and criteria is given in the reference material [R7.04.03].***

### ***1.1 Data available***

***For a line of piping given, one generally lays out:***

- telegraphic geometry of the line,***
- geometrical characteristics of the various sections of piping, and components  
(transitions from thicknesses, elbows, prickings, connections with large components),***
- loadings (mechanical and transients thermal) which must undergo the line during  
its operation,***
- materials composing the line (characteristics function of the temperature).***

***Example (drawn from test RCCM02 [V3.01.113]): data of modeling of line VVP:***

***The line comprises 10 elbows. It is directed since node NGV until node NBR***

***NGV  
NBR***

***Elementary characteristics:***

***Right parts:***

***•  
R= 406.4 mm, EP=32.mm***

**Pipe Steam Generator,  $R = 410.mm$ ,  $EP = 38.mm$ ;**

.

**Exit Br,  $R = 444.4mm$ ,  $EP = 70.mm$ ;**

**Elbows:**

.

**Group meshes corresponding to the elbows:  $R = 406.4mm$ ;  $EP = 34.mm$ ;**

.

**Coefficient of flexibility for all the elbows,  $c_{flex} = 6.032$ ;**

.

**Rays of bending of the elbows:  $1220mm$**

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**Moreover for seismic calculation, 6 discrete elements (DIS\_T) are added in 3 points of the line (1 vertical DAB and horizontal by point of anchoring). They have as stiffnesses:**

**$K1 = 0.5.108 NR /m$**

**$K2 = 1.0.108 NR /m$**

**Characteristics of materials**

**Line VVP is out of A48 steel. Calculations of the efforts are carried out with various values of temperature. One thus considers the properties of materials according to the temperature:**

**Temperature (°C) Modulus Young (GPa) average Dilation coefficient (from 20°C)**

**0.0 205**

**1.092e-05**

**20.0 204**

**1.092e-05**  
**50.0 203**  
**1.114e-05**  
**100.0 200**  
**1.15e-05**  
**150.0 197**  
**1.187e-05**  
**200.0 193**  
**1.224e-05**  
**250.0 189**  
**1.257e-05**  
**300.0 185**  
**1.289e-05**  
**350.0 180**  
**1.324e-05**

**Poisson's ratio: 0.3**

**The characteristics used for L `analyzes with tiredness according to RCC-M'S are:**

**m=3**  
**n=0.2**  
**Sm=133.6 MPa**

**The curve of WOHLER is defined by: (interpolation logarithmic curve):**

**Salt (Mpa)**

**A number of cycles**

**0.01 1.E15**  
**86 1000000**  
**93 500000**  
**114 200000**  
**138 100000**  
**160 50000**  
**215 20000**  
**260 10000**  
**330 5000**  
**440 2000**  
**570 1000**  
**725 500**  
**1070 200**  
**1410 100**  
**1900 50**  
**2830 20**

**4000 10**

***The densities integrate heat insulation:***

***Density (Kg/m3)***

***Blank line***

***Full line***

***Current part***

**8706.3**

**14200.0**

***Exit Br***

**7850.**

**10295.7**

***Pipe Steam Generator***

**8548.0**

**13500**

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***The thermal characteristics are provided to the average temperature of the calculated transient:***

***Transient 2: average temperature = 273.5°C,***

***Transient 6: average temperature = 281°C,***

***Temperature °C***

**273.5**

**281**

***Thermal conductivity (W/m.°C)***

**46.595**

**46.37**

**Heat-storage capacity (J/m<sup>3</sup>.°C)**

**4.25 106 4.27**

**106**

***Boundary conditions and loadings***

***The various elementary mechanical loadings considered constitute the stabilized states corresponding to the situations of design of line VVP:***

***Loadings of thermal dilation:***

***One carries out a calculation by loading, which combines the efforts of thermal dilation opposed in the line at the prescribed temperature, those caused by displacement of the Steam Generator:***

***Number of***

***Temperature °C***

***Ux Steam Generator (mm)***

***Uy Steam Generator (mm)***

***Uz Steam Generator (mm)***

***loading***

***1***

***10***

***0***

***0***

***0***

***2 287***

***0.046466***

***-0.0304945***

***0.076***

***3 274.5***

***0.046466***

***-0.0304945***

***0.072***

***4 272.5***

***0.046466***

***-0.0304945***

***0.072***

***5 286***

***0.046466***

***-0.0304945***

***0.076***

***6 275***



**0.046466**  
**-0.0304945**  
**0.072**  
**7 290**  
**0.046466**  
**-0.0304945**  
**0.077**  
**8 284**  
**0.046466**  
**-0.0304945**  
**0.077**  
**10 256**  
**0.0360129**  
**-0.0245167**  
**0.067**  
**12 257**  
**0.0360129**  
**-0.0245167**  
**0.067**  
**14 (test**  
**20**  
**0**  
**0**  
**0**  
**hydraulics)**

***Boundary conditions: for all the preceding loadings node NBR is embedded.***

***Moreover, for the hydraulic test ends NGV and NBR are blocked and of the supports weight are additions for this loading: they are modelled by a condition  $DZ=0$ , applied in 7 nodes.***

***Seism: the spectra of floor corresponding to SNA (seism considered for tiredness) are:***

***Frequency (Hz)***  
***Acceleration (G)***  
***Spectrum of horizontal floor (SNA)***  
**1.0 0.18**  
**2.2 1.56**  
**3.0 1.56**  
**10.0 0.513**  
**20.0 0.281**  
**25.0 0.245**  
**50.0 0.245**

***Frequency (Hz)***

***Acceleration (G)***

***Spectrum of vertical floor***

***1.0 0.11***

***2.0 0.21***

***3.0 0.265***

***4.0 0.31***

***6.4 0.31***

***9.0 0.21***

***10.0 0.17***

***25.0 0.1***

***50.0 0.1***

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***Associated displacements of anchoring are:***

***.***

***node NBR: Dx=4mm, Dy=7mm, Dz=5mm,***

***.***

***node NGV: Dx=11.9mm, Dy=mm, Dz=1mm.***

***Definition of the situations:***

***Situation Designation***

***Numbers***

***Pressure***

**Number of  
Transient  
occurrences  
(Bar)  
loading  
thermics**

**1  
Passage cold Stop  
190 1**

**1  
-  
nominal operation  
71.5**

**2  
2  
Fluctuations in mode  
1300000 58.9**

**3  
2  
permanent  
57.6**

**4  
3  
Maintenance level Steam Generator  
4000**

**70  
5  
6  
59  
6  
4**

**Fluctuations year stop with  
100000 73.4**

**7  
2  
heat  
68.1**

**8  
5  
Wrap situations 16080 71.5**

**9  
6  
normals**

**44**

**10**

**6**

**Wrap situations 790 74.5**

**11**

**6**

**disturbed**

**44**

**12**

**7 Seism**

**SNA**

**10**

**- Seism -**

**390 under-cycles**

**11 Test**

**hydraulics**

**13**

**112 14 -**

**1**

**Thermal transients: two transients “wraps” of the whole of the transients are calculated. It correspond to a condition of exchange in internal skin of axisymmetric calculation definite**

**by a coefficient of  $H=30000W/m^2 \cdot ^\circ C$  exchange and two stories of temperatures fluid:**

**Transient 2**

**Transient 6**

**Time (S)**

**Fluid temperature ( $^\circ C$ )**

**Time (S)**

**Fluid temperature ( $^\circ C$ )**

**0.0 274.5 0.0 272.0**

**10.0 274.5**

**11.0 272.0**

**310.0 272.5**

**20.0 290.0**

**610.0 274.5**

**40.0 290.0**

**910.0 272.5**

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## **1.2**

### ***Grids to be envisaged***

*Two types of grids must be made up:*

·  
*grid of the line, in telegraphic elements (meshs SEG2),*

·  
*a grid corresponding to each particular type of geometry for the transients thermics.*

*For example for the telegraphic grid, the elbows are discretized each one in 4 elements.*

*The meshs composing the elbow will be associated modeling POU\_C\_T. Right parts will be affected modeling POU\_D\_T.*

*Notice on the discretization: with regard to the static loadings, the discretization in elements POU\_D\_T does not need to be fine to provide precise solutions [R3.08.01]. By against for the dynamic analysis, to be able to obtain high clean modes with a precision sufficient, it is necessary to discretize more finely. For example, 4 elements per right part are generally sufficient for the first 10 Eigen frequencies.*

*With regard to the grids used for thermal calculations, it will be necessary to take care to net finely in the direction of the conduction of heat. For example, partly current of piping, the grid is a section of tube, modelled into axisymmetric. Only one element is enough in the direction axial. The 2 grids above correspond to the two thicknesses characteristic of the line.*

*For modeling, it is preferable (to obtain a correct solution) to use modelings*

with diagonalized thermal mass (AXIS\_DIAG, 3D\_DIAG).

## **1.3 Calculations mechanics**

### **1.3.1 Characteristics of materials**

**The elastic characteristics are to be provided according to the temperature (to take care to define a beach of sufficiently broad temperature to cover the whole of the thermal conditions seen by line. This is preferable with the definition of the prolongations which can lead to aberrations). One can use the catalogue material which gathers in particular the characteristics of all them materials of the RCCM.**

**For seismic calculations, it is necessary to add the density (integrating the weight of the water and of heat insulator). It is also necessary to introduce the characteristics of tiredness: coefficients  $N$  and  $m$  for calculation of  $K_e$ , and curve of Wöhler. It is preferable for the latter (being given its definition) to define an interpolation logarithmic curve).**

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**For example, the data material for line VVP are:**

**YOUNG=DEFI\_FONCTION (NOM\_PARA=' TEMP',  
VALE=(20.0, 20400000000.0, 50.0, 20300000000.0, 100.0, 20000000000.0,...),);**

**C\_ALPHA=DEFI\_FONCTION (NOM\_PARA=' TEMP',**

**VALE= (20.0, 1.092e-05,50.0, 1.114e-05,100.0, 1.15e-05,...,);**  
**NU=DEFI\_CONSTANTE (VALE=0.3);**

**# CURVED OF A48 TIREDNESS (one defines Nadm according to Salt)**

**WOHLER=DEFI\_FONCTION (NOM\_PARA=' SIGM',**

**VALE= (86000000.0, 1000000.0,**

**93000000.0,500000.0,**

**114000000.0,200000.0,**

**138000000.0,100000.0,**

**160000000.0,50000.0,**

**.....**

**INTERPOL=' LOG',);**

**RHOV = 8706.3;**

**MAT\_A48V=DEFI\_MATERIAU (ELAS\_FO=\_F (E=YOUNG, NU=NU,**

**RHO=RHOV,**

**TEMP\_DEF\_ALPHA=20.0,**

**ALPHA=C\_ALPHA,)**

**FATIGUE=\_F (WOHLER=WOHLER, E\_REFE=2.07E11,)**

**RCCM=\_F (SM=1.336E8,**

**N\_KE=0.2,**

**M\_KE=3.0,);**

### **1.3.2 Characteristics**

#### **elementary**

*They are entirely defined by AFFE\_CARA\_ELEM. With regard to the elbows, it is more practical in AFFE\_CARA\_ELEM to provide the orientations of the arcs using CENTER or POIN\_TANG. One can check (INFO=2) that radii of curvature recomputed by Aster correspond well to the rays of the elbows. It is necessary to define the coefficients of flexibility (definite for example in RCC-M B3600 [bib2]) correspondent with each elbow. For example:*

**CARA\_POU=AFFE\_CARA\_ELEM (MODELE=MODELE, INFO=2,**

**POUTRE= (\_F (GROUP\_MA=' TUYAU', SECTION=' CERCLE',**

**CARA= ("R", "EP"), VALE= (RTUB, EPTUB,)),**

**\_F (GROUP\_MA=' L1', SECTION=' CERCLE',**

**CARA= ("R", "EP"), VALE= (RGV, EPGV,)),**

**....**

**DEFI\_ARC= (\_F (GROUP\_MA=' C3', CENTRE= (10.62, - 4.9, 30.78,)), COEF\_FLEX=C\_FLEX,)**

**\_F (GROUP\_MA=' C7', CENTRE= (...**

**DISCRET= (\_F (GROUP\_MA=' RIG1', CARA=' K\_T\_D\_L', VALE= (0.0, 0.0, 0.0,)),**

**\_F (GROUP\_MA=' RIG2',....**



### ***1.3.3 Loadings and boundary conditions***

#### ***1.3.3.1 Boundary conditions common***

***In general there are boundary conditions common to all the loadings (for example one embedding corresponding to the passage of the line by a fixed point). For example:***

***BLOCBR=AFFE\_CHAR\_MECA (MODELE=MODELE,  
DDL\_IMPO= (\_F (GROUP\_NO=' NBR',  
DX=0.0,  
DY=0.0,  
DZ=0.0,  
DRX=0.0,  
DRY=0.0,  
DRZ=0.0),***

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#### ***1.3.3.2 Definitions of the loadings***

***The stabilized states defining the situations are in general the combination of loadings purely mechanical (actual weight, displacement imposed by a component in one or more points of the circuit) and thermal dilations (one does not consider the thermal transient here but only efforts due to the opposed dilation of the line for each state stabilized of each situation). This requires to define constant fields of temperature by zones or for all line, using CREA\_CHAMP. For example, the state stabilized number 5 is entirely defined by following loadings:***

```
CHAR1=AFFE_CHAR_MECA (MODELE=MODELE,
DDL_IMPO=_F (GROUP_NO=' NGV',
DX=0.046466,
DY=-0.0304945,
DZ=0.076,
DRX=0.0,
DRY=0.0,
DRZ=0.0),,);
```

```
TEMP286=CREA_CHAMP (TYPE_CHAM=' NOEU_TEMP_R',
OPERATION=' AFFE', MAILLAGE=MAILL,
AFFE=_F (TOUT=' OUI', NOM_CMP=' TEMP', VALE=286.0),,);
```

```
CHT286=AFFE_CHAR_MECA (MODELE=MODELE,
TEMP_CALCULEE=TEMP286,);
```

### *1.3.4 Calculations statics*

*A calculation (using MECA\_STATIQUE) is to be carried out for each stabilized state, by adding calculation efforts in option of calculation. Here for the loading number 5:*

```
RMECA5=MECA_STATIQUE (MODELE=MODELE, CHAM_MATER=CHAMPMAV,
CARA_ELEM=CARA_POU,
EXCIT= (_F (CHARGE=BLOCBR),
_F (CHARGE=CHT286,),
_F (CHARGE=CHAR1,)),,
OPTION=' EFGE_ELNO_DEPL',);
```

### *1.3.5 Calculations seismic*

*Seismic calculations are composed of inertial calculations, and static calculations of displacements anchorings. The latter are similar to static calculations previously described. One must carry out a calculation by component of displacement for each anchoring. For example, in the case of the line VVP, one needs a calculation for each component of displacement imposed on node NBR, and of even on node NGV:*

```
ANC_BRDX=AFFE_CHAR_MECA (MODELE=MODELE,
DDL_IMPO=_F (GROUP_NO=' NBR',
DX=4.0E-3, DY=0.0, DZ=0.0,
DRX=0.0, DRY=0.0, DRZ=0.0),,);
```

**RANCBRD**X=MECA\_STATIQUE (MODELE=MODELE, CHAM\_MATER=CHAMPMAV,  
CARA\_ELEM=CARA\_POU,  
EXCIT= (\_F (CHARGE=BLOCGV),,  
\_F (CHARGE=CHT20),,  
\_F (CHARGE=ANC\_BRDX),),  
OPTION=' EFGE\_ELNO\_DEPL');

*The calculation of the inertial answer requires several stages:*

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### *1.3.5.1 Calculation*

#### *modal*

*That can be easily carried out using MACRO\_MATR\_ASSE and MODE\_ITER\_SIMULT. It is necessary to take care to take into account sufficient clean modes (here 11). Here modal calculation is carried out with the line full of water (modified densities) and the blocked DAB.*

**MACRO\_MATR\_ASSE** (MODELE=MODELE,  
CHAM\_MATER=CHAMPMAV,  
CARA\_ELEM=CARA\_DAB,  
CHARGE= (CHT287, BLOCGVBR),  
NUME\_DDL=CO ("NUME"),  
MATR\_ASSE= (\_F (MATRICE=CO ("RIGIDITY"), OPTION=' RIGI\_MECA'),,  
\_F (MATRICE=CO ("MASS"), OPTION=' MASS\_MECA'),,));

**TABL\_MAS=POST\_ELEM (MASS\_INER=\_F (TOUT=' OUI'), MODELE=MODELE, CHAM\_MATER=CHAMPMAV, CARA\_ELEM=CARA\_DAB,);**

**MODE\_MEC=MODE\_ITER\_SIMULT (MATR\_A=RIGIDITE, MATR\_B=MASSE, CALC\_FREQ=\_F (OPTION=' PLUS\_PETITE', NMAX\_FREQ=11),);**

**MODE\_MEC=CALC\_ELEM (reuse =MODE\_MEC, MODELE=MODELE, CHAM\_MATER=CHAMPMAV, CARA\_ELEM=CARA\_DAB, OPTION=' EFGE\_ELNO\_DEPL', RESULTAT=MODE\_MEC, EXCIT= (\_F (CHARGE=BLOCGVBR,)\_F (CHARGE= CHT287,)),);**

### **1.3.5.2 Answer inertial**

***It is necessary to define the spectra of accélérogrammes imposed on the supports. The horizontal spectrum is different vertical spectrum in the selected example: (attention with the units chosen for acceleration: here COMB\_SISM\_MODAL awaits accelerations in “G” cf key word SCALE of COMB\_SISM\_MODAL):***

**ACCE\_XY=DEFI\_FONCTION (NOM\_PARA=' FREQ', VALE= (1.0, 0.18, 2.2, 1.56, 3.0, 1.56,...), INTERPOL=' LOG', PROL\_DROITE=' CONSTANT', PROL\_GAUCHE=' CONSTANT',);**

**ACCE\_Z=DEFI\_FONCTION (NOM\_PARA=' FREQ', VALE= (1.0, 0.11, 2.0, 0.21, 3.0, 0.265,...), INTERPOL=' LOG', PROL\_DROITE=' CONSTANT', PROL\_GAUCHE=' CONSTANT',);**

**SPECT\_XY=DEFI\_NAPPE (NOM\_PARA=' AMOR', PARA= (0.015, 0.02, 0.025,), FONCTION= (ACCE\_XY, ACCE\_XY, ACCE\_XY,), INTERPOL= (“FLAX”, “LOG”),);**

**SPECT\_Z=DEFI\_NAPPE (NOM\_PARA=' AMOR', PARA= (0.015, 0.02, 0.025,), FONCTION= (ACCE\_Z, ACCE\_Z, ACCE\_Z,), INTERPOL= (“FLAX”, “LOG”),);**

**MODE\_STA=MODE\_STATIQUE (MATR\_RIGI=RIGIDITE, MATR\_MASS=MASSE, PSEUDO\_MODE=\_F (AXE= (“X”, “Y”, “Z”),),);**

**MODE\_STA=CALC\_ELEM (reuse =MODE\_STA, MODELE=MODELE, CHAM\_MATER=CHAMPMAV, CARA\_ELEM=CARA\_DAB, OPTION=' EFGE\_ELNO\_DEPL', RESULTAT=MODE\_STA, EXCIT= (...)**

**SISM\_SPE=COMB\_SISM\_MODAL (MODE\_MECA=MODE\_MEC, MODE\_CORR=MODE\_STA,  
AMOR\_REDUIT=0.02, MASS\_INER=TABL\_MAS,  
CORR\_FREQ='NON',  
EXCIT=\_F (MONO\_APPUI='OUI',  
TRI\_SPEC='OUI',  
SPEC\_OSCI= (SPECT\_XY, SPECT\_XY, SPECT\_Z),  
ECHELLE= (9.81, 9.81, 9.81,)),  
COMB\_MODE=\_F (TYPE='SRSS'),  
COMB\_DIRECTION=\_F (TYPE='QUAD'),  
OPTION= ("DEPL", "EFGI\_ELNO\_DEPL",));**

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## **1.4 Calculations**

### **thermics**

**The purpose of transitory thermal calculations are, in the case of the RCCM B3600, to evaluate the gradients**

**of maximum temperature during transients, in each part of the line. For the parts current to pipings, in theory, a thermal calculation of conduction 1D would be enough. In practice, one**

**will be able to carry out an axisymmetric calculation of a section of tube (the axial length with a grid not having**

**no importance). For the more complex zones, it can be necessary to carry out a grid 2D or precise 3D of the zone.**

**To reduce the command files, it can be useful to build each thermal modeling in a clean file, which will be included (order INCLUDE) in the principal command file**

*at the object time.*

### **1.4.1 Characteristics thermics**

*They can be extracted from the catalogue MATERIAL of Code\_Aster. They can be a function of temperature (in which case will have to be carried out a nonlinear thermal calculation), or interpolated with*

*average temperature of each transient to be calculated (practical current, but to validate in all rigour). For example, for each of the 2 transients of line VVP:*

**# COEFS AVERAGE OF COEF A 273.5**

**MATHER=DEFI\_MATERIAU (THER=\_F (LAMBDA=46.595, RHO\_CP=4.25E6,,));**

**CHMAT=AFFE\_MATERIAU (MAILLAGE=MA,  
AFFE=\_F (TOUT=' OUI', MATER=MATHER,,));**

**# COEFS AVERAGE OF COEF A 281**

**MATHER2=DEFI\_MATERIAU (THER=\_F (LAMBDA=46.37, RHO\_CP=4.27E6,,));**

**CHMAT2=AFFE\_MATERIAU (MAILLAGE=MA,  
AFFE=\_F (TOUT=' OUI', MATER=MATHER2,,));**

### **1.4.2 Calculations of the transients**

*They are often characterized by a history of temperature in internal skin of piping (fluid temperature) and a coefficient of exchange. It will have to be taken care that the temporal discretization*

*that is to say sufficiently fine for good “to collect” the variations in temperature (to carry out several tests).*

**COEFH=DEFI\_CONSTANTE (VALE=3.E4,);**

**TR2=DEFI\_FONCTION (NOM\_PARA=' INST', VALE= (0.0, 274. , 10.0, 274. , 310.0, 272....),);**

**CHTH2=AFFE\_CHAR\_THER\_F (MODELE=MOTHER,  
ECHANGE=\_F (GROUP\_MA= (“ECHAND”, “ECHANC”),,  
COEF\_H=COEFH, TEMP\_EXT=TR2,,));**

**LISTH2=DEFI\_LIST\_REEL (DEBUT=0.0,  
INTERVALLE= (\_F (JUSQU\_A=10.0, PAS=10.0),  
\_F (JUSQU\_A=310.0, PAS=10.0), \_...),);**

**TEMP2=THER\_LINEAIRE (SOLVEUR=\_F (RENUM=' MDA'), MODELE=MOTHER,  
CHAM\_MATER=CHMAT, EXCIT=\_F (CHARGE=CHTH2,));**

**INCREMENT=\_F (LIST\_INST=LISTH2,)  
TEMP\_INIT=\_F (VALE=274.5,));**

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### **1.4.3 Extraction of the results**

**For the analysis with POST\_RCCM, it is necessary to extract the values and the average temperatures, for every moment calculated, on a segment defined by INTE\_MAIL\_2D (or a group of nodes, reorientated using DEFI\_GROUP, OPTION = 'SEGM\_DROI\_ORDO') energy of the skin interns towards external skin. For example:**

**TABTH2D=POST\_RELEVE\_T (ACTION=\_F (INTITULE='temp2', GROUP\_NO='BASD', RESULTAT=TEMP2, NOM\_CHAM='TEMP', NOM\_CMP='TEMP', OPERATION='EXTRACTION',));**

**TABMO2D=POST\_RELEVE\_T (ACTION=\_F (INTITULE='temp2', GROUP\_NO='BASD', RESULTAT=TEMP2, NOM\_CHAM='TEMP', NOM\_CMP='TEMP', OPERATION='MOYENNE',));**

### **1.5**

**Post treatment following the RCCM**

**It any more but does not remain to call POST\_RCCM with the B3600 option, while providing [U4.83.11]:**

- 
- geometry of the line of piping,*
- 
- the material field: it is the chart of materials assigned to the groups of meshes of grid by AFFE\_MATERIAU for which it is necessary to add the curve of tiredness, E\_REFE, m and N (key words RCCM),*
- 
- AFFE\_CARA\_ELEM makes it possible to affect the elementary characteristics,*
- 
- indices of constraints (in each node of the grid),*
- 
- the scenario of operation containing the list of the situations:*
  - *for each situation:*
  - *numbers of occurrences of each situation (thus of each stabilized state),*
  - *pressure and average temperature of each stabilized state,*
  - *list of the mechanical loadings (characterized by a number) of each state stabilized,*
  - *the group of membership of the situation,*
  - *the associated thermal transient,*
- 
- results of calculations for each mechanical loading (including the seism), (located by its number, with for information the name of the loading case): field by elements with the nodes generalized efforts, for each loading (EFGE\_ELNO\_DEPL, or SIEF\_ELNO\_ELGA),*
- 
- for each node, a reference to a definite thermal result below,*
- 
- results of thermal calculations: calculations EF 2D or 3D which give these infos depend at the same time on the geometry and transient. There is thus a thermal calculation by type of junction, and by type of transient.*

*To complete the example of line VVP, the call to POST\_RCCM is as follows (INFO=2 allows to obtain details of calculations):*

```
TBRCCM1=POST_RCCM (OPTION=' FATIGUE_B3600', INFO=2,  
CHAM_MATER=CHAMPMAV, MODELE=MODELE, CARA_ELEM=CARA_POU,  
# zone of analysis  
ZONE_ANALYSE=_F (MESH = ("M1", "m2")),  
# results mechanical (calculated with MECA_STATIQUE)  
RESU_MECA= (  
_F (NUME_CHAR=1,  
NOM_CHAR=' STATE 1 SITUATION 1 ',  
TOUT_ORDRE=' OUI', RESULTAT=RMECA1,
```



*NOM\_CHAM=' EFGE\_ELNO\_DEPL',),*

*\_F (NUME\_CHAR=2,  
NOM\_CHAR=' STATE 2 SITUATION 1 ',  
TOUT\_ORDRE=' OUI', RESULTAT=RMECA2\_9,  
NOM\_CHAM=' EFGE\_ELNO\_DEPL',),*

.....

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*# Seism inertial answer (COMB\_SISM\_MODAL)*

*\_F (NUME\_CHAR=1000,  
NOM\_CHAR=' SNA',  
TYPE\_CHAR=' SEISME',  
RESULTAT=SISM\_SPE,  
NOEUD\_CMP= ("COMBI", "QUAD"),  
NOM\_CHAM=' EFGE\_ELNO\_DEPL',),*

*# displacement of anchoring on the level left Br following DX*

*\_F (NUME\_CHAR=1001,  
NOM\_CHAR=' SNA DEPL ANC BR DX',  
TYPE\_CHAR=' SEISME',  
TOUT\_ORDRE=' OUI', RESULTAT=RANCBRDX,  
NOM\_CHAM=' EFGE\_ELNO\_DEPL',),*

....

),

**# indices of constraints**

```

INDI_SIGM= (
  _F (TOUT=' OUI', TYPE_ELEM_STANDARD=' DRO'),
  _F (C1=1.0,
K1=1.10,
C2=1.0,
K2=1.10,
C3=0.60,
K3=1.10,
MAILLE= ("M1"), NOEUD= ("N79"),
TYPE_ELEM_STANDARD=' COU'),
  ...
),

```

**# results thermal**

```

RESU_THER= (
# results on the right tubes transient 2
  _F (NUME_RESU_THER=12,
TABL_RESU_THER=TABTH2D,
TABL_MOYE_THER=TABMO2D,
GROUP_MA=' POU DT'),
# results on the right tubes transient 6
  _F (NUME_RESU_THER=16,
TABL_RESU_THER=TABTH6D,
TABL_MOYE_THER=TABMO6D,
GROUP_MA=' POU DT'),
# results on the elbows transient 2
  _F (NUME_RESU_THER=22,
TABL_RESU_THER=TABTH2C,
TABL_MOYE_THER=TABMO2C,
GROUP_MA=' POU CT'),
# results on the elbows transient 6
  _F (NUME_RESU_THER=26,
TABL_RESU_THER=TABTH6C,
TABL_MOYE_THER=TABMO6C,
GROUP_MA=' POU CT'),
),

```

**# situations**

```

SITUATION= (
  _F (NB_OCCUR=190, NUME_SITU=1,
NOM_SITU=' Passage cold stop

```

*operation nominal',  
NUME\_GROUPE=1,  
PRES\_A=1.0E5,  
PRES\_B=71.5E5,  
TEMP\_REF\_A=10.0,  
TEMP\_REF\_B=287.0,  
CHAR\_ETAT\_A=1,  
CHAR\_ETAT\_B=2,)*

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*\_F (NB\_OCCUR=1300000, NUME\_SITU=2,  
NOM\_SITU=' fluctuations in mode permanent',  
NUME\_GROUPE=1,  
PRES\_A=58.9E5,  
PRES\_B=57.6E5,  
TEMP\_REF\_A=274.5,  
TEMP\_REF\_B=272.5,  
CHAR\_ETAT\_A=3,  
CHAR\_ETAT\_B=4,  
NUME\_RESU\_THER= (12,22),)*

*\_F (NB\_OCCUR=10,  
NB\_CYCL\_SEISM=390,  
NUME\_SITU=7,  
NOM\_SITU=' Seism SNA',  
COMBINABLE=' OUI',*

**NUME\_GROUPE=1,  
CHAR\_ETAT\_A=(1000,1001,1002,1003,1004,1005,1006),),**

**\_F (NB\_OCCUR=13,  
NUME\_SITU=11,  
NOM\_SITU=' Test hydraulique',  
# NUME\_GROUPE=2,  
NUME\_GROUPE=1,  
PRES\_A=112.0E5,  
PRES\_B=1.0E5,  
TEMP\_REF\_A=20.0,  
TEMP\_REF\_B=10.0,  
CHAR\_ETAT\_A=1,  
CHAR\_ETAT\_B=14),**

**),**

**);**

*It any more but does not remain to print the produced table:*

**IMPR\_TABLE (TABLE=TBRCM1,);**

*One obtains then:*

**TABL\_POST\_RCCM**

<b>NET</b>	<b>TYPE</b>	<b>MAILLE</b>	<b>NODE</b>	<b>SM</b>	<b>SN</b>	<b>SN_MAX</b>	<b>SN/3SM</b>	<b>SALT_MAX</b>	<b>FACT_USAGE_CUMU</b>
<b>M1</b>	<b>DRO</b>	<b>N80</b>	<b>1.33600E+08</b>	<b>1.35615E+08</b>	<b>3.38360E-01</b>	<b>7.44376E+07</b>	<b>4.58400E-03</b>		
<b>M1</b>	<b>NECK</b>	<b>N79</b>	<b>1.33600E+08</b>	<b>1.35207E+08</b>	<b>3.37342E-01</b>	<b>8.15106E+07</b>	<b>5.58793E-03</b>		
<b>M2</b>	<b>NECK</b>	<b>N79</b>	<b>1.33600E+08</b>	<b>1.50176E+08</b>	<b>3.74690E-01</b>	<b>8.69347E+07</b>	<b>6.30413E-03</b>		
<b>M2</b>	<b>DRO</b>	<b>N78</b>	<b>1.33600E+08</b>	<b>1.49870E+08</b>	<b>3.73926E-01</b>	<b>8.05593E+07</b>	<b>5.37650E-03</b>		

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**2**

**Complete detailed calculation of an unspecified component and analyze lawful B3200 using POST\_RCCM**

**This type of analysis is justified when one wants to analyze a component subjected to one or with little of transients (and not of seism), in order to check the various criteria of the RCC-M B3200 (deformation excessive, progressive deformation, tiredness according to appendix ZH210).**

**If one wishes to analyze a component with tiredness, for the whole of the situations to which it will be subjected, and in particular with the seism, it is preferable to use the method described in the following chapter.**

**This type of analysis functions only for modelings of continuous mediums 2D (D\_PLAN, C\_PLAN, AXIS) or 3D.**

**One will take for example tests RCCM01, and SSLV100.**

**2.1**

**Calculation of the component**

**It is a question here of carrying out the direct calculation of the component, for the loadings which one wants to evaluate criteria.**

**To model the elbows or prickings, it is convenient to use tools ASCOUF (macros orders MACR\_ASCOUF\_MAIL and MACR\_ASCOUF\_CALC) and ASPIC (MACR\_ASPIC\_MAIL and MACR\_ASPIC\_CALC).**

**With the exit of these calculations, one lays out of a certain number of concepts results, thermoelastic 2D or 3D, produced by MECA\_STATIQUE or STAT\_NON\_LINE, and for which one calculated the option SIGM\_ELNO\_DEPL (by taking care in CALC\_ELEM to provide the load containing them temperatures) or better: SIEF\_ELNO\_ELGA (CALC\_ELEM).**

***For example (RCCM01):***

```
RESU2=MECA_STATIQUE (MODELE=MO, CHAM_MATER=CHMAT,  
LIST_INST=LINST,  
EXCIT= (_F (LOAD = CHTHER),  
_F (LOAD = CHMEC, FONC_MULT = FCTMUL)),  
OPTION= ("SIGM_ELNO_DEPL",  
)
```

**2.2**

***Definition of the segments and extraction of the constraints***

***It is a question of extracting, on each segment studied, the constraints, for each transient. Let us recall***

***that the criteria of the RCC-M B3200 are to be checked for the whole of the possible segments, crossing the component of the skin interns to the external skin. The choice of the maximizing segment the criteria is the responsibility of the user. For a complex geometry, this one will have to thus calculate a certain number of segments.***

***In practice, in Code\_Aster, several methods are possible to define the segments of analysis then to extract the constraints there:***

***the first consists in using orders INTE\_MAIL\_2D or INTE\_MAIL\_3D, according to geometrical dimension of the problem, to define an unspecified segment passing in through grid then to extract the constraints by POST\_RELEVE\_T:***

```
LIGNE1=INTE_MAIL_2D (MAILLAGE=MA,  
DEFI_SEGMENT=_F (ORIGIN = (-1.0, 0.5),  
END = (1.0, 0.5)),  
INFO=2)
```

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**TAB2=POST\_RELEVE\_T (ACTION=\_F (ENTITLES = "LINE",  
WAY = LIGNE1,  
RESULT = RESU2,  
NOM\_CHAM = "SIGM\_ELNO\_DEPL",  
OPERATION = "EXTRACTION",  
TOUT\_CMP = "YES"),),)**

*the second method consists in using a preexistent group of nodes in the grid, defining a segment. This method obligatorily requires to reorder as a preliminary the group of nodes, so that the nodes the component are arranged skin interns towards external skin:*

**MA=DEFI\_GROUP (reuse=MA, MAILLAGE=MA,  
CREA\_GROUP\_NO= (\_F (OPTION = "SEGM\_DROI\_ORDO",  
NAME = "LINE",  
GROUP\_NO=' GNI',  
NOEUD\_ORIG = "N22",  
NOEUD\_EXTR = "N12",  
PRECISION = 1.E-03,  
CRITERION = "RELATIVE"))**

**TAB2=POST\_RELEVE\_T (ACTION=\_F (ENTITLES = "LINE",  
GROUP\_NO = LINE,  
RESULT = RESU2,  
NOM\_CHAM = "SIGM\_ELNO\_DEPL",  
OPERATION = "EXTRACTION",  
TOUT\_CMP = "YES"),),)**

*the last method consists in using macro-order MACR\_LIGN\_COUPE to define the segment of analysis starting from its ends and to extract the constraints:*

**MACR\_LIGN\_COUPE (RESULTAT=RESU2,  
NOM\_CHAM=' SIGM\_ELNO\_DEPL',  
MODELE=MO,  
LIGN\_COUPE=\_F (NB\_POINTS=5,**

***COOR\_ORIG= (-1.0, 0.5),  
COOR\_EXTR= (1.0, 0.5),  
TABLE=CO ("TAB2"),),)***

## **2.3**

### ***Calculation of the various criteria using POST\_RCCM***

***The criteria available are:***

- .  
criteria of level 0 by option PM\_PB,***
- .  
criteria of level A (except tiredness) by the option SN,***
- .  
criteria of tiredness (also of level A) by option FATIGUE\_ZH210.***

#### **2.3.1 Option PM\_PB**

***Option allowing to calculate the criteria of level 0 which aim at securing the material against damage of excessive deformation, plastic instability and elastic and elastoplastic instability.***

***These criteria require the calculation of the equivalent constraints of membrane  $m$   
 $P$ , of membrane***

***local  $L$***

***$P$ , of inflection  $B$***

***$P$  and of membrane plus inflection  $m$***

***$P + B$***

***$P$ . The points of calculation are both ends of the segment of analysis. If several segments of extraction were used to define one even table of constraints, calculation is done successively for each one of them.***

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In each point end of the segment of analysis length  $L$ , one calculates:

$P_m = m_y$  (moy

fle

flax

$X_{ij}$ )

$P_b = m_y$  (

$X_{ij}$ )

$P_m + P_b =$

(

max  $ij$ )

T

Eq Tresca

.

T

Eq Tre

.

sca

T

Eq Tr

. ESCA

L

L

moy

l

fle

6

*L*  
*with*

=

*ds,*  
=  
*S -*  
*ds*  
*flax*  
*moy*  
*fle*  
*ij*  
,

*L*  
*ij*  
*ij*  
*l2*  
*ij*  
*ij*  
*ij*  
*ij*

2  
=  
±

0  
0

*The values limit are  $S_m$  and  $1.5 S_m$ ,  $S_m$  being working stress function of material and of the temperature, given by the key word  $SM$  of key word  $RCCM$  in  $DEFI\_MATERIAU$  [U4.43.01].*

**Note:**

*The calculation of  $PM$  and  $PMPB$  is only done starting from the primary constraints, therefore out constraints of thermal origin. If  $TABL\_SIGM\_THER$  is indicated, it is supposed that it result indicated in  $TABL\_RESU\_MECA$  corresponds to a thermomechanical calculation and one him thus withdrawn the thermal stresses. If only  $TABL\_RESU\_MECA$  is indicated, calculation is done directly starting from the constraints indicated in the table.*

### 2.3.2 Option

#### SN

Option allowing to calculate the criteria of level A (except tiredness) which aim at securing the material against the damage of progressive deformation. They require the calculation of the amplitude of variation

of constraint linearized in a point, noted  $S_n$ .

If the user asks it (presence of operand `TABL_SIGM_THER`) one also the calculation carries out of  $S^*$

$N$ . The points of calculation are the two ends of the segment of analysis. If several segments of extraction were used to define the same table of constraints, calculation is done successively for each one of them.

In each point end of this segment length  $L$ , one calculates:

$$S_n = \max_{ij} \left( \frac{\sigma_{ij}(T1) - \sigma_{ij}(T2)}{L} \right)$$

$T1$   
Eq Tre

.

$L$   
 $L$

moy

1

fle

6

$L$

with

=

$d_s$ ,

=

$S -$

$d_s$

flax

moy

*fle*

*ij*

,

*L*

*ij*

*ij*

*l2*

*ij*

*ij*

*ij*

*ij*

*2*

*=*

*±*

*0*

*0*

*with T1 and t2 traversing the whole of the moments of (or of) transitory. The limiting Sn value is S*

*.*

*3 m, Sm being the working stress function of material and the temperature, given by key word SM of the key word factor RCCM in DEFI\_MATERIAU [U4.43.01].*

**Note:**

*Key word TABL\_RESU\_MECA can be repeated several times under only one key word TRANSIENT. For the calculation of SN and SN\*, there will be however no combination enters situations thus defined: each table of constraints will be treated successively.*

**2.3.2.1 Calculation**

**of**

**Sn\***

*If operand TABL\_SIGM\_THER of the key word TRANSITORY factor is present, one carries out also it calculation of S \**

*N which is equal to the amplitude Sn calculated without taking into account the constraints of thermal inflection of origin. One calculates for each end:*

*\**

*S*

*\* = max*  
*max (flax T*  
*T*  
*T*  
*T*  
*ij (1) -*  
*fleth*  
*ij*  
*(1) - (linij (2) - fleth*  
*ij*  
*( 2 )*

*N*  
*T1*  
*Eq Tresca*  
*T*  
*.*  
*2*

*L*  
*fleth*

*= 6*  
*L*  
*S*  
*ds*  
*ij*  
*2*

*- HT*  
*L*  
*2*  
*0*  
*ij*

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**HT***ij coming from the constraints provided in TABL\_SIGM\_THER.**It is necessary, so that calculation is coherent and in conformity with the RCC-M, that constraints provided in**TABL\_SIGM\_THER were obtained with a thermal loading only, knowing that the result given by TABL\_RESU\_MECA can be due to a combination of this thermal loading with other loadings. It is necessary thus that the moments of table TABL\_SIGM\_THER correspond to those of table TABL\_RESU\_MECA.***2.3.3 Option****FATIGUE\_ZH210***Option allowing to calculate the factor of use resulting from the combination of one or more transients, according to the method of additional RCC-M ZH210.**The amplitude of variation of constraint in each end of the segment of analysis is calculated to leave tables of constraints TABL\_RESU\_MECA, for each combination of moments belonging to (X) transient (S) definite (S) by the user. Then one applies a method of combination and office plurality for to obtain the factor of total use. Among the various methods suggested by the RCC-M to calculate the factor of use in fatigue, that of appendix ZH210 has the advantage of not making an assumption on the directions of the principal constraints. From the transients given by the user (of results with sequence numbers or moments possibly specified), calculation proceeds into 3 phases:**.  
Definition of states of loading for each transient**- state of loading  $K = \{urgent T + tensor (T) + a number of occurrences Nocc (that of$*

*transient)}*

.

*At each end of the segment, for two states of loading K and L:*

*- calculation of  $S_p(K, L)$  = amplitude of variation of constraint (not linearized) between the states K and L,*

*-  $S_n$  calculation  $(K, L)$  = amplitude of variation of constraint linearized between the states K and L,*

*- calculation of  $S_{alt}(K, L) = \frac{1}{2} E_c/E K_e(K, L) S_p(K, L)$ ,*

*- by the curve of tiredness of Wöhler to deduce from it  $N_{adm}(K, L)$ ,*

*- factor of use  $U(K, L) = NR(K, L)/N_{adm}(K, L)$ ,*

*$NR(K, L) = \min(N_{occ}(K), N_{occ}(L))$*

.

*Method of combination*

*- Data at each end of the segment*

*- symmetrical square matrix  $[U(K, L)]$  and vector  $N_{occ}(K)$  of dimension: the total number states of loading*

.

*Factor of total use U*

*-  $U = 0$*

*- Research of the factor of elementary use maximum =  $U(m, N) = \max(U(K, L))$  on all the combinations K, L where  $N_{occ}(K)$  and  $N_{occ}(L)$  nonnull*

*- office plurality:  $U = U + U(m, N)$*

*If  $N_{occ}(m) < N_{occ}(N)$  then*

*$N_{occ}(N) = N_{occ}(N) N_{occ}(m)$*

*$N_{occ}(m) = 0$*

*If not,*

*$N_{occ}(m) = N_{occ}(m) N_{occ}(N)$*

*$N_{occ}(N) = 0$*

*This method of combination of the cycles is identical in the uniaxial case to method RCCM of POST\_FATIGUE. However, in POST\_FATIGUE, the moments (states of loadings) intermediate between two extreme states between which the constraints vary linearly are eliminated.*

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*In POST\_RCCM, which treat general states of stresses, therefore multiaxial, this elimination automatic is not carried out. It is the responsibility of the user who can define the moments corresponding to the extreme states by NUME\_ORDRE, INST or LIST\_INST.*

**Note:**

*Key word TABL\_RESU\_MECA can be repeated several times under only one key word TRANSIENT. For the fatigue analysis, the results contained in each table of constraints will be combined between them.*

**2.4**

**Description of the produced tables**

**2.4.1 Option**

**PM\_PB**

*Calculation with option PM\_PB is done in the following way:*

```
PMPB1=POST_RCCM (MATER=MAT,
TYPE_RESU=' VALE_MAX',
OPTION=' PM_PB',
TITRE=' INST PM_PB, RESULT: RESU1',
TRANSITOIRE=_F (TABL_RESU_MECA = TAB1,)
)
```

*The table produced in case TYPE\_RESU= `DETAILS', printable with order IMPR\_TABLE, give the value of each parameter calculated (SN, PB and PM-PB) for each moment:*

```
ENTITLE PLACE SM 3SM TABL_RESU INST PM PB PMB
Li1 ORIG 9.78000E+01 2.93400E+02 TAB1 0.00000E+00 4.69111E+01 2.38704E+01 2.87530E+01
Li1 ORIG 9.78000E+01 2.93400E+02 TAB1 1.00000E+00 4.69101E+01 2.38703E+01 2.87526E+01
Li1 ORIG 9.78000E+01 2.93400E+02 TAB1 2.00000E+00 4.69092E+01 2.38703E+01 2.87522E+01
Li1 ORIG 9.78000E+01 2.93400E+02 TAB1 3.00000E+00 4.69092E+01 2.38703E+01 2.87522E+01
Li1 ORIG 9.78000E+01 2.93400E+02 TAB1 4.00000E+00 4.69092E+01 2.38703E+01 2.87522E+01
Li1 EXTR 9.78000E+01 2.93400E+02 TAB1 0.00000E+00 4.69111E+01 2.38704E+01 7.05172E+01
```

...



*In case TYPE\_RESU= `VALE\_MAX', only the maximum values of each parameter calculated and the moment of corresponding calculation are posted for the origin and the end of the segment:*

```

ENTITLE PLACE SM 3SM TABL_RESU INST_PM PM INST_PB PB INST_PMB PMB
Li1 ORIG 9.78000E+01 2.93400E+02 TAB1 8.75000E+02 4.69111E+01 - - - -
Li1 EXTR 9.78000E+01 2.93400E+02 TAB1 8.75000E+02 4.69111E+01 - - - -
Li1 ORIG 9.78000E+01 2.93400E+02 TAB1
- - 7.42000E+02 2.38704E+01 - -
Li1 EXTR 9.78000E+01 2.93400E+02 TAB1
- - 7.42000E+02 2.38704E+01 - -
Li1 ORIG 9.78000E+01 2.93400E+02 TAB1
- - - -
- 9.40000E+02 2.87530E+01
Li1 EXTR 9.78000E+01 2.93400E+02 TAB1
- - - -
- 8.00000E+02
7.05172E+01

```

## **2.4.2 Option**

### **SN**

*Calculation with the option SN is done in the following way:*

```

SN1=POST_RCCM (MATER=MAT,
TYPE_RESU=' VALE_MAX',
OPTION=' SN',
TITRE=' INST SN, RESULT: RESU1',
TRANSITOIRE=_F (TABL_RESU_MECA = TAB1,
TABL_SIGM_THER = TABTH)
)

```

*The table produced in the case TYPE\_RESU = “DETAILS” gives the value of each parameter calculated (SN and, possibly, SN\*) for each combination of moments:*

```

ENTITLE PLACE SM 3SM TABL_RESU_1 INST_1 TABL_RESU_2 INST_2 SN SN*
Li1 ORIG 9.78000E+01 2.93400E+02 TAB1 0.00000E+00 TAB1 0.00000E+00 2.87530E+01 2.87530E
+01
Li1 ORIG 9.78000E+01 2.93400E+02 TAB1 0.00000E+00 TAB1 1.00000E+00 3.87825E+00
2.40790E-01
Li1 ORIG 9.78000E+01 2.93400E+02 TAB1 0.00000E+00 TAB1 2.00000E+00 1.27703E+01
8.46220E-01

```

*Li1 ORIG 9.78000E+01 2.93400E+02 TAB1 0.00000E+00 TAB1 3.00000E+00 2.40816E+01 1.68294E+00*

...

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*In the case TYPE\_RESU = 'VALE\_MAX', only the maximum values of each parameter calculated and the moment of corresponding calculation are posted:*

*ENTITLE PLACE SM 3SM TABL\_RESU\_1 INST\_SN\_1 TABL\_RESU\_2 INST\_SN\_2 SN INST\_SN\*\_1  
INST\_SN\*\_2 SN\**

*Li1 ORIG 9.780E+01 2.934E+02 TAB1 5.5000E+01 TAB1 9.2500E+02 4.7530E+02 - - -*

*Li1 EXTR 9.780E+01 2.934E+02 TAB1 5.5000E+01 TAB1 9.2500E+02 5.0004E+02 - - -*

*Li1 ORIG 9.780E+01 2.934E+02 TAB1*

*- TAB1*

*- - 6.5000E+01 6.5000E+01*

*6.48451E+01*

*Li1 EXTR 9.780E+01 2.934E+02 TAB1*

*- TAB1*

*- - 6.5000E+01 6.5000E+01*

*9.60261E+01*

### **2.4.3 Option**

#### **TIRE**

*Calculation with the option TIRES is done in the following way:*

```
FAT1=POST_RCCM (MATER=MAT,  
TYPE_RESU=' VALE_MAX',  
OPTION=' FATIGUE',  
TITRE=' FATIGUE_ZH210, RESULT: RESU2+RESUTH',  
TRANSITOIRE= (_F (TABL_RESU_MECA = TAB1,  
INST = (0. , 1. , 2. ), NB_OCCUR = 200),  
_F (TABL_RESU_MECA = TABTH,  
INST = (0. , 1. , 2. ), NB_OCCUR = 200),  
)
```

*The table produced in the case TYPE\_RESU = “DETAILS” gives, for each combination of moments (of occurrences NB\_OCCUR\_1 and NB\_OCCUR\_2) and for each end: SN, SN\*, SP, KE, SALT, NADM and DAMAGE (= min (NB\_OCCUR\_1, NB\_OCCUR\_2) /NADM). Value DOMMAGE\_CUMU, indicated at the end of the table for each end of the segment, corresponds to the combination of the damage of all under-cycles.*

*The table produced in the case TYPE\_RESU = “VALE\_MAX” gives only the maximum value of each the parameters listed above and corresponding moment. It should be noted that the number of acceptable cycles posted is the maximum of this parameter on the whole of the combinations, and it thus does not correspond to the SALT and the maximum DAMAGE indicated on the same line. SN values and SN\* indicated are the same ones as those which would come from a calculation with the option “SN”.*

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### **3 lawful Study of a particular zone of one component subjected to many loadings**

*This chapter relates to the analysis with the tiredness of a component, or a particular zone of one component pertaining to a line of piping, modelled in a detailed way in 2D or 3D, and subjected to the same situations as the lines of pipings of the first chapter. That means that it will be necessary to know the constraints on one or more segments, for each loading, with in private individual the seism, and each thermal transient.*

*The management of many results being expensive, it is of use in this case to carry out calculations mechanics for unit loadings (a loading by direction, of standard 1) then to carry out linear combinations to obtain the response in each state stability of each situation. This process in the case of reduces the mechanical number of calculations with 7 a component to two ends (elbow, transition from thickness...) : 6 unit loadings and 1 unit pressure.*

#### **3.1**

#### **Definition of the zone of analysis**

*The zone to be analyzed must be selected such as the limits of the models correspond to points where torques of efforts applied are known. Right parts of the zone with a grid, assimilable to grids 3D of pipes, must be sufficiently long, so that the mechanical solution with ends is close to a solution of the beam type: displacements and constraints varying linearly in the thickness. In this case, one will be able to apply at the ends the 6 components of a torque unit, via a connection 3D-beam (key word LIAISON\_ELEM of AFFE\_CHAR\_MECA), with an element of beam, or even with a discrete element having of the degrees of freedom of translation and of rotation.*

*Guard should well be taken to define the geometry 3D in a reference mark coinciding with the local reference mark of the zone analyzed during the calculation of the efforts of beam, so that the torques are defined in the same one locate. In the contrary case, the user will have to carry out a change of reference mark of the torques.*

*In the case of an elbow, whose inflection generates an ovalization, one will be able to benefit from the connection 3D PIPE, which makes it possible to connect the end 3D of the grid to pipe sections, which have degrees of freedom of ovalization. This makes it possible to decrease the length of the right parts with a grid in 3D.*

*Let us take the example of test RCCM04 [V3.04.136] resulting from the study [bib1]: it is about the detailed study of a longitudinal under-thickness in an elbow line VVP studied in chapter 1. This elbow is*

with a grid using ASCOUF.

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## 3.2

### ***Preliminary calculation of the efforts in extreme cases of the zone of analysis***

*Efforts applied to the limits of the model, corresponding to each loading of the list of situations, will have to be calculated as a preliminary by an analysis of the beam type, as in chapter 1. One then obtains the values of the components of the torques applied to the limits of the model 3D, for each stabilized state of each situation. (The list of the situations is that given to chapter 1). For the elbow studied in [bib1], that gives for example:*

#### ***Loading case FX (kN)***

***FY (kN) FZ (kN) MX (Nm) MY (Nm) MZ (Nm) P (absolute Bars)***

*Loading*

1 -0.501

-1.000

0.775 5947 3144 6334

0

*Loading 2*

0.962

-11.769 -3.762

-41084

-25691

91767

71.5  
*Loading 3*  
0.662  
-10.475 -3.081  
-34253  
-20695  
83346  
58.9

*Loading 4*  
0.534  
-10.194 -2.934  
-32752  
-19577  
81995  
57.6

*Loading 5*  
0.897  
-11.628 -3.688  
-40330  
-25129  
91090  
70

*Loading 6*  
0.689  
-10.533 -3.111  
-34565  
-20928  
83625  
59

*Loading 7*  
1.031  
-12.078 -3.925  
-42718  
-26884  
93803  
73.4

*Loading 8*  
0.666  
-11.282 -3.509  
-38457  
-23711  
89984  
68.1

*Loading 9*

0.962  
-11.769 -3.762  
-41084  
-25691  
91767  
71.5

*Loading 10*

1.128  
-11.374 -4.088  
-43556  
-28408  
86849  
44

*Loading 11*

1.031  
-12.078 -3.925  
-42718  
-26884  
93803  
74.5

*Loading 12*

1.181  
-11.490 -4.148  
-44175  
-28869  
87403  
44

*Loading*

13  
0.000  
0.000  
0.000  
0 0 0  
0

*Loading 14*

-19.968  
0.182  
0.150  
1381  
5671  
-3179  
112

*Seism 23.425*

*-50.966*

*36.902*

*240270*

*107195*

*16786 0*

*These values will be directly introduced into POST\_RCCM which will carry out the linear combinations corresponding.*

### **3.3**

#### ***Characteristics of materials***

*The definition of materials is identical to that of chapter 1, excluded the density, useless here. The thermal characteristics are similar. One will be able to use the catalogue material for to profit from the characteristics of the RCC-M according to the temperature.*

#### ***Notice concerning the values to use:***

*The RCC-M B3200 specifies that in the case of combination of mechanical loadings and thermics, which is the case general, it is necessary to take  $S_m$  at the maximum temperature of each transient. On the other hand the use in B3600 is to choose  $S_m$  at the average temperature of studied transients.*

*It is essential to check the relevance of the system of units. Let us note for example that the use of MACR\_ASCOUF\_MAIL implies to use the mm as unit of length. Therefore, all constraints will be in MPa ( $N/mm^2$ ). In the same way, it is necessary to take guard with the units used in the characteristics thermics.*

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### 3.4

#### ***Elementary characteristics of the discrete or linear elements***

*Characteristics of the possible elements of beam, used to apply the torques of efforts, must correspond to that of piping in the studied zone, and with the grid 3D. In definition of the section, R indicates the external ray of the section. The example of two here is given connections: embedded side, one applies a connection with a discrete element. Other side, one apply torques, the connection is of the 3D-beam type:*

```
MOD=AFFE_MODELE (MAILLAGE=MA,
AFFE= (
_F (GROUP_MA=' 3D', MODELING = "3D", PHENOMENON = "MECHANICAL"),
_F (GROUP_MA= ("AB",), MODELING = "POU_D_T", PHENOMENON = "MECHANICAL"),
_F (GROUP_NO = "It, MODELING = "DIS_TR", PHENOMENON = "MECHANICAL"))
)
CELEM=AFFE_CARA_ELEM (MODELE=MOD,
POUTRE=_F (GROUP_MA = ("AB",), SECTION = "CIRCLE",
CARA = ("R", "EP",), VALE = (0.8128, 0.032)),
DISCRET=_F (GROUP_NO = "It,
CARA = "K_TR_D_N", VALE = (0. , 0. , 0. , 0. , 0. , 0. ,)))
```

*It is necessary to give the characteristics of stiffness to the discrete element, for reasons data processing.*

### 3.5

#### ***Boundary conditions for the calculation of the unit loadings***

*It is thus necessary to apply to the limits of the model each component of the torque applied by the line of piping in this point. In practice, one embeds an end (via a connection 3D-beam or 3D-pipe, which avoids the stress concentrations), and one apply the torques to each other end (either 6 components in the case of an elbow or of a right part, and 12 components in the case of a pricking).*

```
CL=AFFE_CHAR_MECA (MODELE=MOD, LIAISON_ELEM= (
# Connection 3D-DISCRET
_F (OPTION = "3D_POU",
GROUP_MA_1 = "KNOWN",
GROUP_NO_2 = "It),
# Connection 3d-BEAM
```

```
_F (OPTION = "3D_POU",  
GROUP_MA_1 = "SF",  
GROUP_NO_2 = "A"),  
# Embedding of the specific discrete element  
DDL_IMPO=_F (GROUP_NO = "It, DX = 0. , DY = 0. , DZ = 0. , DRX = 0. ,  
DRY = 0. , DRZ = 0.),  
)  
# a component of the torque:  
FX=AFFE_CHAR_MECA (MODELE=MOD,  
FORCE_NODALE=_F (GROUP_NO = "B", FX = 1000.))  
  
MX=AFFE_CHAR_MECA (MODELE=MOD,  
FORCE_NODALE=_F (GROUP_NO = "B", MX = 1.))
```

**Note:**

*The "unit" value of the loadings depends on the unit of the torques which will be provided to POST\_RCCM. Here, the efforts are in kN and the moments in N.m. the pressures are in bars. In the example presented here, one applies a unit effort of 1kN, one unit moment of 1N.m and a unit pressure of 1bar (either 1E5 Pa).*

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*For the loading of pressure, it is necessary to apply to the surface meshes intern a pressure unit, without forgetting the basic effect (which can be defined as follows, or directly using key word EFFE\_FOND):*

```

REXT= 0.8128
EPTUB= 0.032
PINT= 1.E5
RINT= REXT-EPTUB
SINT= PI* (RINT*RINT)
FTOT= PI* (RINT*RINT)
SEXT= PI* (REXT*REXT)
SFON= SEXT-SINT
FREP= FTOT/SFON
PRES1=AFFE_CHAR_MECA (MODELE=MODMECA,
PRES_REP=_F (GROUP_MA=' SURFINT',
PRES=PINT),
FORCE_FACE=_F (GROUP_MA=' EFOND',
FX=FREP,));

```

**Note:**

*It is always preferable to direct the meshes of face where the pressures are applied, because they are not always directed suitably by the mailleurs. This is done simply using operator MODI\_MAILLAGE:*

```

MAIL=MODI_MAILLAGE (reuse =MAIL, MAILLAGE=MAIL,
ORIE_PEAU_3D= (_F (GROUP_MA=' SURFINT',),
_F (GROUP_MA=' EFOND',)),
MODELE=MODMECA,);

```

**3.6 Calculations****statics**

*7 static calculations will be carried out: one by unit component of torque, and for the pressure. seism does not intervene on this level, because it is translated in fact by torques, whose components have unknown signs. It is POST\_RCCM which will carry out all the combinations of sign.*

**3.7****Statements of the constraints**

*After having determined a certain number of segments on which the criteria will be evaluated, it remains to extract the values from constraints (SIEF\_ELNO\_ELGA or SIGM\_ELNO\_DEPL) for each loading, on each segment. Let us recall that the criteria of the RCC-M B3200 are to be checked for the whole of the possible segments, crossing the component of the skin interns to the skin external. The choice of the segment maximizing the criteria is the responsibility of the user. For one complex geometry, this one will have to thus calculate a certain number of segments.*

*In practice, in Code\_Aster, three methods of definition of the segments are possible:*

.  
*the first consists in using orders INTE\_MAIL\_2D or INTE\_MAIL\_3D, according to geometrical dimension of the problem, to define an unspecified segment passing in through grid:*

```
LIGNE1=INTE_MAIL_2D (MAILLAGE=MA,  
DEFI_SEGMENT=_F (ORIGIN = (-1.0, 0.5,)),  
END = (1.0, 0.5,)),  
INFO=2)
```

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.  
*the second consists in using a preexistent group of nodes in the grid, defining a segment. This method obligatorily requires to reorder the group as a preliminary nodes, so that the nodes the component are arranged internal skin towards the skin external:*

```
MA=DEFI_GROUP (reuse=MA, MAILLAGE=MA,  
CREA_GROUP_NO= (_F (OPTION = "SEGM_DROI_ORDO",  
NAME = "LINE",  
GROUP_NO=' GNI',  
NOEUD_ORIG = "N22",  
NOEUD_EXTR = "N12",  
PRECISION = 1.E-03,  
CRITERION = "RELATIVE"))
```

the third consists in using *MACR\_LIGN\_COUPE*, which carries out a projection of the fields constraints realised with the nodes on a grid 1D whose one provides the ends and it a number of elements:

```
MACR_LIGN_COUPE (RESULT = RESUT, NOM_CHAM=' SIGM_NOEU_DEPL',
MODEL = MODMECA,
LIGN_COUPE = (_F (NB_POINTS = 10,
COOR_ORIG = (0,3,0.18),
COOR_EXTR = (0,3,0.2),
COUNT = CO ("TAB2")),))
```

To reduce calculations, the tables results of these extractions could be written on a file with assistance of *IMPR\_TABLE*, with the format *ASTER*. Thus postprocessing will not have any more but to read again these tables (with assistance of *LIRE\_TABLE* [U7.02.03]) without having to manage results of big sizes.

The tables have the following form:

```
#DEBUT_TABLE
#TITRE ASTER 6.4 CONCEPT TRCA_1 CALCULATES THE 03/11/2002 A 09:06: 13 SOUS_EP
LONGI
#TITRE TABL_POST_RELEVE NUMBER 1 EFFORT FX
NODE NOM_CHAM ABSC_CURV SIXX SIYY SIZZ SIXY SIXZ SIYZ
K8 K16 R R R R R R R
N1678 SIEF_ELNO_ELGA 0.00000E+00 -1.27858E-03 -3.15954E-03 -4.34084E-02 -3.34792E-13 -
7.38056E-03 -
1.79181E-12
N1680 SIEF_ELNO_ELGA 5.33333E+00 -1.12894E-03 -6.39054E-03 -4.14610E-02 3.92425E-14 -
6.51754E-03 -
1.41419E-12
N1682 SIEF_ELNO_ELGA 1.06667E+01 -9.36233E-04 -9.61344E-03 -3.95320E-02 4.40551E-13 -
5.65075E-03 -
1.03617E-12
N1684 SIEF_ELNO_ELGA 1.60000E+01 -8.84555E-04 -1.30290E-02 -3.74732E-02 5.69397E-13 -
5.52805E-03 -
6.68335E-13
N1686 SIEF_ELNO_ELGA 2.13333E+01 -7.91024E-04 -1.64407E-02 -3.54349E-02 7.02376E-13 -
5.30574E-03 -
3.05450E-13
N1688 SIEF_ELNO_ELGA 2.66667E+01 -1.23405E-03 -2.07044E-02 -3.16426E-02 5.06784E-13 -
6.18022E-03
4.51977E-13
```

N1690 SIEF\_ELNO\_ELGA 3.20000E+01 -1.76201E-03 -2.49802E-02 -2.78113E-02 2.79785E-13 -  
7.15807E-03  
1.21395E-12  
#FIN\_TABLE

### **3.8 Calculations** ***thermomechanical***

***Thermal calculations must be carried out for each thermal transient to take in count. Guard should be taken to be netted finely, for example with the assistance the linear elements with mass diagonalized (modeling 3D\_DIAG), which makes it possible to avoid the goings beyond of maximum. Steps times must be optimized, to collect the variations in temperature in the thickness due to thermal transients violent one.***

***If one wants to model transients of great amplitude, it is more precise to carry out calculations nonlinear thermics (THER\_NON\_LINE) by considering the variable thermal characteristics with the temperature.***

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***Generally, the thermal loadings consist of stories of temperatures fluid in skin intern, with coefficients of exchange constant, or function of time. They are often used expression following to estimate the coefficients of exchange according to the flow of the fluid (formula of Colburn):***

*F*  
*0.8*  
*.*  
*4*  
*.*  
*0*  
*4Q*  
*H = 0.023*

*.*  
*0*  
*Re Pr with Re =*  
*where Q is the flow of the fluid, D the diameter interns*

*D*  
*D<sup>2</sup> v*  
*F*  
*F*

*pipng, the thermal conductivity of water, v kinematic viscosity and Pr the number of*

*F*  
*Prandtl. All these characteristics vary in fact according to the temperature. One can choose*  
*average temperature of each transient to evaluate these quantities.*  
*That can be introduced directly into the command file in the form:*

*PRANDTL= 1.35*  
*LF= 0.45*  
*NF= 0.123E-6*  
*DF= 0.1319*  
*DEBIT=20/3600*  
*RE1= 4\*DEBIT/NF/PI/DF/DF*  
*COEFH= 0.0023\* (PRANDTL \*\* (0.4))\* (RE1 \*\* (0.8))\*LF/DF*

*The others faces (external face and ends) are often isolated, which results in a condition*  
*null flow (not of condition particular to introduce for thermal calculation). The coefficient of*  
*Prandtl is adimensional, thermal conductivity is in W/m.°C, the flow in m<sup>3</sup>/s and viscosity*  
*kinematics in m<sup>2</sup>/s.*

*The thermal results resulting from preceding calculations are introduced like loadings for*  
*thermomechanical calculations. One will use preferably meshes of order 2. Fields of*  
*P1 temperature will thus be projected on this P2 grid, using PROJ\_CHAMP.*

*TEMP2 = PROJ\_CHAMP (*  
*METHODE=' ELEM',*  
*RESULTAT=TEMP,*  
*MODELE\_1=MODTHER,*

*MODELE\_2=MODMECA,  
TOUT\_ORDRE=' OUI')*

*With MODTHER the thermal model (3D\_DIAG, elements of order 1) and MODMECA the mechanical model (3D, elements of order 2). One can arrive at the same quality of results (without using 3D\_DIAG) with a single grid, of order 2, sufficiently end to be able to use steps of fine times.*

*The boundary conditions associated must make it possible to avoid the movements of solid body (embedding of the one of the ends via the discrete element for example).*

*Once thermomechanical calculation carried out, one **extracts the constraints** by one from the three methods already quoted. One will then obtain, for each segment, and each transient, a table containing the 6 components of constraints, for each moment (the list of moments can be reduced to the moment of the extraction).*

### **3.9**

#### ***POST\_RCCM on each segment***

*On each segment, it is necessary to call POST\_RCCM, option PM\_PB, SN or TIREDNESS. Analysis more complete corresponds to the option TIRES.*

*The material east supposes single along the segment. One must thus provide to POST\_RCCM material (defined by DEFI\_MATERIAU or INCLUDE\_MATERIAU) containing the mechanical characteristics with maximum temperature of the transients.*

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More precisely [R7.04.03], the calculation of the amplitude of constraints  $\text{alt}(I, J)$  was carried out, for each couple of stabilized states  $(I, J)$ , and each end of the segment, starting from the tensor of constraints  $S$

, and of the tensor of the linearized constraints  $S$

, by taking of account it

$N(p, Q)$

$p(I, J)$

report/ratio of the Young moduli at the maximum temperature of the transient and the temperature of reference of the curve of Wöhler:

$I$

,  
= .

.

,

.

,

$\text{alt}(I$

)

$E$

$J$

$C_{Ke}(S_n(p, Q), S_p(I, J))$

2nd

with:

*EC.:* Young modulus of reference for the construction of the curve of Wöhler, provided by the user in *DEFI\_MATERIAU*, under key word *E\_REFE*, of the key word factor *TIRES*.

Ke the elastoplastic concentration factor defined in the §B3234.6 of the RCC-M. Ke can be calculated of two ways:

· KE\_MECA: it is the original method, only available in the versions former to version 7.2 [cf R7.04.03]:

1

if  
S

$N(p, Q)$   
3.Sm

-

K  
=  
+  
-  
<  
<

$E(SN($   
N  
SpQ  
p, Q)  
1  
N(  
)  
1

N(  
SpQ  
m  
. m -).  
1 3.S

if

,  
3. S

*m*  
*N* (  
)  
*m*  
*l*  
*3.S*

*m*  
*l*

*if*  
*S*

*N* (*p*, *Q*)  
*3. S*  
*m m*  
*N*

*with m and N depend on material, and provided by the user in DEFI\_MATERIAU, under key words M\_KE\_RCCM and N\_KE\_RCCM, of the key word factor TIRES.*

*· KE\_MIXTE: since the modifying 1997 of the RCC-M, one can choose another formula, based on a decomposition of Salt:*

*l*  
*(I,)*  
*E*  
*J*  
*C*  
*= .*

*·*  
*,*  
*·*  
*,*  
*+*  
*,*  
*·*  
*,*

*with:*

*alt*  
*(Kmecca (Sn (p Q) Smeca*

*p*  
*(I J) K ther (Sn (p Q) Sther*

*p*  
*(I J)*  
*2nd*  
*E*  
*E*  
*K meca (S*

,  
*is equal to Ke defined in [R7.04.03], and*  
*N (p Q)*  
*E*

*1*

*ther*  
*K*  
*S p Q*  
  
*E*  
*(N (,)*

*1*  
*= max*

*.*  
*.86*  
*1*

*1*

*-*

*. S*

*66*

.  
*I*  
+ *N*

*Sm*

*S meca*

*P*

*(I, J)* represents the quantity *Sp*, amplitude of variation on mechanical behalf of constraints, between the moments *I* and *J*, or maximum value of this quantity during the transient, calculated on the basis of request of mechanical origin: pressure, actual weight, seism (inertial and displacements of anchoring), thermal expansion.

*S ther*, represents the *Sp* quantity calculated starting from the generated mechanical constraints

*P*

*(I J)*

only by the thermal transients.

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*In the studied example, the orders are as follows (for a segment):*

*One extracts the tables containing the extractions from constraints on the segment, for each one of 7 unit loadings, and for each thermal transient:*

*TLIG1\_FX = LIRE\_TABLE (UNITE=38, TITRE=' TLIG1\_FX', NUME\_TABLE=1)*

...

*TLIG1\_PR = LIRE\_TABLE (UNITE=38, TITRE=' TLIG1\_PR', NUME\_TABLE=55,)*

*# RESULTS THERMOMECHANICAL**TLIG1\_T2 = LIRE\_TABLE (UNITE=38, TITRE=' TLIG1\_T2', NUME\_TABLE=64,)**TLIG1\_T6 = LIRE\_TABLE (UNITE=38, TITRE=' TLIG1\_T6', NUME\_TABLE=73,)**# THE MATERIAL EAST SUPPOSES SINGLE ALONG THE SEGMENT**TBRCCM1=POST\_RCCM (TYPE\_RESU=' VALE\_MAX',**TYPE\_RESU\_MECA=' UNITAIRE',**OPTION=' FATIGUE',**MATER=MAT\_A48,**TYPE\_KE**=**“KE\_MECA”,**INFO=2,**# the situations are defined as for FATIGUE\_B3600**SITUATION= (**\_F (NB\_OCCUR=190,**NUME\_SITU=1,**NOM\_SITU=' Passage cold stop - operation nominal',**NUME\_GROUPE=1,**PRES\_A=1.0E5,**PRES\_B=71.5E5,**TEMP\_REF\_A=10.0,**TEMP\_REF\_B=287.0,**CHAR\_ETAT\_A=1,**CHAR\_ETAT\_B=2,)**\_F (NB\_OCCUR=1300000,**NUME\_SITU=2,**NOM\_SITU=' fluctuations in mode permanent',**NUME\_GROUPE=1,**PRES\_A=58.9E5,**PRES\_B=57.6E5,**TEMP\_REF\_A=274.5,**TEMP\_REF\_B=272.5,**CHAR\_ETAT\_A=3,**CHAR\_ETAT\_B=4,**NUME\_RESU\_THER=2,)**...*

```
_F (NB_OCCUR=10,  
NB_CYCL_SEISME=390,  
NUME_SITU=7,  
NOM_SITU=' Seism SNA',  
COMBINABLE=' OUI',  
NUME_GROUPE=1,  
PRES_A=0.0,  
PRES_B=0.0,  
TEMP_REF_A=20.0,  
TEMP_REF_B=20.0,  
CHAR_ETAT_A= (1000,1001),  
CHAR_ETAT_B= (1000,1001)),  
)
```

*# torques mechanical: for each stabilized state (thus 2 per situation):*

```
CHAR_MECA= (  
_F (NUME_CHAR=1, NOM_CHAR=' STATE 1 SITUATION 1 ',  
FX=-0.501, FY=-1.000, FZ=0.775, MX=5947., MY=3144., MZ=6334.),  
_F (NUME_CHAR=2, NOM_CHAR=' STATE 2 SITUATION 1 ',  
FX=0.962, FY=-11.769, FZ=-3.762, MX=-41084., MY=-25691., MZ=91767.),  
_F (NUME_CHAR=3, NOM_CHAR=' STATE 3 SITUATION 2 ',  
FX=0.662, FY=-10.475, FZ=-3.081, MX=-34253., MY=-20695., MZ=83346.),  
...  
_F (NUME_CHAR=1000, NOM_CHAR=' SNA', TYPE_CHAR=' SEISME',  
FX=23.425, FY=-50.966, FZ=36.902, MX=240270., MY=-107195., MZ=16786.),  
)
```

*# results thermomechanical*

```
RESU_THER= (  
_F (NUME_RESU_THER=2,  
TABL_RESU_THER=TLIG1_T2),  
_F (NUME_RESU_THER=6,
```

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*TABL\_RESU\_THER=TLIG1\_T6,)*  
*),*

*# profiles of constraints resulting from unit mechanical calculations*

*RESU\_MECA\_UNIT= (*  
*\_F (TABL\_FX=TLIG1\_FX,*  
*TABL\_FY=TLIG1\_FY,*  
*TABL\_FZ=TLIG1\_FZ,*  
*TABL\_MX=TLIG1\_MX,*  
*TABL\_MY=TLIG1\_MY,*  
*TABL\_MZ=TLIG1\_MZ,*  
*TABL\_PRES=TLIG1\_PR,)*  
*), );*

*IMPR\_TABLE (TABLE=TBRCCM1,);*

### ***3.10 Description of the produced tables***

*The table produced for option PM\_PB contains the values of PM, PB and PM-PB at the ends of segment for each situation of loading. The value indicated corresponds to the maximum of parameter considered, calculated with the mechanical states A and B defined by the user. If the group of situations includes/understands a loading of the type SEISM, the value indicated for a situation (out seism) of this group corresponds to the maximum obtained by taking of account the loadings not signed seism. The value without seism of this situation can be found in the file message if INFO=2.*

*The table produced for the option SN contains values SN and SN\* at the ends of the segment for each situation of loading. If the group of situations includes/understands a loading of the SEISM type, the value indicated for a situation (except seism) of this group corresponds to the maximum obtained in taking into account the not signed loadings of the seism. The value without seism of this situation can be found in the file message if INFO=2.*

*The table produced for the option TIREDNESS shows same information as for the options the preceding ones (PM, PB, PM-PB, SN and SN\*) for each situation, and the value of the factor of use*



*FACT\_USAGE and its contribution %\_FACT\_USAGE for each combination of possible situation. Lastly, for the two ends of the segment, one finds SN\_MAX, SP\_MAX, SALT\_MAX and FACT\_USAGE\_CUMU:*

*ASTER 6.03.18 CONCEPT TBRCCM1 CALCULATES THE 01/10/2002 A 10:51: 56 OF TYPE TABL\_POST\_RCCM*

*PLACE SM SN/3SM SN\_MAX SP\_MAX SALT\_MAX FACT\_USAGE\_CUMU  
ORIG 1.33600E+08 3.48221E-02 1.39567E+07 1.43295E+07 7.27012E+06 1.39288E-05  
EXTR 1.33600E+08 5.23888E-02 2.09974E+07 2.19719E+07 1.11475E+07 3.76647E-05*

*It is possible to obtain the detail of calculations with INFO=2: the values of SN and SP are then indicated in the file message for each combination of loading of each group. matrices SALT are also indicated to each iteration of the calculation of the cumulated damage.*

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[2]

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***Key COURTEOUS Mr.***

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***Organization (S): EDF R & D /AMA***

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***Note of use of the Code\_Aster-Zmat coupling***

***Summary:***

*One describes here the use of the coupling between Code\_Aster and Zmat, module of integration of behaviors of code Zebulon, ENSMP. The coupling is operational starting from version 8.1 of Code\_Aster. Instruction manual U2.10 booklet: External couplings HT-62/06/004/A*

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## **1 Methods**

**of use**

### **1.1**

#### **Description of the Zmat library**

**Within the framework of partnership EDF (MMC-AMA-LAMSID) - School of the Mines (Center of Materials), it**

**coupling between Zmat, which is the module of definition of the behaviors of the Zebulon code, and Code\_Aster was carried out. Zmat contains a module of integration of laws of behavior and one library of behaviors including/understanding élasto-visco-plasticity, the damage, the models multi-scale...**

**Moreover, the user can define his own behavior, by describing the equations governing it behavior using a high-level language (Zebfront), integration being then realized by Zmat.**

### **1.2**

#### **Licence and right of access**

**The use of Zmat for Code\_Aster is envisaged, within the framework of the partnership School of the Mines - EDF,**

**for calculations of R & D only, which excludes in particular studies IPS. Extension of these conditions of use starting from the introduction of version 8 (at the end of 2006) is being studied.**

*Out of this framework, the licence of Zmat can be acquired near the Center of Materials of the ENSMP.*

*For as much Zmat is not pre-necessary of Code\_Aster, one can build and use Code\_Aster with or without the Zmat library.*

*Corrective and evolutionary maintenance (in particular compared to the evolution of the systems of exploitation, and compilers) of the Zmat library concerns the ENSMP. Routines of interface are maintained by the team of development of Code\_Aster.*

### **1.3**

#### ***Machines usable at EDF R & D***

*Zmat is physically installed on the waiter of centralized development of Code\_Aster (Alphaserveur), like on departmental Linux waiters (clp50a8 with AMA, ret20fi with MMC). However the access to the centralized machine is necessary for the access to the licence of use.*

### **1.4 Documentation**

*The documentation of Zmat is available in the form of files to format pdf, in the repertory of installation of Zmat, in general [ASTER\_ROOT] /public/Z8.3/HANDBOOK where [ASTER\_ROOT] is the principal repertory of the installation of Code\_Aster, and is worth /opt/aster in general or .*

*On the waiter Aster, the documentation of Zmat is in the repertory /aster/local/Z8.3/HANDBOOK.*

*The documents relating to Zmat are z\_mat\_manual.pdf and devel\_manual.pdf.*

### **1.5**

#### ***Limitations and prospects***

*The interface (and Zmat modulates it) does not expect that one variable of order (scalar): the temperature.*

*To define a material dependent on another variable of order (fluence, corrosion, drying...) the interface should be modified.*

*The behaviors, in version 8.1, are accessible only in small deformations (key word DEFORMATION=' PETIT' or "PETIT\_REAC").*

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**Notice on the performances**

**The integration of the behavior by using the Zmat library takes 2 to 3 times more time that the integration of the model equivalent included to Code\_Aster.**

**Precaution for use**

**The user defines certainly his behavior and the values of the coefficients material in Zmat file, but it must also define an elastic material (E and) if it wants to use the matrix rubber band or the elastic prediction. Guard should then be taken required values coherent with those of the Zmat files. In the same way, for the orders of postprocessing (CALC\_ELEM, CALC\_NO, POST\_ELEM), certain options use the elastic coefficients: in this case, even notices that previously.**

**As currently realized, the Code\_Aster-Zmat interface does not make it possible to establish a bond between materials managed by Zmat and those managed by Code\_Aster (in particular the catalogue material).**

**If the need is felt some, a stronger bond with DEFI\_MATERIAU would be to envisage, so that the users can give the characteristics material in the formalism Aster, them to store in the catalogue material, by generating the corresponding Zmat data.**

**2**

**To use a behavior of the library of Zmat**

**2.1**

**Contents of card-indexing Zmat**

*To card-index Zmat at the same time allows to define the behavior to provide the values of the parameters (constant or variable with the temperature) for this behavior. The syntax of this file is described in the document z\_mat\_manual.pdf.*

*The following file is that used in the case-test zmat001a:*

```
% file zmat001a.33
*** material
*integration theta_method_a 1. 1.e-9 50
*** behavior gen_evp
** elasticity
Young 145200.
fish 0.3
** potential gen_evp
*flow plasticity
*criterion settings
*kinematic nonlinear
C 63767.
D 341.
*isotropic nonlinear
R0 87.
B 2.3
Q 64.
*** return
```

*Who corresponds to model VISC\_CIN1\_CHAB of Code\_Aster (extracted the case-test ssnv101d):*

```
ACIER1=DEFI_MATERIAU (ELAS=_F (E = 145200. ,
NAKED = 0.3,),
CIN1_CHAB=_F (R_I = 151. ,
R_0 = 87. ,
B = 2.3,
C_I = 63767. ,
G_0 = 341. ,))
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```

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### *2.2 Characteristics of driving orders and profile of study of Code\_Aster*

*The use of Zmat is translated for the user of Code\_Aster in the following way:*

- Under key word COMP\_INCR of STAT\_NON\_LINE, it is necessary to specify RELATION='ZMAT', for to go to read the file containing the Zmat data. This file makes it possible to describe the parameters material.*
- Toujours under COMP\_INCR, a key word UNIT makes it possible to define the logical unit on which have comes to read to card-index it Zmat and of course the usual key words: GROUP\_MA, DEFORMATION (SMALL or PETIT\_REAC for the moment),*
- Key word NB\_VARI (under COMP\_INCR) makes it possible to specify the number of internal variables behavior. The number of internal variables can be larger than necessary (it storage of the internal variables will occupy more place than necessary in memory), but of course not lower than the number really used (Zmat then provided an error message). It a number can be calculated thanks to the Zpreload utility, whose example of call via python is given in the test zmat001a.*
- In astk, compared to a traditional study, it is enough to add the Zmat file and to associate it it logical number of unit defined in the key word UNIT.*
- Dans le cas d'une calcul de STAT/DYNA\_NON\_LINE en continuation, il est nécessaire de penser à fournir à nouveau à card-index it Zmat in the profile of study. The test zmat003a makes it possible to illustrate this point.*

### *2.3 Examples*

*The case-tests zmat001 with zmat004 validate the coupling between Code\_Aster and Zmat, but constitute*



*also a base of examples of implementation.*

· *zmat001: test of traction-shearing with a law of Chaboche (similar to the test ssnv101 with VISC\_CINI\_CHAB) in plane deformations (modeling A) and 3D (modelings B and C).*

*One also finds a possibility there of using Zpreload to recover the number of variables intern Zmat behavior.*

· *zmat002: thermoplasticity in simple traction (VMIS\_ISOT\_TRAC), modeling A in axisymmetric, modeling B in plane constraints. The interest of this test is to describe variation of the coefficients with the temperature.*

· *zmat003: test of traction-shearing using a law defined in the file zmat003a.32 (see following paragraph). This test also validates the use in CONTINUATION.*

· *zmat004: test of comparison enters the model MONOCRYSTAL and its analogue Zmat.*

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*3*

*To define a new behavior in Zmat*

*The new behavior is defined in a file which will be compiled, independently of Code\_Aster, in order to produce a dynamic library, used by the Zmat library principal at the object time.*

*Neither the file “source”, nor the built library need to appear in the profile astk.*

### 3.1

#### *To write a new behavior in Zmat*

*The writing of a new behavior is done using a high-level language (Zebfront, allowing tensorial operations...) on the basis of C++. One will refer to the documentation of Zmat for the description of syntax: [devel\\_manual.pdf](#).*

#### **Warning**

*Zmat imposes that the name of this file starts with a capital letter and has the extension “.z” during the compilation run.*

*Here the file (named `Chab1.z` for the following examples) defining the behavior `chab1` used in the test `zmat003` (file `zmat003a.32`), equivalent of behavior `VISC_CIN1_CHAB` of `Code_Aster`:*

```
#include <Elasticity.h>
#include <External_parameter.h>
#include <Basic_nl_behavior.h>
#include <Basic_nl_simulation.h>
#include <Flow.h>
#include <Criterion.h>
#include <Isotropic.h>
#include <Print.h>

@Class CHAB1: BASIC_NL_BEHAVIOR {
@Name chab1;
@SUBCLASS ELASTICITY E;
@Coefs R0, Q, B;
@Coefs K, N, C, D;
@tVarInt eel, alpha;
@sVarInt evcum;
@tVarAux evi, X;
@sVarAux R;
};

@StrainPart {
evi = eto - eel;
sig = *E*eel;
yew (m_flags&CALC_TG_MATRIX) m_tg_matrix=*E;
}

@Derivative {
sig = *E*eel;
```

$X = (2.0 * C / 3.0) * \alpha;$   
 $R = R0 + Q * (1. - \exp(-b * \text{evcum}));$

*TENSOR2 sigeff = deviator (sig - X);*  
*double J = sqrt (1.5 \* (sigeff/sigeff));*  
*double F = J - R;*

*deel = deto;*

*yew (f>0.0) {*  
*devcum = pow (f/K, N);*

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*TENSOR2 norm = sigeff\* (1.5/J);*

*decl - = devcum\*norm;*

*yew (C>0.0) dalpha = devcum\* (norm - D\*alpha);*

}

}

### **3.2**

#### ***Compilation of the new behavior***

*One describes the various stages hereafter to be followed to build the dynamic bookshop which will be used*

*by Zmat to integrate the behavior user.*

#### ***Notice preliminary***

*The dynamic bookshop will be used by Zmat on the object computer of calculation Code\_Aster, it must thus be compiled on this same machine to avoid the problems of heterogeneity of the libraries.*

*0. Organization of the files (while taking as /home/user/repertoire bases):*

*/home/user/repertoire/*

*library\_files*

*/*

*material*

*/*

*/*

*material*

/

*Chab1.z*

*1. To create a file library\_files container:*

*! MESSAGE To use Z7 project*

*! SIGNAL Makefile.Motif.c++*

*! DYNAMIC*

*#! INSTALL\_LIBS*

*! CFLAGS - I\$ {Z7PATH} /include*

*! BFLAGS - L\$ {Z7PATH} /PUBLIC/lib-\$ {Z7MACHINE}*

*! MAKE target: lib*

*#*

*# The hand places for to use files.*

*#*

*! Inc material*

*! SRC material material*

*The file .z will be taken in*

*sub-directory*

*material*

*! DEBUG material*

*! LIBLIB - ZL Zmat\_base*

*! LIB Zmat\_ut\_TyPeMaCHiNe material*

*The dynamic bookshop will be named*

*libZmat\_ut\_Linux4.so*

*under Linux,*

*libZmat\_ut\_OSF1.so under TRU64, etc*

*!! RETURN*

*1. To charge the Zmat environment (in ksh, bash) by reading the aster\_profile.sh file (to replace /aster by /opt/aster or other according to the installation).*

*prompt> ./aster/ASTK/ASTK\_SERV/conf/aster\_profile.sh*

*2. Creation*

*Makefile Zmat:*

*prompt> Zsetup*

### *3. Compilation of the behavior deposited in the repertory material*

*prompt> Zmake*

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### **3.3**

#### ***Use of the behavior user***

*In the profile of study astk, one provides like previously a file containing the value of parameters for the behavior user. The name chab1 is important and must correspond to name provided to the attribute @Name of the file .z (here the file zmat003a.33):*

**\*\*\* behavior chab1**

**\*\* YE isotropic**

*Young 195000.*

*fish 0.3*

**\*\* model\_coef**

*K 600.0*

*N 3.5*

*C 0.0*

*D 0.0*

*R0 30.0*

*Q 270.*

*B 100.*

**\*\*\* return**

*One provides the command file in which it is necessary to define the variable of environment ZEBU\_PATH to indicate to Zmat where is the dynamic library which one has just compiled. One finds then in the file (extracted from zmat003a.com m):*

```
# definition of variable ZEBU_PATH  
importation bone  
os.environ ["ZEBU_PATH"] = "/home/user/repertoire"
```

*[...]*

```
# definition of the elastic properties of material  
# which must be coherent with that of the Zmat file  
ACIER=DEFI_MATERIAU (ELAS=_F (E = 195000. ,  
NAKED = 0.3),)
```

*[...]*

```
# use of the behavior in nonlinear calculation  
# UNIT must correspond to the value defined in astk  
CALCNL=STAT_NON_LINE (...,  
COMP_INCR=_F (RELATION = "ZMAT",  
UNIT = 33,  
NB_VARI = 26,  
DEFORMATION = "SMALL"),  
..., )
```

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***Summary:***

***This document presents the graphic tool of layout of curves Grace, tool powerful to trace and handle curves produced by Code\_Aster.***

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## **1 General information**

### **1.1 Presentation**

#### **Grace**

**Grace is a tool of graphic layout of curve (WYSIWYG) under licence LPG available on system standard Unix/Linux and related to other platforms (of which Windows). Strong points of Grace are as follows:**

- modification of the layouts in a graphic environment by contextual menu;**
- very precise control of the elements on the curves (traced, legends, axes, etc...);**
- re-examined quality “publication”;**
- export (E) PS, pdf, JPG, png (according to platform and installation);**

**Internet site of Grace is <http://plasma-gate.weizmann.ac.il/Grace>**

### **1.2**

#### **Object of this tutorial**

**The goal of this tutorial is to make it possible the user of Aster to rather quickly take in hand one powerful tool allowing him to plot curves.**

**This tutorial presents the two great stages to plot the curves:**

- to import and modify the data;**
- to specify the graphic aspects of the curves.**

### **1.3**

#### **Other sources of information**

**Only basic handling will be presented here; for a more precise description of functionalities of Grace, the reader will refer to the user guide (in English): <http://plasma-gate.weizmann.ac.il/Grace/doc/UsersGuide.html>**

*A FAQ is diponible on the site of Grace: <http://plasma-gate.weizmann.ac.il/Grace/doc/FAQ.html>*

**2**

## ***Creation/importation of data***

*This paragraph describes the part “given” of Grace. There are three ways of obtaining data to be traced in Grace:*

- by importation of data in files;*
- by creation of data (via sampled mathematical functions);*
- by duplication and modification of existing data.*

### ***2.1 Importation***

*Grace is able to import curves starting from textual files. These files should not contain that data (except for lines starting with # which are regarded as lines comments).*

*The data must be in column (separated by spaces or tabulation characters). Attention, a file can contain one “storage block”, i.e of the data on several columns and several lines (contrary to the files .dogr previously used by the Agraf tool).*

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*Grace can read the various columns in the form:*

- only one curve (“individual set”): XY, Grace takes column 1 for X and column 2 for y; or well a curve XYDX, Grace takes X then in column 1, y in column 2 and dx (uncertainty on X) in column 3; multiples types of curves are envisaged;*
- several curves which shares the same X-coordinates (“NXY”): column 1 contains the X-coordinates common to all the curves; the columns (i+1) the ordinates of the curve (I) contain.*
- several curves with X-coordinates potentially different (“block dated”): one interface opens to define the number of column where are arranged X-coordinates or ordered of each curve - an entry “index” allows to define a curve more ((1, y1), (2, y2),..., (N, yn)) -.*

*In practice, the importation is done starting from the menu “Dated/Import/Ascii...”, who opens the window of dialogue above. One notes:*

- the part “selector of file” in top;*
- the possibility of sending the data imported on the graph of its choice (cf further the organization from Grace in graphs and curves): “Read to graph”*
- selection of the type of importation (“Load have” and “standard Set”). In the case of an importation in the form of “block dated”, afterwards validation by “ok”, Grace analyzes the file and a news fenestrate opens which makes it possible to affect the various columns. One will notice that in top of this window, Grace indicates the number*

*columns and lines which it found in the file. One will note also that one can define the type of the curve by “standard Set”. Lastly, the difference between the button “apply” and “accept” is interesting to know: “apply” load the curve while leaving limp of dialogue open (to be used if the user has several curves to be imported of the same file), while " accept " load the curve and firm limps it of dialogue (to be used for the importation of only one curve starting from the same file).*

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*2.2  
Creation of data per mathematical function*

*To define a curve, enchainner is needed the following orders:*

- *Edit/Dated sets...*
- *Right Clic in the zone in lower part of “Dated sets”;*
- *Chosir “Create New/By Formula”, which opens limps it following, that should be filled. By example, to trace  $\sin(X) + 2.5$  from -10 to 10 in 100 steps;*
- *After “Accept” then “Closed”, possibly button “Autoscale” (tool (see paragraph [§5] detailing the bar of tool of Grace) “ACE” on the right of the magnifying glass of the zoom) to post the curve with the good scale.*

*One can also use tests (use of the characters “?” equivalent of a “then” and”: “equivalent of a “else”) in the formulas, as on the following examples:*

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***One can also use symbol pi:***

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**2.3**

## ***Duplication and modification of existing data***

***Let us suppose that Grace has already the following curve:***

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***To duplicate/modify a curve, there are two solutions. Some it is the adopted solution is necessary to open the operator console. With the first solution, one starts by duplicating the curve to modify it in the operator console; with the second, all is done in the console of order.***

### ***2.3.1 Duplication then modification in the console***

***It is supposed that there is at least a curve available in Grace.***

***The sequence of orders is as follows:***

- Edit/Set Operations,***
- to select G0 like graph to be copied, S0 like curve to be copied and G0 like graph of destination and “Copy” like operation to be carried out, finally “accept”,***
- it is now necessary to modify the column Y of the set S1; that is done by opening the console of order: Window/Commands, and to type “s1.y = s0.y^2” to obtain the preceding curve squared (cf [§5.4] of User' S Guides for a complete list of the authorized operations).***

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### ***2.3.2 creation in the console***

***One opens the operator console immediately: Window/Commands.***

- One creates initially the curve by specifying the number of points (identical to the number of points set S0) “s1 length s0.length”,***
- then one duplicates the X-coordinates “s1.x = s0.x”,***
- finally one defines the ordinates “s1.y = s0.y^2”***

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3

***Organization of Grace in graphs and curves***

**3.1 General**

***For Grace, a graph is a graph which can contain several curves, a “project” Grace (being able to be safeguarded in a file carrying the extension “agr) can contain several graphs.***

***The graphs are named G0, G1,...***

***The curves are named S0, S1,...***

3.2

***Management of the graphs***

***The user can manage the graphs in each list of selection of graphs (for example in menus Edict/Arranges Graphs, Edit/Set Operations, Edit/Overlay Graphs, Plot/Graph Appearance as on the illustration below or Dated/Import/Ascii).***

***In the zone in lower part of “Graph”, one finds a list of graphs here (, the project comprises two graphs, the first including/understanding three curve, the second including/understanding only one curve). It will be noted***

***“(–)” in front of the first graph, which means that the first graph “is hidden” (hidden, i.e not posted), while it (+) in front of the second means that it is posted (showed). Graphs put in intensified brightness are the graphs concerned with the action in progress: here, modification of the***

## **graph**

*relate to G0 (even if it is hidden!). In the same way, with the importation of a curve:*

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*the curve which the user prepares to import will go in the G0 graph (like previously, if graph being hidden, the imported curve will not be posted).*

*In certain menus (Stud/Graph Appearance for example), it is possible to select several graphs (in a usual way: Left Ctrl + click for a selection of graph “one by one” or Shift + left click on the first and last element of a contiguous list or left click + displacement of mouse on a list....), while other menus (Dated/Import/Ascii for example) authorizes only one only selected graph.*

*An order important (and not very intuitive) is the right click on the list of the graphs, which opens a menu comprising the following orders:*

- x-ray to: to define the active graph (useful if several graphs are posted: the active graph is that which receives the actions when the user uses the icons, in the same way to manage them curves of a graph, it is necessary that the graph is the active graph);*
- hide: hide the graph;*
- show: post the graph;*
- duplicate: duplicate the graph and all its curves;*
- kill: destroyed the graph;*

- *swap: exchange two graphs (one needs two graphs placed in intensified brightness);*
- *create new: create a new graph (vacuum).*

*In short, to create a new graph, it is necessary to open the list of the graphs (while using for example Stud/Graph Appearance), to click on the right on the list of the graphs and to choose “Create New”). One will note that there is not menu making it possible to make this action directly.*

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*3.3*

*Management of the curves*

*The principle of management of the curves is about the same one as that concerning the graphs. Grace*

*post the list of the curves (active graph: attention, once again, the active graph is not inevitably visible!) in the menus which handles the curves: Edict/Dated Sets, Edit/Set Operations, Dated/Data set operations, Plot/Set Appearance as on the following illustration:*

*The active graph is G0 here (he is recalled in prefix of the curves in the list), he has three curves (one will note the mention, between hook, behind the name of the curves of dimension here 2 for X and Y and the length here, the curves have all 150 points -).*

*In the list of the curves, right click opens a menu:*

- *hide: hiding place the curve;*
- *show: post the curve;*
- *bring to face: put the curve at the foreground;*
- *send to back: put the curve at the background;*
- *duplicate: duplicate the curve;*
- *kill: remove the curve;*
- *kill dated: remove the data but not the curve, i.e all working is preserved, what can be very practical if the user has two identical graphs to realize from different data: it is enough to create a graph, then to remove all the data with "kill dated ", to import the second set of data: the two graphs will have the same one exactly aspect;*
- *swap: exchange the position of the two curves*
- *edict: publish the data;*
- *create new: create a new curve;*
- *pack all sets: ?*
- *selector operations: left preferably menu for the posting of this list of curves.*

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*Note:*

*All the preceding operations on the curves are done inside the same graph. In case where the user would need to copy a curve of a graph from another, it is necessary to use it small Edict/Set Operations.*

## **4** ***Working of the graphs and the curves***

### **4.1** ***Provision of graphs on a page***

***Grace makes it possible to post several graphs on a page. The menu which manages this function is Edict/Arranges Graphs:***

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***The choices above indicate to trace a matrix of (2x2) graphs (more of the options concerning the order of classification of the graphs and various margins), which makes it possible to obtain a page of form:***

## **4.2**

## ***Working of the graphs***

***The small Stud/Graph Appearance makes it possible to define working of the graphs, i.e all the settings in forms common to all the curves of the graph, out the definition of the axes, which is accessible by Stud/Properties Axis.***

***One is satisfied here with a summary description, for more advanced functions, simplest is to undoubtedly traverse directly the mitres of the window of dialogue of Stud/Graph Appearance.***

***To put a title at a graph, the text of the title is to be put in the mitre Main, the size of characters being able to be regulated in the mitre.***

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***The decision to post or not a legend is given in the mitre Main, the position of limps of caption being defined in the Leg mitre. Box, the size of the caracatères used is specified in the mitre Legend. The text of legend, definite curves by curve, will be seen further.***

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*For the axes (thus the small Stud/Properties Axis), one is also satisfied with the orders more current. First of all it is necessary to note in limps of dialogue opened by Plot/Axis Properties it drop-down menu which makes it possible to define the axis which one is modifying (X axis, Y axis, ...). In this one limps can choose the values of beginning and end of the axis (by the fields Start and End), thus that the type of graduation (linear, algorithmic, etc).*

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*One can give a title (label) to the axes in the mitre Main, the size of the characters like their orientation being defined in the mitre “Axis label & bar”.*

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***The great graduations (Major spacing, which is provided with an indication of value) and the small ones***

***(minor ticks, which is only one feature) are also defined in the Main mitre; it should be noted that definition of the great graduations is made in the unit of the axes (for example put 10 for an axis going from 0 to 100 to number of 10 into 10) while the small ones are in a number of subdivision between each great graduation (for example to put 9 to graduate the preceding subdivisions of 10 all the 1 or 1 to graduate all the 5): to see following illustrations. The way of registering the values correspondent with each great graduation is defined in Tick labels, the way of tracing the large ones and small graduations being indicated in Tick marks.***

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## 4.3

### **Working of the curves**

*Working of the curve is controlled starting from small Plot/Set Appearance. In limps of dialogue opened by this menu, there is first of all a list of the curves contained in the graph running, which makes it possible to select the curve which one publishes the properties.*

*To attach a legend to a curve, it is necessary to define the text of the legend in the Main mitre (Legend, String). It will be noted that it is possible to carry out complex legends.*

*One can choose the style of line, his color and his thickness as well as the symbols used for to materialize each point in the mitre Hand (Line Properties and Symbol Properties). Definitions more precise can be added in the mitres Line and Symbols respectively.*

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**5**

***Use of the bar of tool***

*The bar of tool vertically posts in top on the left Grace window:*

- *The magnifying glass allows zoomer by defining a zone in the mouse;*
- *The icon “HAVE” (for autoscale), allows to redefine framing (zoom) automatically.*

- Buttons “Z” and “Z” are used for die-zoomer and zoomer respectively.
- The arrows are used to move the traced zone.
- AutoT: automatic definition of the graduations starting from the curve more near to the clicked point.
- AutoO: automatic framing starting from the curve nearest to the point clicked
- ZX, ZY: like the magnifying glass but in only one direction (X or Y)
- AX, AY: automatic framing in only one direction (X or Y)

The other buttons relate to the management of the pile of graphs and will not be explained here.

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**6**

***Tricks and easy ways***

**6.1**

***Extended characters, in particular Greek alphabet***

*It is possible to use other pig iron and cast iron of characters that the standard cast iron in any zone of text*

*(legend of curve, label of axes, etc...). In particular, it is possible to use the cast iron “Symbol” for to insert Greek characters.*

*For that, if in the field "String" of the legend one puts the chains following "test \ F {Symbol} test \ F {Arial} test ", like that:*

*one obtains a legend which resembles that (the order \ F {X} changing the cast iron)*

*One will find in User' S Guide in the paragraph the 7.1 various orders allowing of to control working of the zones of text (in particular pig iron and cast iron, size, the color, etc) and with paragraph [§6.1] the mechanism of definition of different the pig iron and cast iron usable by Grace.*

## **6.2**

### **Not or comma?**

*By defect, Grace is based on the environment user to know if it must represent the figures decimal with a point or a comma. On the majority of the recent systems, in France, it will use thus the comma. If it is necessary to print curves with points, under linux, it is necessary to make following handling: before launching Grace, making "export LC\_NUMERIC=POSIX" or "setenv LC\_NUMERIC POSIX " following Shell used.*

## **6.3 Batch**

*It is possible to do without the graphic interface, in particular for the repetitive tasks, one will find examples of the use of the batch in the turorial:*

*<http://plasma-gate.weizmann.ac.il/Grace/doc/Tutorial.html>*

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### **Version**

**7.4**

### **Titrate:**

**Layout of curves with Code\_Aster**

### **Date:**

**26/05/05**

### **Author (S):**

**Key COURTEOUS Mr.**

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**Summary:**

**This document explains how, starting from a computation result, one can produce tables or functions, to extract the values from these tables or functions, to handle them, and finally lastly to use the orders of impression to plot curves.**

**If you have of a function or a table and that you wish simply to represent it in form from a curve, go directly in the paragraph [[§ 4](#)], and [consult documentations of IMPR\\_FONCTION \[U4.33.01\] and of IMPR\\_TABLE \[U4.91.03\]](#).**

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### ***Notice preliminary***

***Postprocessing must be carried out in CONTINUATION and not following calculation.***

***Several reasons with that:***

- in the event of error, one does not lose the hours of calculation which made it possible to reach it result,***
- one can carry out many postprocessings directly while launching Stanley on the base result of calculation (see astk [U1.04.00] or STANLEY [U4.81.31]),***
- to simplify postprocessing, one can use the possibilities offered by Python who require to be in PAR\_LOT='NON' in CONTINUATION what prevents the use of eficas for this type of postprocessing, whereas it is simpler to use eficas to build the principal data file.***

## ***1***

***To extract the data using the orders Aster***

***It is supposed that the user has a computation result obtained to leave, for example, order MODE\_ITER\_SIMULT for a calculation of clean modes, STAT\_NON\_LINE for a calculation nonlinear statics, or DYNA\_NON\_LINE for a nonlinear dynamic calculation...***

***One has in all the cases a concept result which will be for example of mode\_meca type, mode\_flamb, dyna\_trans, tran\_gene, evol\_elas, evol\_noli, evol\_ther, etc according to order used and which contains fields of values that one wishes to represent in the form of curves.***

## ***1.1***

***To produce a function or a table***

## **Recall**

*A function is made up of two lists of values, X-coordinates and ordered; X-coordinates are necessarily monotonous.*

*A table is not necessarily a standard agglomerate of values in the same way to which one reaches via a parameter, "name of column". In the use of the tables which us interest here, one will generally produce columns of real numbers; their variation is unspecified.*

*For more details on than is a table, one will be able to consult the documentation of IMPR\_TABLE [U4.91.03].*

*The values can be extracted by using the following orders:*

- RECU\_FONCTION [U4.32.03]: product a function starting from a result, of a field, one count... Example: temporal evolution of a component of a field in a particular point.*
- POST\_RELEVE\_T [U4.81.21]: product a table starting from a result or of a field. One can to extract a quantity associated with the components from a field (a component, one invariant...) in certain particular points or along a way not necessarily rectilinear.*
- MACR\_LIGN\_COUPE [U4.81.13]: product a table starting from a result or of a field length of a line of cut (straight line made up of regular segments).*
- RECU\_TABLE [U4.71.02]: product a table starting from the values of one or more parameters of a result. For example: evolution of the parameter of piloting during a calculation. One can also to extract a table from some structures of particular data.*
- CREA\_CHAMP [U4.72.04]: allows to extract a field from a structure of data result. This can be useful when an order cannot treat certain results. One can by example then to recover a function via RECU\_FONCTION/CHAM\_GD.*

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**1.2**

**To treat storage blocks**

**A storage block is simply a table of values to NR lines, P columns.**

**In certain cases, one lays out of one or more files made up each one of one or more blocks of data, separated by lines from text. To build functions starting from such files, one can use LIRE\_FONCTION [U4.32.02].**

**For example, one carries out a parametric study, each calculation produces a table which comes to enrich**

**a file of result; the file can also be built by a single calculation or manually, it does not matter. Such a file could resemble that:**

**WITH PARA=1.23**

**INST COOR\_X DY**

**1.00000E+00 1.00000E+01 -3.02717E-2**

**1.20000E+00 1.00000E+01 -8.14498E-2**

**1.40000E+00 1.00000E+01 -7.97278E-2**

**1.60000E+00 1.00000E+01 -3.86827E-2**

**1.80000E+00 1.00000E+01 -8.48309E-2**

**2.00000E+00 1.00000E+01 -9.37561E-2**

**2.20000E+00 1.00000E+01 7.18293E-2**

**2.40000E+00 1.00000E+01 6.05322E-2**

**WITH PARA=1.98**

**INST COOR\_X COOR\_Y DX DY**

**1.00000E+00 1.00000E+01 0.00000E+00 -3.02717E-2 2.07127E-01**

**1.10000E+00 1.00000E+01 0.00000E+00 -8.14498E-2 4.14928E-01**

**1.20000E+00 1.00000E+01 0.00000E+00 -7.97278E-2 7.92728E-01**

**1.80000E+00 1.00000E+01 0.00000E+00 -7.86827E-2 6.88227E-01**

**2.45000E+00 1.00000E+01 0.00000E+00 8.48309E-2 3.43029E-01**

**There are several blocks which inevitably do not have the same number of columns.**

**Let us suppose that one wants to compare displacement DY obtained with the two values of PARA, one**

**will use for example:**

**fDY1=LIRE\_FONCTION (**  
**TYPE=' FONCTION',**  
**INDIC\_PARA= (1,1,), # the X-coordinates are taken in block 1, column 1**  
**INDIC\_RESU= (1,3,), # the ordinates are taken in block 1, column 3**  
**UNITE=38,**  
**NOM\_PARA=' INST',**  
**NOM\_RESU=' DY',)**

**fDY2=LIRE\_FONCTION (**  
**TYPE=' FONCTION',**  
**INDIC\_PARA= (2,1,), # the X-coordinates are taken in block 2, column 1**  
**INDIC\_RESU= (2,5,), # the X-coordinates are taken in block 2, column 5**  
**UNITE=38,**  
**NOM\_PARA=' INST',**  
**NOM\_RESU=' DY',)**

**# traced traditional of two functions with IMPR\_FONCTION:**

**IMPR\_FONCTION (FORMAT=' XMGRACE',**  
**UNITE=29,**  
**COURBE= (\_F (FONCTION=fDY1,**  
**LEGENDE=' PARA=1.23',),**  
**\_F (FONCTION=fDY2,**  
**LEGENDE=' PARA=1.98',),),**  
**TITRE=' DY=f (T) ',)**

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*To transform the values of a table or a function into python objects*

*Notice*

*The treatments in Python which are used from now force to be in PAR\_LOT='NON' in CONTINUATION (or BEGINNING).*

*The object is here to recover the values of a table or a function in a Python object for to handle then. Let us note that it is sometimes practical to produce a function starting from the data of a table, by filtering possibly certain lines of the table; it is a use of RECU\_FONCTION [U4.32.03], which we will not approach here.*

*On the objects of the function type, one has the methods:*

- Valeurs to recover the X-coordinates and the ordinates in 2 lists Python of realities.*

*With the data of the preceding paragraph:*

```
>>> lx, ly = fDY2.Valeurs ()
```

*One obtains:*

```
>>> print lx
```

```
[1.0, 1.1, 1.2, 1.8, 2.45]
```

```
>>> print ly
```

```
[0.207127, 0.414928, 0.792728, 0.688227, 0.343029]
```

- Absc and Ordo makes it possible to recover the X-coordinates and the ordinates separately.*

```
>>> lx = fDY2.Absc ()
```

```
>>> ly = fDY2.Ordo ()
```

*One can reach the contents of a cell of a table with [nom\_parameter, numéro\_ligne]:*

```
>>> print ["DY", 2]
```

```
-8.14498E-2
```

*One can also transform object (JEVEUX) table into an authority of the Python class Counts.*

```
>>> tabpy = tab.EXTR_TABLE ()
```

*The document [U1.03.02] details the Python methods available on the objects of the Table type. For the extraction of the values, one has in particular a method been worth () which turns over a dictionary*

*whose keys are the names of parameters (ex "DY") and the values the lists of the values of the table.*

*Caution*

*The Python lists are indexed of 0 with n-1 (for N elements), the equivalent of ["DY", 2] is thus tabpy ["DY"] [1]!*

*For the layout of curves starting from lists of real Python, to see [[§ 4](#)].*

### *3*

#### *To handle the values in Python*

*One gives here some examples of handling of the values obtained previously in the form of lists or of Numeric tables.*

*Numeric is optional a Python module (i.e. not included with the distribution of Python provided on [www.python.org](http://www.python.org), will be it perhaps in Python 2.5) but essential to use Code\_Aster, one can thus to make Numeric importation on all installations of Code\_Aster.*

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### *3.1*

*With lists Python*

*The Python lists are easily easy to handle by using the loops. Let us take the example of the note [U2.51.01] for  $10. < X < 10.$  in 100 steps:*

*y = -1.5*

*if sin (X) <0*

*y = -5.*

*if not*

*One thus seeks to build two lists of realities, lx and ly.*

*As always in Python, it is possible several to make, more or less simply, more or less elegantly!*

```
x0=-10.
pas=20. /100
lx= []
or
lx= [x0+i*pas for I in arranges (101)]
for I in arranges (101):
lx.append (x0+i*pas)
```

```
def F (X):
yew sin (X) <0.:
return -1.5
else:
return -5.
```

```
ly=map (F, lx)
who applies the function F to all the elements of lx
```

*One can plot this curve by using the key words X-COORDINATE and ORDINATE of IMPR\_FONCTION ([cf \[§ 4\]](#)).*

### 3.2

*With Numeric tables*

*The handling of the data in the form of Numeric tables is simplified by the use very powerful operations (called ufunc) on the whole table (in the following example one uses sin ()). Numeric also manages the tables with several dimensions.*

*By taking again the preceding example:*

```
from Numeric import *
lx = arrayrange (- 10. , 10.+0.2, 0.2, Float)
ly = array (map (F, lx))
```

*or without using F:*

```
ly = -1.5*less (sin (lx), 0.) + (- 5.)* (1. - less (sin (lx), 0.))
```

*Let us note that map () turns over a list and not a Numeric table. The second expression is between*

*10 and 20 times faster on very large tables (105 106 terms), which is however rather little often the case of the functions or tables resulting from Aster.*

*One can plot this curve by using the key words X-COORDINATE and ORDINATE of IMPR\_FONCTION in*

*taking care to convert Numeric tables into list, for example (cf [[§ 4](#)]):*

*X-COORDINATE = lx.tolist ()*

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*4*

*Examples of use of IMPR\_FONCTION/IMPR\_TABLE*

*4.1*

*Function rebuilt starting from two lists Python*

*Example where one readjusts the results obtained to be able to compare them with a reference solution*

*(the X-coordinates are reversed, it is necessary to compare the absolute value, [SSLS501a]), the methods are used*

*allowing to extract the X-coordinates and the ordinates from a function:*

*IMPR\_FONCTION (FORMAT=' XMGRACE',*

*UNITE=53,*

*COURBE=\_F (ABSCISSE= [57766.1-x for X in MTAST.Absc ()],*

**ORDONNEE= [ABS (y) for y in MTASt.Ordo ()],),**  
**TITRE=' Curves recalée',**  
**LEGENDE\_X=' P2',**  
**LEGENDE\_Y=' MT',)**

## 4.2

### *Layout of a result according to an other*

*This example is extracted partly from the case-test [FORMA03a], it acts of a plate perforated in traction.*

*After a calculation carried out with STAT\_NON\_LINE, one wishes to trace the effort resulting from traction in*

*function of the average vertical displacement of the higher part of the test-tube.*

*Details of postprocessing:*

**CONTINUATION ()**

**SOLNL2=CALC\_NO (Calculation of the nodal forces**  
**reuse = SOLNL2, RESULT = SOLNL2,**  
**OPTION = "FORC\_NODA",)**

**M=DEFI\_GROUP (Definition of the group of nodes of**  
**reuse=M, examination, the higher line of the plate**

**MAILLAGE=M,**

**CREA\_GROUP\_NO=\_F (GROUP\_MA = "LFG",**  
**NAME = "LINE",),**

**)**

**tab=POST\_RELEVE\_T (**

**ACTION= (**

**\_F (ENTITLES = "Umoyen", Relevé of average displacement to all them**

**RESULT = SOLNL2, moments of calculation**

**NOM\_CHAM = "DEPL",**

**NOM\_CMP = "DY",**

**TOUT\_ORDRE = "YES",**

**GROUP\_NO = "LINE",**

**OPERATION = "AVERAGE",**

**),**

**\_F (ENTITLES = "Fresultante", Relevé of the resulting effort**

**RESULT = SOLNL2,**

**NOM\_CHAM = "FORC\_NODA",**

**TOUT\_ORDRE = "YES",**

**GROUP\_NO = "LINE",**

**RESULTANT = “DY”,  
OPERATION = “EXTRACTION”,),),)**

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*IMPR\_TABLE (TABLE=tab,) Just to locate the name of the parameters*

*Contents (partial, limited to the first 3 moments) of the table:*

*ENTITLE NODE RESU NOM\_CHAM NUME\_ORDRE INST DY SIYY QUANTITY*

*Umoyen - SOLNL2 DEPL 1 1.00000E+00 2.38745E-02 - MOMENT\_0*

*Umoyen - SOLNL2 DEPL 1 1.00000E+00 -3.70291E-04 - MOMENT\_1*

*Umoyen - SOLNL2 DEPL 1 1.00000E+00 2.36709E-02 - MINIMUM*

*Umoyen - SOLNL2 DEPL 1 1.00000E+00 2.40291E-02 - MAXIMUM*

*Umoyen - SOLNL2 DEPL 1 1.00000E+00 2.40597E-02 - MOYE\_INT*

*Umoyen - SOLNL2 DEPL 1 1.00000E+00 2.36894E-02 - MOYE\_EXT*

*Umoyen - SOLNL2 DEPL 2 1.20000E+00 2.86494E-02 - MOMENT\_0*

*Umoyen - SOLNL2 DEPL 2 1.20000E+00 -4.44349E-04 - MOMENT\_1*

*Umoyen - SOLNL2 DEPL 2 1.20000E+00 2.84050E-02 - MINIMUM*

*Umoyen - SOLNL2 DEPL 2 1.20000E+00 2.88350E-02 - MAXIMUM*

*Umoyen - SOLNL2 DEPL 2 1.20000E+00 2.88716E-02 - MOYE\_INT*

*Umoyen - SOLNL2 DEPL 2 1.20000E+00 2.84273E-02 - MOYE\_EXT*

*Umoyen - SOLNL2 DEPL 3 1.40000E+00 3.34244E-02 - MOMENT\_0*

*Umoyen - SOLNL2 DEPL 3 1.40000E+00 -5.18504E-04 - MOMENT\_1*

*Umoyen - SOLNL2 DEPL 3 1.40000E+00 3.31393E-02 - MINIMUM*

*Umoyen - SOLNL2 DEPL 3 1.40000E+00 3.36410E-02 - MAXIMUM*

*Umoyen - SOLNL2 DEPL 3 1.40000E+00 3.36837E-02 - MOYE\_INT*

*Umoyen - SOLNL2 DEPL 3 1.40000E+00 3.31652E-02 - MOYE\_EXT*

*[...]*

*Fresultante - SOLNL2 FORC\_NODA 1 1.00000E+00 2.50000E+03 - -*

*Fresultante - SOLNL2 FORC\_NODA 2 1.20000E+00 3.00000E+03 - -*

*Fresultante - SOLNL2 FORC\_NODA 3 1.40000E+00 3.50000E+03 - -  
[...]*

*Dy=RECU\_FONCTION (Filtering of the table from it to extract Dy=f(T)  
COUNT =,  
PARA\_X = "INST",  
PARA\_Y = "DY",  
FILTER = (  
\_F (NOM\_PARA = "ENTITLES",  
VALE\_K = "Umoyen",),  
\_F (NOM\_PARA = "QUANTITY",  
VALE\_K = "MOMENT\_0",),),)*

*Fy=RECU\_FONCTION (Filtering of the table from it to extract Fy=f(T)  
COUNT =,  
PARA\_X = "INST",  
PARA\_Y = "DY",  
FILTER = (  
\_F (NOM\_PARA = "ENTITLES",  
VALE\_K = "Fresultante",),),)*

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*IMPR\_FONCTION (Traced ordinates of Fy according to*

*Dy*

*UNIT = 29,*

*FORMAT = "XMGRACE",  
CURVE = (  
\_F (FONC\_X = Dy,  
FONC\_Y = Fy),),  
TITRATE = "Plate perforated in traction",  
LEGENDE\_X = "average Displacement",  
LEGENDE\_Y = "resulting Effort",)*

*What gives us the following curve:*

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## ***4.3***

### ***Layout of a great number of curves***

*In certain applications, one is brought to plot many curves. Let us suppose that one wish to compare our results with 50 points of measurement obtained in addition. It would be then tiresome of to define 50 files in astk and to use 50 different logical units in the command file! It is then enough to use the type "repe" in result in astk (cf [U1.04.00]):*

*One proceeds then thus in the command file in PAR\_LOT='NON' in CONTINUATION:*

*# definition of the 50 groups of nodes of examination*

*lgrno = ["point01", "point02", ..., "point50"]*

*# for each node of examination...*

*for not in lgrno:*

*links = 29*

*# the DEPL\_point0i.dat files will be recopied in curved Resultats/*

*DEFI\_FICHER (UNITE=unit, FICHER= `./REPE\_OUT/DEPL\_ "+point+" .dat')*

*tab=POST\_RELEVE\_T (*

*ACTION=\_F (ENTITLES = "VonMises",*

*RESULT = resM,*

*NOM\_CHAM = "EQUI\_ELNO\_SIGM",*

*NOM\_CMP = "VMIS",*

*TOUT\_ORDRE = "YES",*

*GROUP\_NO = not,*

*OPERATION = "EXTRACTION",),)*

*IMPR\_TABLE (*

*UNIT = links,*

*COUNT =,*

*FORMAT = "XMGRACE",*

*NOM\_PARA = ("INST", "VMIS"),)*

*# one "releases" the unit to re-use it for the following curve*

*DEFI\_FICHER (UNITE=unit, ACTION= `LIBERER')*

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*Some useful easy ways*

*One proposes here some handling of the data of the recurring tables in Python when of one wants to go further in the generation of curves since Code\_Aster.*

***To extract from the table resulting from POST\_RELEVE\_T the list from the nodes from postprocessing:***

*When one post-draft a size on a group of nodes (with more than one node) for several moments, the nodes appear for each moment, it is thus necessary to extract the list from these nodes without repetition.*

```
tabpy = tab.EXTR_TABLE ()
```

*Creation of the object Counts Python*

```
tno = tabpy.NOEUD.values ()
```

*One extracts the values from the column NODE*

```
lno = dict ([(i.strip (), 0) for I in tno]) .keys ()
```

*Powerful method to eliminate them*

*let us double with a dictionary*

```
lno.sort ()
```

*Sorting by ascending order*

***To build one or more key words dynamically:***

*This can in particular be useful to inform the key word factor FILTERS IMPR\_TABLE in function context; one builds in this case a dictionary which is then provided in argument of order.*

*This:*

```
IMPR_TABLE (
```

```
UNIT = links,
```

```
COUNT =,
```

```
FORMAT = "XMGRACE",
```

```
FILTER = (_F (NOM_PARA=' NOEUD',
```

```
VALE_K = "N4"),
```

```
_F (NOM_PARA='NOEUD',  
VALE_K = "N4",),),  
NOM_PARA = ("INST", "VMIS"),  
)
```

*is equivalent to that:*

```
mfac = {"FILTER": [{"NOM_PARA": "NODE", "VALE_K": "N4"},  
{"NOM_PARA": "ENTITLES", "VALE_K": "example"},],  
"NOM_PARA": ["INST", "VMIS"],  
"UNIT": links,  
"FORMAT": "XMGRACE",}
```

```
IMPR_TABLE (  
COUNT =,  
** mfac  
)
```

*The interest being of course to be able to build the dictionary as one wishes it.*

### **Notice**

*The key words factors (here FILTER) can be built by using *\_F* (mot-clé = value), but it is more flexible to see them like a list of dictionaries.*

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*Organization (S): EDF-R & D /AMA*

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U3.0- booklet: Grid  
Document: U3.01.00***

***Description of the file of grid of Code\_Aster***

***Summary:***

***This file makes it possible to describe a grid of Code\_Aster. It can be built by an automatic interface between a maillor and the code, but can also be written with the hand. It contains:***

***.  
a possible title,***

***.  
a list of nodes with their co-ordinates,***

***.  
lists of meshes, each mesh is described by the list of the nodes which defines its topology, and sound orientation,***

***.  
groups of nodes and groups of meshes.***

***Note:***

***A concept of the grid type, once read on the file of grid, can be enriched using operators of Code\_Aster by information which cannot be currently described in the file of grid. This relates to in particular the static under-structuring. It is of more possible, now, of***

*to create groups of nodes or meshes under study.*

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*Version*

*7.4*

*Titrate:*

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*Date:*

*06/06/05*

*Author (S):*

*J. Key PELLET*

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*1*

*Structure of the file of grid*

*The file of Aster grid is read first line until the first occurrence of a line begin with the FINE word. This key word is obligatory.*

*The file of Aster grid consists of a succession of under files of grid, independent.*

*UNDER FILE 1*

*UNDER FILE 2*

*UNDER FILE NR*

*END*

*The file of Aster grid is a file with format, within the meaning of FORTRAN:*

.  
*the length of line is limited to 80 characters (any information starting from column 81 is simply been unaware of);*

.  
*the 26 tiny a-z are converted automatically in capital letters,*

.  
*the white character ““and the comma”,” are only the recognized separators,*

.  
*the character % is a character reserved to indicate the beginning, until the end of the line, of one comment,*

.  
*the numerical data are interpreted in free format:*

*1 = 1. = 1.0 = 1.E+0 = .1E1 = 10.D-1*

*The file grid must contain at least:*

.  
*a subfile of co-ordinates of nodes COOR\_2D or COOR\_3D, defined by 2 or 3 numbers realities in a single orthonormé Cartesian reference mark.*

.  
*a subfile by type of mesh used.*

*It can contain, moreover, and that is recommended, a subfile TITRATES. It is practically essential to define, at the time of the grid, the subfiles of groups of meshes GROUP\_MA and of the subfiles of groups of nodes GROUP\_NO.*

*It will be retained that the assignment of a type of finite element, can be done only on one mesh (or exceptionally on a node for the discrete elements) described in the file grid.*

*loadings or the boundary conditions are affected on meshes or nodes according to case.*

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**2**  
**Structure of under file**

**Under file starts with a key word and is finished by the key word imposed FINSF:**

**KEY WORD**  
.....  
.....  
**FINSF**

**This description is sufficient for Aster. The most complete description is as follows:**

**.**  
**each under file comprises 3 parts:**

- 1) the heading of under file,**
- 2) contents of information,**
- 3) the end mark of under file (FINSF).**

**KEY WORD NOM= NBOBJ= NBLIGE= NBLIGT=**

**NUMIN= NUMAX=**

**1**

**AUTEUR= DATE=**  
**XX/XX/XX**  
**%**  
**COMMENTS**

**2**  
**---- INFORMATION ----**

### 3

#### **FINSF**

%

.

*The **KEY WORD** and **FINSF** (fine of under file) are obligatory because they delimit under file with interior of the file of grid.*

.

*The **NAME** is optional. When the key word is **GROUP\_MA** or **GROUP\_NO**, if **NAME** misses then the first character string met after these **KEY WORDS** will form the **NAME** of **GROUP\_MA** or of the **GROUP\_NO**.*

*By convention any character string which follows the characters % is interpreted like one comment.*

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#### **2.1 The heading**

*The role of the heading is to provide total information on the contents of under file:*

***KEY WORD:** in addition to its role of delimiter of under file it informs about the nature of information which will follow. It must be in 1st line of under file **and tallied on the left.***

## **NAME:**

*it is used to indicate a whole of information. It must be in 1st line of the heading of under file. It is optional.*

*all the other key words are currently ignored by the operator  
LIRE\_MAILLAGE [U4.21.01].*

## **2.2**

### **List information**

*They are the information resulting from a maillor and written in free format.  
Information which this file must contain defines of the traditional entities of the method of finite elements:*

.

#### **nodes:**

*points defined by a **name** and their **Cartesian co-ordinates** in space **2D** or **3D**,*

.

#### **meshs:**

*plane or voluminal **named** topological figures (not, segment, triangle, quadrangle, tetrahedron,...), defined by the ordered list of the nodes who constitute them and to whom will be able to apply various types finite elements, boundary conditions or loadings. The order of nodes directs the mesh. This orientation must be scrupulously established because it is in particular used to lay down the orientation of the loadings (pressure,...).*

*One can also define groups of these topological entities.*

.

***groups of nodes:** named lists of names of nodes,*

.

***groups of meshs:** named lists of names of meshs.*

*Systematically, when one has to refer to nodes (or meshs), one will be able to make reference to groups of nodes (or groups of meshs).*

*The interfaces with the mailleurs automatically generate such groups (according to criteria clean with the maillor).*

*These groups facilitate the assignment of the material characteristics on the grid, of the conditions with the limits or the impression of the results. Indeed, at the time of such operations one refers to the nodes*

or with the meshes, which it is interesting to describe by group.

The operator of Code\_Aster *DEFI\_GROUP* [U4.22.01] allows to create groups a posteriori on all concept of the grid type already read.

It will be noted, that all entities handled in the code (nodes, meshes, groups of nodes, groups of meshes) **are named** and usable constantly by their name (**8 characters with maximum**). The classification of the entities is never clarified: it is useful only in-house for to point on the values of the various associated variables.

## 2.3

### **END of subfile**

It is word the “reserved” and obligatory *FINSF* which indicates the end of under file, which begin with a *WORD*

*KEY*.

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## 3

**List key words (standard of under files)**

**TITRATE**

*Description of the file grid in documentary matter. Operators of interface with maillors build a title starting from information clean with each maillor*

*/COOR\_3D*

*Description of the nodes by three space co-ordinates:*

.

*name of the node described (or number interpreted like a name),*

.  
3 co-ordinates,  
/  
COOR\_2D  
Description of the nodes by 2 co-ordinates:  
. name of the node described (or number interpreted like a name),  
. 2 co-ordinates,  
/POI1 points  
)  
/  
SEG2/  
SEG3/  
SEG4 segments  
)  
/  
TRIA3  
/  
TRIA6  
/  
TRIA7  
triangles  
)  
/  
QUAD4  
/  
QUAD8  
/  
QUAD9  
quadrangles  
)  
**connectivity**  
/  
HEXA8  
/  
HEXA20  
/  
HEXA27  
hexahedrons  
) of  
**meshs**

/  
*PENTA6*  
/  
*Pentahedral PENTA15)*  
/  
*TETRA4*  
/  
*TETRA10 tetrahedrons)*  
/  
*PYRAM5*  
/  
*PYRAM13 pyramids*  
)

*GROUP\_MA Groups meshes (attention the name is obligatory)*

*GROUP\_NO Groups nodes (attention the name is obligatory)*

***Note:***

.  
*When a key word was read, there remains interpreted until the appearance of FINSF.*

.  
*After a FINSF, any key word not recognized (typing error) is ignored and a message is emitted.*

.  
*COOR\_2D and COOR\_3D are mutually exclusive.*

.  
*The presence of a frame of reference in universal file IDEAS causes a stop IDEAS/Aster interface.*

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**4**

***The description of the meshes***

*Conventions of description of the topology of the meshes in Aster are summarized here. The use meshes is given here as an indication, it is necessary to refer to documentation suitable for each order.*

*Net associated with a **node** (2D or 3D)*

**POI1**

**1**

*Net associated with a **segment** (2D or 3D)*

**SEG2**

**1**  
**2**

**SEG3**

**1**  
**3**  
**2**

**SEG4**

**1**  
**3**  
**4**  
**2**

**Orientation:**

*The orientation is laid down by the order of the nodes tops*

**1**  
**2**

*This orientation is possibly supplemented by characteristics given according to the type of affected finite element on the mesh by the key word factor **ORIENTATION** of operator **AFFE\_CARA\_ELEM** [U4.42.01].*

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**Net associated with a triangle (2D or 3D)**

**3**

**TRIA3**

**1**

**2**

**6**

**3**

**TRIA6**

**5**

**4**

**1**

**2**

**6**

**3**

**TRIA7**

**7**

**5**

4  
1  
2

***Orientation:***

***The orientation is laid down by the order of the nodes tops which are given to define it direct trigonometrical direction.***

***normal external with the mesh***

3  
1  
2

***This orientation is possibly supplemented by characteristics given to elements by operator AFFE\_CARA\_ELEM [U4.42.01], in particular for the elements of hull by the key word factor HULL.***

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***Net associated with a quadrangle***

***(2D or 3D)***

**4**

**3**

***QUAD4***

**1**

**2**

**4**

**7**

**3**

***QUAD8***

**8**

**6**

**5**

**1**

**2**

**4**

**7**

**3**

**8**

***QUAD9***

**9**

**6**

**5**

**1**

**2**

***Orientation:***

***The orientation is laid down by the order of the nodes tops which are given to define it***

***direct trigonometrical direction***

***normal external with the mesh***

***4***  
***3***  
***1***  
***2***

***This orientation is possibly supplemented by characteristics given to elements by operator AFFE\_CARA\_ELEM [U4.42.01], in particular for the elements of hull by the key word factor HULL.***

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***Net associated with a tetrahedron (3D)***

***4***

**TETRA4**

3

1

2

4

10

8

**TETRA10**

9

7

3

1

6

5

2

**Net associated with a pyramid (3D)**

5

4

**PYRAM5**

3

1

2

5

13

4

12

10

11

8

**PYRAM13**

9

1

3

6

7

2

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*Net associated with a pentahedron (3D)*

**6**

**4**

**5**

**PENTA6**

**3**

**1**

**2**

**6**

**15**

**4**

**14**

**12**

**13**

**5**

**PENTA15**

**10**

**9**

**3**

**11**

**8**

**1**

**7**

**2**

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***Net associated with a hexahedron (3D)***

***8***

***5***

***7***

***6***

***4***

***HEXA8***

***1***

***3***

***2***

**20**

**8**

**5**

**19**

**7**

**17**

**6**

**16**

**13**

**HEXA20**

**18**

**4**

**11**

**15**

**12**

**1**

**14**

**3**

**9**

**2**

**10**

**8**

**19**

**20**

**26**

**7**

**5**

**16**

**17**

**18**

**25**

**24**

**15**

**4**

**13**

**22**

**6**

**27**

**11**

**12**

**23**

**14**

**21**

**3**

**1**

**HEXA27**

**9**

**10**

**2**

**8**

**7**

**5**

**25**

**26**

**24**

**4**

**22**

**6**

**11**

**23**

**27**

**21**

**3**

**1**

**2**

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***5***  
***List formats of description***

***We will describe the format of description of information by a continuation of items.***

***5.1***  
***Correspondence Item - Standard FORTRAN***

***NOM\_DE\_NOEUD***  
***CHARACTER\*8***  
***NOM\_DE\_MAILLE***  
***CHARACTER\*8***  
***COORD***  
***REAL\*8***  
***LIGNE\_DE\_TEXTE***  
***CHARACTER\*80***

***5.2***  
***FORMAT of reading associated with the key word***

***FORMATS recognized by Aster***  
***key word***

***(1\*NOM\_DE\_NOEUD, 3\*COORD)***  
***COOR\_3D***  
***(1\*NOM\_DE\_NOEUD, 2\*COORD)***  
***COOR\_2D***  
***(1\*NOM\_DE\_MAILLE, 1\*NOM\_DE\_NOEUD) POI1***  
***(1\*NOM\_DE\_MAILLE, 2\*NOM\_DE\_NOEUD) SEG2***

*(1\*NOM\_DE\_MAILLE, 3\*NOM\_DE\_NOEUD) SEG3, TRIA3*  
*(1\*NOM\_DE\_MAILLE, 4\*NOM\_DE\_NOEUD) QUAD4, TETRA4, SEG4*  
*(1\*NOM\_DE\_MAILLE, 5\*NOM\_DE\_NOEUD) PYRAM5*  
*(1\*NOM\_DE\_MAILLE, 6\*NOM\_DE\_NOEUD) TRIA6, PENTA6*  
*(1\*NOM\_DE\_MAILLE, 7\*NOM\_DE\_NOEUD) TRIA7*  
*(1\*NOM\_DE\_MAILLE, 8\*NOM\_DE\_NOEUD) QUAD8, HEXA8*  
*(1\*NOM\_DE\_MAILLE, 9\*NOM\_DE\_NOEUD) TRIA9*  
*(1\*NOM\_DE\_MAILLE, 10\*NOM\_DE\_NOEUD) TETRA10*  
*(1\*NOM\_DE\_MAILLE, 13\*NOM\_DE\_NOEUD) PYRAM13*  
*(1\*NOM\_DE\_MAILLE, 15\*NOM\_DE\_NOEUD) PENTA15*  
*(1\*NOM\_DE\_MAILLE, 20\*NOM\_DE\_NOEUD) HEXA20*  
*(1\*NOM\_DE\_MAILLE, 27\*NOM\_DE\_NOEUD) HEXA27*  
*(1\*NOM\_DE\_NOEUD) GROUP\_NO*  
*(1\*NOM\_DE\_MAILLE) GROUP\_MA*  
*(LIGNE\_DE\_TEXTE)*  
*TITRATE*

### 5.3

#### *Repetition of the Format*

.

*Any repetition of the format must start at the beginning of line.*

#### *Examples:*

##### *Is ILLICIT:*

*COOR\_2D*

*N1 1.*

2.

*N2 1.*

3.

*FINSF*

##### *Is LICIT:*

*COOR\_2D*

*N1 1.*

2.

*N2 1.*

**3.**  
**FINSF**  
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**6**

**Examples of under file**

**Examples of under files describing the space co-ordinates of 5 nodes expressed in the reference mark total Cartesian basic. Here the contents of information is the same one for the 2 pennies files, it is its mode of representation which differs.**

**6.1**

**File resulting from the interface IDEAS-Aster**

**COORD\_3D NOM=MAILLAGE1**

**NBOBJ=5 NBLIGE=5**

**NBLIGT=12**

**NUMIN=4 NUMAX=14**

**AUTEUR=INTERF\_ST/TF**

**DATE=27/11/89**

**%**

**XMAX=10.0**

**YMAX=20.0**

**ZMAX=0.0**

**%**

**XMIN=0.0**

**YMIN=0.0**

**ZMIN=0.0**

**%FORMAT= (1\*NOM\_DE\_NOEUD, 3\*COORD)**

**NO4**

**0.0 0.0**

**0.0**

**NO7**

**5.0 0.0**

**0.0**

**NO8**

**5.0 5.0**

**0.0**

**NO10**

**10.0 20.0**

**0.0**

**NO14**

**5.0 10.0 0.0**

**FINSF**

**6.2**

**Example illustrating the possible formats of writing**

**TITRATE**

**%**

**it is**

**titrate**

**THAT IT IS BEAUTIFUL MY FILE GRID**

**% self-satisfaction**

**FINSF**

**COORD\_2D %**

**co-ordinates**

**2D**

**%**

**presentation**

**licit**

**but**

**little**

**advisable**

**NOEUD1**

**0**

**0.0**



***NOEUD2***

***1***

***1.D+0***

***NOEUD3***

***2.213564***

***2.32E+00***

***FINSF***

***SEG 2%***

***some***

***meshs***

***MAILLE1 NOEUD1***

***NOEUD2***

***%***

***who***

***suits me***

***MAILLE3 NOEUD2***

***NOEUD3***

***FINSF***

***POI1***

***MAILLE2 NOEUD2***

***FINSF***

***GROUP\_MA***

***%***

***group***

***of***

***meshs***

***GROUP1***

***MAILLE1 MAILLE3***

***FINSF***

***GROUP\_NO***

***NAME***

***=***

***GROUP2***

***NOEUD1***

***NOEUD2***

***FINSF***

***END***

***%***

***obligatory***

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**6.3**

**Example illustrating the assignment by groups made up**

**This example is, obviously, diagrammatic to describe the principal rules of assignment.**

**Grid 2D: a quarter of a plane field**

**be4**

**N10**

**For the assignment of**

**N6**

**8**

**be3**

**.**

**m10**

**N03**

**loadings on the edges**

**m9**

**interior and outside:**

**N8**

**groups of meshes**

**N4**

**m8**

**6**  
***BORD\_EXT and BORD\_INT***  
***m7***  
***be2***

***N02***  
***m6***  
***m4***  
***.***

***boundary conditions:***  
***m3***

***N9***  
***N2***  
***groups of nodes SYME1***  
***4***  
***m2***  
***and SYME2***  
***N7***

***bi2***  
***m5***  
***be1***  
***N01***  
***.***

***materials:***  
***m1***

***bi1***  
***groups of meshes***  
***2***  
***N1***  
***N3***  
***N5***  
***mail1 and mail2***

***1***  
***2***  
***4***  
***6***  
***8***

***COOR\_2D***

***N1 4. 2.  
TRIA3  
N2 2. 4.  
m2 N01 N7 N02  
N3 6. 2.  
m3 N01 N02 N8  
N4 2. 6.  
m6 N7 N9 N03  
N5 8. 2.  
m7 N7 N03 N02  
N6 2. 8.  
m8 N8 N02 N03  
N7 6. 3.8  
m9 N8 N03 N10  
N8 3.8 6.  
FINSF  
N9 8. 4.***

***N10 4. 8.  
QUAD4  
N01 3. 3.  
m1 N1 N3 N7 N01  
N02 5. 5.  
m5 N3 N5 N9 N7  
N03 7. 7.  
m4 N2 N01 N8 N4  
FINSF  
m10 N4 N8 N10 N6***

***FINSF  
GROUP\_MA name = BORD\_INT***

***bi1 bi2  
SEG2 name = B\_INT  
FINSF  
bi1 N1 N01  
GROUP\_MA name = BORD\_EXT  
bi2 N01 N2  
be1 be2 be3 be4  
FINSF  
FINSF***

**GROUP\_NO name = SYME1**

**SEG2 name = B\_EXT**

**N1 N3 N5**

**be1 N5 N9**

**FINSF**

**be2 N9 N03**

**be3 N03 N10**

**GROUP\_NO name = SYME2**

**be4 N10 N6**

**N2 N4 N6**

**FINSF**

**FINSF**

**GROUP\_MA name = mail1**

**END**

**m5 m6 m7**

**FINSF**

**GROUP\_MA name = mail2**

**m8 m9 m10**

**FINSF**

**Instruction manual**

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---

**Code\_Aster ®**

**Version**

**7.4**

**Titrate:**

**Description of the file of grid of Code\_Aster**

**Date:**

**06/06/05**

**Author (S):**

**J. Key PELLET**

**:**

**U3.01.00-D Page**

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*Intentionally white left page.*

*Instruction manual*

*U3.0- booklet: Grid HT-66/05/004/A*

---

**Code\_Aster** ®

*Version*

7.4

*Titrate:*

*Interface file of grid GMSH with Aster*

*Date:*

07/06/05

*Author (S):*

**Key COURTEOUS Mr.**

:

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*Organization (S): EDF-R & D /AMA*

***Instruction manual***

***U3.0- booklet: Grid***

***Document: U3.02.01***

***Interface file of grid GMSH with Aster***

***Summary:***

***GMSH is a tool for modelling, grid and postprocessing diffused under licence GNU LPG (achievable <http://www.geuz.org/gmsh>,, sources and documentation available on this site).***

***One describes here the principle of the interface which makes it possible to use in Aster a file resulting from GMSH.***

***This interface is implemented in Aster by order PRE\_GMSH [U7.01.31].***

***Instruction manual***

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***Code\_Aster ®***

***Version***

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***Titrate:***

***Interface file of grid GMSH with Aster***

***Date:***

***07/06/05***

***Author (S):***

***Key COURTEOUS Mr.***

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***1***

***Use of GMSH***

***GMSH is a free or regulated tool for grid which integrates a modeller and functionalities of post-treatment. The modeller, easy to use, allows to prepare the grid of structures by geometrical constructions (creation of lines, surfaces, translations/rotations, extrusions...). The model of the structure can be built interactivement (with the mouse) or by a file of orders.***

***The documentation of GMSH is available at this address (it is possible that this direct bond is modified, pass by the banner page in this case): <http://www.geuz.org/gmsh/doc/texinfo/gmsh.html>.***

***The description of the geometry of the structure is contained in a file .geo, the produced grid is recorded with the extension .msh; this file which will be converted by order PRE\_GMSH with format Aster.***

***2***



## ***Entities GMSH and Aster groups***

***The modeller of GMSH handles points, lines, surfaces or volumes as entities geometrical (nonwith a grid). Grid GMSH is built by netting in this order the lines, them surfaces then the volumes supported on those.***

***In general, one handles parts of the grid to apply the properties materials, them boundary conditions or the loadings. To reach these under-parts of the grid, it is necessary to define “physical” in GMSH. A physical is made up of one or more geometrical entities. The interface GMSH-Aster produces a group of meshes for each physical: if the physical 21 consists of two volumes, the group of mesh GM21 contains the meshes of these two volumes.***

### ***Note:***

***In GMSH, one visualizes the entities constituting a physical by small Tools/Visibility and by selecting the number. One can then use order DEFI\_GROUP in Aster to handle a more explicit name of group of meshes.***

### ***Caution:***

***Physicals should not be created gathering others physicals, because that would lead to to produce double meshes.  
The number of the physicals must be lower than 1.000.000.***

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***Date:***

***07/06/05***

***Author (S):***

***Key COURTEOUS Mr.***

***:***

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### 3 Examples

#### 3.1

#### Geometry and grid GMSH

*A very simple geometry is created: a square on side 1. Here, one creates the points, the lines, surface; one could also have done it by translation/extrusion...*

**NB:**

*One creates a physical which contains the square surface of number 107.*

**$L=1$ ;**

**$d=0.45$ ;**

**Not (1) = {0, 0, 0, D};**

**Not (2) = {L, 0, 0, D};**

**Not (3) = {L, L, 0, D};**

**Not (4) = {0, L, 0, D};**

**Line (1) = {1, 2};**

**Line (2) = {2, 3};**

**Line (3) = {3, 4};**

**Line (4) = {4, 1};**

**Line Loop (106) = {2, 3, 4, 1};**

**Plane Surface (6) = {106};**

**Physical Surfaces (107) = {6};**

*The grid created with the anisotropic algorithm 2D is:*

*The file of grid GMSH contains the description of the nodes and the meshes:*

**\$NOD**

**9**

**1 0 0 0**

**2 1 0 0**

**3 1 1 0**

**4 0 1 0**

**5 0.49999999999999931 0 0**

**6 1 0.49999999999999931 0**

**7 0.5000000000000007 1 0**

**8 0 0.5000000000000007 0**

**13 0.5000000000000001 0.5 0**

**\$ENDNOD**

*\$ELM*

8

1 2 107 6 3 13 1 5

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***Code\_Aster*** ®

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*Titrate:*

*Interface file of grid GMSH with Aster*

*Date:*

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*Author (S):*

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2 2 107 6 3 8 1 13

3 2 107 6 3 5 2 13

4 2 107 6 3 13 2 6

5 2 107 6 3 6 3 13

6 2 107 6 3 13 3 7

7 2 107 6 3 7 4 13

8 2 107 6 3 13 4 8

*\$ENDELM*

*The syntax of this file is described in the section “Spins formats/Gmsh mesh file format” of the handbook of GMSH.*

**3.2**

***File of grid Aster produced by operator PRE\_GMSH***

*TITRATE*

*AUTEUR=INTERFACE\_GMSH DATE=17/07/2003*

*FINSF*

%

*COOR\_3D NBOBJ=9*

*%FORMAT= (1\*NOM\_DE\_NOEUD, 3\*COORD)*

*N1 0.000000000000000E+00 0.000000000000000E+00 0.000000000000000E+00*  
*N2 1.000000000000000E+00 0.000000000000000E+00 0.000000000000000E+00*  
*N3 1.000000000000000E+00 1.000000000000000E+00 0.000000000000000E+00*  
*N4 0.000000000000000E+00 1.000000000000000E+00 0.000000000000000E+00*  
*N5 4.99999999999993E-01 0.000000000000000E+00 0.000000000000000E+00*  
*N6 1.000000000000000E+00 4.99999999999993E-01 0.000000000000000E+00*  
*N7 5.000000000000007E-01 1.000000000000000E+00 0.000000000000000E+00*  
*N8 0.000000000000000E+00 5.000000000000007E-01 0.000000000000000E+00*  
*N13 5.000000000000000E-01 5.000000000000000E-01 0.000000000000000E+00*

*FINSF*

*%*

*TRIA3 NOM=INDEFINI NBOBJ=8*

*M1 N13 N1 N5*

*M2 N8 N1 N13*

*M3 N5 N2 N13*

*M4 N13 N2 N6*

*M5 N6 N3 N13*

*M6 N13 N3 N7*

*M7 N7 N4 N13*

*M8 N13 N4 N8*

*FINSF*

*%*

*GROUP\_MA NOM=GM107*

*M1 m2 m3 M4 M5 M6 M7 M8*

*FINSF*

*%*

*END*

*The eight triangles composing the square with a grid are then accessible in Aster in the group from net GM107.*

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*Titrate:*

*Interface file of grid IDEAS with Aster*

*Date:*

*26/05/05*

*Author (S):*

**Key COURTEOUS Mr.**

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**Organization (S): EDF-R & D /AMA**

**Instruction manual**

**U3.0- booklet: Grid**

**Document: U3.03.01**

**Interface file of grid IDEAS with Aster**

**Summary:**

**The purpose of this document is to describe the principle of interface IDEAS (SDRC) with Aster.**

**This interface is activated in Aster by procedure PRE\_IDEAS [U7.01.01].**

**The datasets of universal file I-DEASTM read again by the interface IDEAS-Aster are the dataset 151 (title), them**

**datasets 15, 781 or 2411 (co-ordinates of the nodes), the datasets 71, 780 or 2412 (description of the meshes),**

**the datasets 752, 2417, 2429, 2430, 2431, 2432, 2435 or 2467 (groups of nodes or meshes) and the dataset**

**735 (nodes or meshes attached to the curves, meshes area and meshes volume).**

*So versions I-DEASTM currently supported are versions 4, 5 and 6 as well as versions 1. , 2. , 3. , 4. , 5. , 6. , 7. , 8. , 9. and 10. of Master Series.*

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*Author (S):*

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*1 Vocabulary*

*IDEAS*

*“geometry”*

*together of geometrical entities on which the grid is based. They can be curves (“curve”) of surfaces (“mesh area”), of volumes (“mesh volume”).*

*“curve”*

*linéique geometrical entity being able to be made up of under-entities, segments, arcs of circles, options. The meshes which are based on these under-entities are segments with 2 or 3 nodes.*

*“mesh area”*

*geometrical entity surface broadside by “curves” on which the meshes rest of surface: triangles with 3 or 6 nodes or quadrangles with 4 or 8 nodes.*

*“mesh volume”*

*geometrical entity voluminal broadside by “mesh areas”. Meshes of volume which are based on these under-entities are hexahedrons with 8 or 20 nodes, pentahedrons with 6 or*

*15 nodes or of the tetrahedrons with 4 or 10 nodes.*

**“group”**

*an unspecified grouping (chosen by the user) of geometrical entities, nodes or of meshes; the user gives him a name.*

**“universal file”**

*the formatted file produces by IDEAS constitutes the data file of the interface. It contains all the geometrical grid (nodes and meshes), entities, groups and associations geometrical entities - grid.*

**“geometrical association entity - grid”**

*list nodes or meshes being based on a given geometrical entity.*

.  
*for each “curve”, the nodes which make it up,*

.  
*for each “mesh area”:*

-  
*the nodes which make it up,*

-  
*in 2D the meshes which make it up.*

.  
*for each “mesh volume”:*

-  
*nodes and the meshes which make it up.*

-  
*the nodes which make it up,*

-  
*in 3D the meshes which make it up.*

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**2**

**Interface of grid drank**

**The information contained in universal file IDEAS (for versions 4, 5 and 6 and poured them 1. , 2. , 3. , 4. , 5. , 6. , 7. , 8. , 9. and 10. of Master Series) are retranscribed in the file of grid. That relate to in particular the co-ordinates of the nodes, the meshes, the groups of nodes and meshes. It generally acts of simple transfers of subfiles, except for the meshes where a permutation nodes is necessary.**

**The names created by the interface are:**

**.**

**for the nodes: NO followed by the number of node IDEAS,**

**.**

**for the meshes: MA followed by the number of element IDEAS.**

**The meshes are gathered in subfiles of the homogeneous type: SORTED., QUAD., TETRA., PENTA., HEXA.**

**.**

**for the groups of nodes or meshes created by the user and named in IDEAS, it name is simply retranscribed in capital letters:**

**-**

**8 alphanumeric to the maximum (if not truncation of the name),**

**-**

**the underlined white is allowed.**

**Note:**

**The name of the group cannot start with "COUL\_" if not it is ignored by the interface (a message of alarm informs the user of it).**

**.**

**in IDEAS, one can assign a color to each mesh generated (by defect, the meshes are of green color). The colors are located by a number (for example 7 for green).**

**To keep this information in Aster, interface PRE\_IDEAS can generate groups**



***meshs of name COUL\_ n• color IDEAS containing all the meshs of color “n• color IDEAS ”. To generate these groups of meshs, the user must ask it explicitly by CREA\_GROUP\_COUL = “yes” in order PRE\_IDEAS.***

***Without explicit request of the user, these groups of meshs are not create in order to limit the number of groups of meshs and not to increase the size of the file unnecessarily of grid.***

***From geometrical associations entities - grid, the interface built:***

***GROUP\_MA associated with the “mesh volume” in 3D or with the “mesh area” in 2D. They bear the name M\_VOLUi or M\_AREAi for the geometrical entity of origin, number I.***

***GROUP\_NO associated with the “mesh volume”, “mesh area” or “curve”, which bears the names M\_VOLUi, M\_AREAi, CURVEi following the cases.***

***Note:***

***The mesh area and the mesh volume do not exist any more in versions 1. , 2. , 3. , 4. , 5. , 6. , 7. , 8. , 9. and 10. of Master Series. The user must thus take care to define the groups of nodes and groups of meshs which it needs for its study.***

***The interface of grid (PRE\_IDEAS) does not retranscribe the boundary conditions and loadings possibly present in the universal file.***

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***Titrate:***

***Interface file of grid IDEAS with Aster***

***Date:***

***26/05/05***

***Author (S):***

***Key COURTEOUS Mr.***

***:***

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**3**  
**Example: Grid IDEAS**

**There is also the group of nodes**  
**FACE\_INF 1 2 5 8 9 11**

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**U3.0- booklet: Grid HT-66/05/004/A**

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**Code\_Aster** ®  
**Version**  
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**Titrate:**  
**Interface file of grid IDEAS with Aster**

**Date:**  
**26/05/05**  
**Author (S):**  
**Key COURTEOUS Mr.**  
**:**  
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**File grid Aster produced by operator PRE\_IDEAS**

**COOR\_3D**  
**NO1**  
**x1**  
**y1**  
**z1**  
**...**  
**...**  
**...**  
**...**  
**NO12**  
**x12**  
**y12**

**z12**  
**FINSF**  
**HEXA8**  
**MA1**  
**NO1**  
**NO5**  
**NO8**  
**NO2**  
**NO4**  
**NO6**  
**NO7**  
**NO3**  
**FINSF**  
**PENTA6**  
**MA2**  
**NO5**  
**NO9**  
**NO6**  
**NO8**  
**NO11**  
**NO7**  
**MA3**  
**NO6**  
**NO9**  
**NO10**  
**NO7**  
**NO11**  
**NO12**  
**FINSF**  
**GROUP\_NO NAME = FACE\_INF**  
**NO1**  
**NO2**  
**NO5**  
**NO8**  
**NO9**  
**NO11**  
**FINSF**  
**GROUP\_NO NAME = CURVE1**  
**NO1**  
**NO4**  
**FINSF**

...

...  
...  
...

*other GROUP\_NO for CURVE2 with CURVE11*

**GROUP\_NO NAME = CURVE12**

**NO10**

**NO12**

**FINSF**

**GROUP\_NO NAME = M\_AREA1**

**NO1**

**NO2**

**NO3**

**NO4**

**FINSF**

...  
...  
...  
...

*other GROUP\_NO for M\_AREA2 with M\_AREA5*

**GROUP\_NO NAME = M\_AREA6**

**NO1**

**NO5**

**NO9**

**NO11**

**NO8**

**NO2**

**FINSF**

**GROUP\_NO NAME = M\_VOLU1**

*% totality of the nodes*

**NO1**

... .. NO12

**FINSF**

**GROUP\_MA NAME = M\_VOLU1**

*% totality of the meshes*

**MA1**

**MA2**

**MA3**

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***4***

***Local classification of the meshes of IDEAS and Aster***

***Notice preliminary:***

***The numbers being reproduced on the diagrams which follow are the local numbers of the nodes.***

***4.1***

***Classification of TRIANGLES (TRIA6)***

***CLASSIFICATION***

***CLASSIFICATION***

***IDEAS***

***Aster***

***5***

***3***

***TRIA6***

***6***

***4***

***6***

***5***

***1***

***3***

1  
2  
2  
4

**4.2**  
***Classification of QUADRANGLES (QUAD8)***

***The meshes of the type QUAD9 are not available in IDEAS***

**CLASSIFICATION**  
**CLASSIFICATION**  
**IDEAS**

***Aster***

6  
7  
7  
5  
4  
3  
8  
4  
8  
6  
1  
1  
2  
2  
3  
5

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Date:

26/05/05

Author (S):

Key **COURTEOUS Mr.**

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### 4.3

#### **Classification of HEXAHEDRONS (HEXA8 - HEXA20)**

##### **4.3.1 HEXA8**

**6**

**7**

**CLASSIFICATION**

**3**

**8**

**2**

**5**

**IDEAS**

**1**

**4**

**6**

**7**

**CLASSIFICATION**

**2**

**3**

**8**

**5**

**Aster**

**1**

**4**

##### **4.3.2 HEXA20**

**15**

**16**

**17**

**10**

**14**

**18**

**11**

**CLASSIFICATION**

**19**

**3**

**13 20**

**4**

**5**

**IDEAS**

**2**

**9**

**6**

**12**

**1**

**7**

**8**

**6**

**18**

**7**

**14**

**17**

**15**

**19**

**5**

**CLASSIFICATION**

**10**

**3**

**8**

**2**

**20**

**Aster**

**9**

**11**

**13**

**16**

**1**

**12**



4

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***Code\_Aster*** ®

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***Titrate:***

***Interface file of grid IDEAS with Aster***

***Date:***

***26/05/05***

***Author (S):***

***Key COURTEOUS Mr.***

***:***

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***4.4***

***Classification of PRISMS (PENTA6 - PENTA15)***

***4.4.1 PENTA6***

***5***

***CLASSIFICATION***

***6***

***IDEAS***

***2***

***4***

***1***

***3***

***5***

***6***

***4***

***CLASSIFICATION***

***2***

***Aster***

***1***

***3***

## **4.4.2 PENTA15**

**12**

**13**

**11**

**8**

### **CLASSIFICATION**

**10**

**14**

**15**

### **IDEAS**

**3**

**7**

**2**

**4**

**9**

**1**

**6**

**5**

**5**

**14**

**13**

**11**

**6**

**4**

**15**

### **CLASSIFICATION**

**2**

**10**

**Aster**

**7**

**12**

**8**

**1**

**9**

**3**

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**Version**

**7.4**

***Titrate:***  
***Interface file of grid IDEAS with Aster***

***Date:***  
***26/05/05***  
***Author (S):***  
***Key COURTEOUS Mr.***  
***:***  
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## ***4.5***

### ***Classification of TETRAHEDRONS (TETRA4 - TETRA10)***

#### ***4.5.1 TETRA4***

***2***  
***CLASSIFICATION***  
***4***  
***IDEAS***  
***1***  
***3***  
***2***  
***CLASSIFICATION***  
***Aster***  
***4***  
***1***  
***3***

#### ***4.5.2 TETRA10***

***3***  
***8***  
***2***  
***4***  
***CLASSIFICATION***  
***10***  
***7***  
***IDEAS***  
***9***  
***1***  
***6***

5  
2  
9  
**CLASSIFICATION**

5  
9 6  
*Aster*

4  
8  
10  
1  
7  
3

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*Titrate:*  
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*Date:*  
26/05/05  
*Author (S):*  
*Key COURTEOUS Mr.*  
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5  
*Frames of reference*

*The interface IDEAS-Aster transcribes only the grids whose nodes are defined by co-ordinates in Cartesian reference mark.*

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---

*Code\_Aster* ®

**Version**

**7.4**

**Titrate:**

**Interface file of grid GIBI with Aster**

**Date:**

**26/05/05**

**Author (S):**

**COURTEOUS Mr., A.M. DONORE Key**

**:**

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**Organization (S): EDF-R & D /AMA**

**Instruction manual**

**U3.0- booklet: Grid**

**Document: U3.04.01**

**Interface file of grid GIBI with Aster**

**Summary:**

**The use of GIBI (maillor of CASTEM 2000) can be done on workstation Unix/Linux according to**

*versions available.*

*One describes here the principle of the interface which makes it possible to use in Aster a file resulting from CASTEM 2000.*

*This interface is implemented in Aster by order PRE\_GIBI [U7.01.11].*

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*26/05/05*

*Author (S):*

*COURTEOUS Mr., A.M. DONORE Key*

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*1*

*Use of GIBI*

*CASTEM 2000 is a code of analysis of the structures by finite elements, which has a unit of functionalities dedicated to the grid in 2D and 3D. The whole of these functions of grid is known under name GIBI.*

*In the continuation of this document, one will name GIBI, the whole of the functions of grid like the whole of the orders for the visualization and the analysis of the results.*

*GIBI is available on a certain number of platforms Unix/Linux. It is a version diffused by the group “Codes of Mechanics” of EDF R & D /AMA within the framework of a contract with the ECA, it is available in remote loading on the <http://www.code-aster.org> site.*

*The memory allocated by GIBI is of 20 megawords per defect. For certain applications it is necessary to increase this size memory. With this intention, it is necessary to define variable ESOPE\_PARAM of following manner:*

*setenv ESOPE\_PARAM "ESOPE=x000000, NTRK=1024, LTRK=1048576"*

*or according to Shell used:*

*export ESOPE\_PARAM=' ESOPE=x000000, NTRK=1024, LTRK=1048576'*

*where X is the number of million words which one wishes.*

*The ECA produces a new version of GIBI each year. Before being brought into service on centralized waiter and to be diffused, this version is tested by the team codes on the whole of the tests Aster. Thus the "standard" version is currently GIBI version 2000, launched in interactive by order gibi2000.x.*

2

*Documentation on the use of GIBI*

*The documentation of GIBI can be obtained by carrying out GIBI with the data file according to:*

*NOTE;*

*END;*

*One recovers then in the listing of work, the list of the chapters corresponding to all the operators GIBI.*

*GIBI has a documentation in line which makes it possible to have the syntax of each operator by order:*

*INFORMATION name of the order;*

*but also the possibility of knowing the whole of the operators dedicated to the grid, gathered by functionalities (operators of creation of points, linear entities, surface entities and voluminal entities...) by the order:*

*INFORMATION DEBU;*

*This information is also available since a navigator Internet (the site depends on the local installation).*

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*7.4*

*Titrate:*

*Interface file of grid GIBI with Aster*

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**26/05/05**

**Author (S):**

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**3**

***The Council of use of GIBI for Aster***

**.**

***Not to forget that each order ends in one “; ”,***

**.**

***Code\_Aster can read again the files created by GIBI having level 3, 4, 5, 6, 8, 9, 10, 11 or 13. This level is related to the change of format,***

**.**

***to think that it is not possible to impose the passage of the grid by a point or a line not being reproduced on external contour. To envisage the geometry division consequently,***

**.**

***to think that GIBI directs with its own conventions the various meshes. Elements can “be thus turned over” (from where negative jacobians and pressures to back!). In GIBI, the user has the operators OPPOSITE and TO DIRECT for modification orientation of elements. One will refer advantageously to order MODI\_MAILLAGE ([U4.23.04], key words ORIE\_PEAU\_2D/3D) to intervene on the orientation of the meshes in Aster,***

**.**

***operator PRE\_GIBI supposes that GIBI was carried out without error, i.e. second line of the file .mgib is “LEVEL LEVEL ERROR 0 DIMENSION...” In the contrary case, one carries out, nevertheless the interface, by emitting an alarm,***

**.**

***the file containing grid GIBI must be produced by the order “TO SAVE FORMAT grid ”; it is the only format read again by interface PRE\_GIBI.***

**4**

***Interface with Aster***

***The interface with Aster is activated by order PRE\_GIBI [U7.01.11].***

**5**

***Entities of grid GIBI and Aster***



***Maillor GIBI handles typified and named objects (cf Doc. of use of GIBI).***

***The types used are:***

- .  
***constants whole, real, text,...,***
- .  
***POINTS,***
- .  
***GRIDS (together of meshes).***

***Order PRE\_GIBI causes:***

- .  
***to write points (GIBI) in the form of nodes (Aster): the names of the Aster nodes are form: Nor where I is number GIBI of the corresponding point,***
- .  
***to write the meshes (Aster) contained in grids (GIBI): names of the meshes Aster are form: Mj where J is the sequence number of mesh GIBI in the file of result GIBI,***
- .  
***to write GROUP\_MA (Aster) corresponding to grids (GIBI) and of same names,***

***Note:***

***The groups of meshes contain only the meshes defining it indeed grid GIBI. They do not contain the meshes of the objects referred in this grid (edges for example).***

- .  
***to write GROUP\_NO (Aster) reduced to only one nodes and whose names are the names of points of GIBI.***

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***It is noticed that PRE\_GIBI does not generate a GROUP\_NO containing several nodes. What would be***

***sometimes very useful to impose boundary conditions on all the nodes of an edge. With this intention, the user has in Aster the order DEFI\_GROUP which makes it possible to create groups of nodes starting from groups of meshes.***

***Key word CREA\_GROUP\_NO of operator DEFI\_GROUP [U4.22.01] makes it possible to circumvent this obstacle.***

## **6 Examples**

**C3**

**4**

**3**

**1**

**y**

**C4**

**C2**

**6**

**5**

**2**

**X**

**B**

**With**

**AB = C1**

**.**

***for GIBI: With and B are named points.***

***One thus finds in the Aster grid of the GROUP\_NO of names A and B***

**.**

***for GIBI: AB, SQUARES, C1,..., C4 are named grids.***

***One thus finds in the Aster grid of the GROUP\_MA of names: AB, SQUARES, C1,..., C4***

**Note:**

***The interface writes only once possibly identical meshes (what arrives sometimes with the operator “AND” of GIBI). This has as a consequence that the names of the Mj meshes can have a “classification with holes”. One should not worry some.***

***The orientation of the meshes is that given by GIBI. This can have importance for some changes: pressure,...***

***It is necessary to be conscious owing to the fact that the operators of grid of GIBI direct the elements (with rules specified in documentation). Certain elements can “be turned over” by report/ratio with others. Another command set GIBI could, for example to generate it grid:***

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***6.1***

***Notice concerning order POIN of GIBI***

***This order can produce results of the different type:***

***.***

***if this order makes it possible to recover only one point,***

*for example:*

*Pa*  
=  
*louse*  
*POIN*  
*PROC*  
*With*  
;

*or*

*Pa*  
=  
*louse*  
*POIN*  
*INITIAL;*

*then Pa is a named point GIBI.*

*As an Aster, there will have a GROUP\_NO of name Pa which contains only one node.*

.

*if this order makes it possible to recover several points:*

*for example:*

*Pa*  
=  
*louse*  
*POIN*  
*RIGHT*  
*With*  
*B*  
*1.0D-2*  
;

*then Pa is a named grid GIBI:*

*This grid consists of meshes POII.*

*As an Aster, there will have a GROUP\_MA of name Pa which contains several POII. To use this object as GROUP\_NO, it will be necessary to use the key word factor CREA\_GROUP\_NO of order DEFI\_GROUP.*

## 6.2

### *Command file GIBI*

*OPTI DIME 2 ELEM TRI3;*

*\**

*\* POINTS NAME:*

*\**

*To = 0.0.0.0;*

*B = 1.0.0.0;*

*\**

*\* GRIDS:*

*\**

*AB = DROI 2 A B;*

*SQUARE = AB TRAN 1 (0. 1.);*

*C1 C2 C3 C4 = DIMENSION SQUARES;*

*\**

*TO SAVE FORMAT SQUARES;*

*END;*

*\**

-----  
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## 6.3

*File of result GIBI: (as an indication)*

*RECORDING OF THE TYPE 4*

**LEVEL 11 LEVEL ERROR 0 DIMENSION 2  
DENSITY 0.00000E+00  
RECORDING OF THE TYPE 7  
INFORMATION CASTEM2000 8 NUMBERS  
IFOUR -1 NIFOUR 0 IFOMOD -1 IECHO 1 IIMPI 0 IOSPI 0 ISOTYP 1  
NSDPGE 0**

**RECORDING OF THE TYPE 2  
CRUSH NUMBER 1NBRE OBJECTS NAME 6NBRE OBJECTS 5  
AB SQUARES C1 C2 C3 C4**

**2 1 2 3 4 5  
4 0 4 3 4  
2 3 4 5  
0 0 0 0  
1 2 3 1 3 4 2 5 3 5  
6 3  
2 0 0 2 2  
0 0  
1 2 2 5  
2 0 0 2 1  
0  
5 6  
2 0 0 2 2  
0 0  
6 3 3 4  
2 0 0 2 1  
0  
4 1**

**RECORDING OF THE TYPE 2  
CRUSH NUMBER 32NBRE OBJECTS NAME 2NBRE OBJECTS 6  
WITH B**

**1 5  
6  
1 3 6 5 2 7**

**RECORDING OF THE TYPE 2  
CRUSH NUMBER 33NBRE OBJECTS NAME 0NBRE OBJECTS 1  
21**

**0.000000000000000E+00 0.000000000000000E+00 0.000000000000000E+00  
1.000000000000000E+00 0.000000000000000E+00 0.000000000000000E+00  
5.000000000000000E-01 0.000000000000000E+00 5.000000000000000E-01  
0.000000000000000E+00 1.000000000000000E+00 0.000000000000000E+00  
0.000000000000000E+00 1.000000000000000E+00 0.000000000000000E+00  
5.000000000000000E-01 1.000000000000000E+00 5.000000000000000E-01  
1.000000000000000E+00 1.000000000000000E+00 0.000000000000000E+00**

***RECORDING OF THE TYPE 5  
AUTOMATIC LABEL: 1***

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**6.4**

**File of grid Aster produced by operator PRE\_GIBI**

TITRATE

%

GIBI

FECIT GROUP\_NO

FINSF

B

N2

%

FINSF

COOR\_2D

%

N1

0.000000000000000E+00 0.000000000000000E+00 GROUP\_NO

N2

1.000000000000000E+00

0.000000000000000E+00

With

N1

N3



5.000000000000000E-01 0.000000000000000E+00 FINSF

N4

0.000000000000000E+00 1.000000000000000E+ 00%

N5

0.000000000000000E+00 1.000000000000000E+00 GROUP\_MA

N6

5.000000000000000E-01 1.000000000000000E+00

C4

N7

1.000000000000000E+00 1.000000000000000E+00 M10

FINSF

FINSF

%

%

TRIA3

GROUP\_MA

M1

N1

N3 N6

C3

M2

N1

N6 N5

M8

M9

M3

*N3*  
*N2 N6*

*FINSF*  
*M4*

*N2*  
*N7 N6*

*%*  
*FINSF*  
*GROUP\_MA*  
*%*

*C2*  
*SEG2*  
*M7*  
*M5*  
*N1*  
*N3*

*FINSF*  
*M6*  
*N3*

*N2*  
*%*

*FINSF*  
*GROUP\_MA*  
%

*C1*  
*SEG2*  
*M7*  
*N2*

*N7*  
*M5*

*M6*  
*FINSF*  
*FINSF*  
%

%  
*SEG2*  
*GROUP\_MA*  
*M8*

*N7 N6*

*SQUARE*  
*M9*

*N6 N5*

*M1*  
*M2 M3 M4*  
*FINSF*  
*FINSF*  
*%*

*%*  
*SEG2*  
*GROUP\_MA*  
*M10*

*N5 N1*

*AB*  
*FINSF*  
*M5*

*M6*  
*%*  
*FINSF*

%

*END*

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*01/06/05*

*Author (S):*

***J.L. FLEJOU, F. LEBOUVIER** Key*

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

***Instruction manual***

***U3.11 booklet: Mechanical elements of structure 1D***

***Document: U3.11.01***

***Modelings POU\_D\_T, POU\_D\_E, POU\_C\_T,  
BAR***

***Summary:***

***Four modelings POU\_D\_T, POU\_D\_E, POU\_C\_T and BAR correspond to the traditional formulations***

***elements of beams and bars, inspired of the Resistance of Materials.***

***They are usable for three-dimensional problems in linear mechanical analysis or not linear isotropic.***

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## ***1 Discretization***

### ***1.1***

#### ***Degrees of freedom***

*For three modelings of beam into three-dimensional the degrees of freedom of discretization are, in each node of the mesh support, six components of displacement (three translations and three rotations). These nodes are supposed to describe a segment of average fibre of the beam.*

#### ***Finite element***

##### ***Degrees of freedom (with each node top)***

*POU\_D\_T*

*DX*

*DY*

*DZ*

*DRX*

*DRY*

*DRZ*

*POU\_D\_E*

*DX*

*DY*

*DZ*

*DRX*

*DRY*

*DRZ*

*POU\_C\_T*

*DX*

*DY*

*DZ*

*DRX*

*DRY*

*DRZ*

*For the modeling of bar into three-dimensional the degrees of freedom of discretization are, in each node of the mesh support, three components of displacement in translation.*

*BAR*

*DX*

*DY*

*DZ*



## **1.2**

### ***Net support of the matrices of rigidity***

*The meshes support of the finite elements, in displacement formulation, are segments with two nodes SEG2:*

#### ***Modeling Nets Element***

#### ***finished***

#### ***Remarks***

*POU\_D\_T SEG2*

*MECA\_POU\_D\_T*

*POU\_D\_E SEG2*

*MECA\_POU\_D\_E*

*POU\_C\_T SEG2*

*MECA\_POU\_C\_T*

*BAR*

*SEG2 MECA\_BARRE*

## **1.3**

### ***Net support of the loadings***

*All the loadings applicable to the elements of beam and bar are treated by discretization direct on the mesh support of the element in displacement formulation.*

*No mesh support of loading is thus necessary for the edge of the elements of beam or of bar.*

## **1.4**

### ***Principal characteristics of modelings***

*Modeling POU\_D\_E (Right Beam of Euler) corresponds to the assumption of Euler-Bernouilli, i.e. the sections remain right and perpendicular to average fibre (assumption of great twinge).*

*Modeling POU\_D\_T (Right Beam of Timoshenko) takes into account the effects of shearing transverse.*

*Modeling POU\_C\_T is similar to POU\_D\_T with a curve (Beam Curves*

*Timoshenko).*

*Modeling BARS treats only the efforts and axial deformations.*

*The beam with warping is treated in [U3.11.04].*

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## ***Assignment of the characteristics***

*For these elements of structures 1D, it is necessary to affect geometrical characteristics which are complementary to the data of grid. The definition of these data is carried out with order **AFFE\_CARA\_ELEM** associated with the key words following factors:*

### **· BEAM**

*Allows to define and affect the characteristics of the cross section and the orientation of principal axes of inertia around neutral fibre.*

*Supported modelings: **POUT\_D\_T, POU\_D\_E, POU\_C\_T***

### **· BAR**

*Allows to define and affect the characteristics of the cross section.*

*Supported modeling: **BAR***

### **· DEFI\_ARC**

*Allows to define and assign to curved beams characteristics related to the curve of the element (radius of curvature and orientation of the plan of the arc).*

*Supported modelings: POU\_C\_T*

· **ORIENTATION**

*Allows to define and affect the principal axes of the cross sections of the elements of the type beam.*

*Supported modelings: POUT\_D\_T, POU\_D\_E, POU\_C\_T*

**Notice on the discretization:**

*With regard to the grid of the beams in meshes SEG2, it is useless to refine excessively these elements whose integrated formulation makes it possible to obtain solutions exact with the nodes in linear statics [R3.08.01]. In modal analysis and dynamics, one will take care to net sufficiently to represent the awaited modes, but without excess: it is necessary that the elements remain a sufficient length, according to dimensions of the section, so that the assumption of beam is valid.*

*For example, for a beam length 1, and a circular section of external ray 0.05 and thickness 0.01, 10 elements are enough to apprehend the 10 first correctly modes. But if one refines enormously, for example with 1000 elements, then each element of beam is very short: length 0.001 for an external ray of 0.05. Matrices elementary are very badly conditioned, in particular for element POU\_D\_E (for POU\_D\_T the terms of transverse shearing improve a little conditioning). With resolution, one then loses 8 decimals for the POU\_D\_E.*

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### **3 Loadings supported**

*The loadings available are as follows:*

· **“CONTACT”**

*Allows to define the zones subjected to conditions of contact.*

*Supported modelings: POU\_D\_T, POU\_D\_E*

· **“EPSI\_INIT”**

*Allows to apply a loading of initial deformation.*

*Supported modelings: POU\_D\_T, POU\_D\_E*

· **“FORCE\_ELEC”**

*Allows to apply the force of LAPLACE acting on a principal driver, due to presence of a secondary driver right.*

*Supported modelings: POU\_D\_T, POU\_D\_E*

· **“FORCE\_POUTRE”**

*Allows to apply linear forces*

*Supported modelings: POU\_D\_T, POU\_D\_E, POU\_C\_T, BARS*

· **“INTE\_ELEC”**

*Allows to apply the force of LAPLACE acting on a principal driver, due to presence of a secondary driver not necessarily right compared to this driver the main thing.*

*Supported modelings: POU\_D\_T, POU\_D\_E*

· **“GRAVITY”**

*Allows to apply a loading of the gravity type.*

*Supported modelings: POU\_D\_T, POU\_D\_E, POU\_C\_T, BARS*

· **“TEMP\_CALCULEE”**

*Allows to apply a thermal loading.*

*Supported modelings: POU\_D\_T, POU\_D\_E, POU\_C\_T, BARS*

**Note:**

*Possible contact between beam and surface [R5.03.50].*

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## **4 Possibilities**

### **non-linear**

#### **4.1**

##### **Law of behaviors**

Laws of behaviors specific to these modelings, usable under **COMP\_INCR** in **STAT\_NON\_LINE, DYNA\_NON\_LINE** and **DYNA\_TRAN\_EXPLI** are as follows (cf [U4.51.11]):

**/“ASSE\_COMBU”**

Supported modelings: **POU\_D\_T, POU\_D\_E**

**/“VMIS\_POU\_LINE”**

Supported modelings: **POU\_D\_T, POU\_D\_E, POU\_C\_T**

**/“VMIS\_POU\_FLEJOU”**

Supported modelings: **POU\_D\_T, POU\_D\_E, POU\_C\_T**

**/“PINTO\_MENEGOTTO”**

Supported modeling: **BAR**

**/“VMIS\_ASYM\_LINE”**

Supported modeling: **BAR**

**Note:**

It is possible for these modelings using a monodimensional state of stresses to use the behaviors 3D, for that it is necessary to use key word **ALGO\_ID** (**METHODE=**

“**DEBORST**”).

## **4.2 Deformations**

Only the linearized deformations “**SMALL**” key word under **DEFORMATION** are available in relations of behavior (cf [U4.51.11]):

## **5**

### **Examples of implementation: case-tests**

#### **· POU\_D\_T**

*Statics*

*linear*

*DEMO004A: Analyze of a lattice 3D without reinforcement, under weight actual and subjected to a force*

*specific.*

*FORMA01A: Analyze of a piping comprising an elbow subjected to a specific force.*

*Statics*

*non-linear*

*SSNL106B [V6.02.106]: Elastoplastic analysis of a right beam in traction and inflection.*

*Dynamics*

*linear*

*SDLL01A [V2.02.01]: Seek Eigen frequencies of a short beam on supports*

*simple.*

*Dynamics*

*non-linear*

*SDNL103A [V5.02.103]: Calculation of the response of a post subjected to a seismic loading unspecified.*

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· **POU\_D\_E**

*Statics*

*linear*

*SSLL102A [V3.01.102]: Analyze of a fixed beam subjected to unit efforts.*

*Statics*

*non-linear*

*SSNL106C [V6.02.106]: Elastoplastic analysis of a right beam in traction and inflection.*

*Dynamics*

*linear*

*FORMA12A: Modal analysis of a beam (multiple modes).*

*Dynamics*

*non-linear*

*SDNL105A [V5.02.105]: Shock of 3 beams between-they - calculation of the transitory answer by under structuring in the case of taken into account of nonlinearity of the type shock enters mobile structures.*

· **POU\_C\_T**

*Statics*

*linear*

*FORMA01A [V5.02.105]: Analyze of a piping comprising an elbow subjected to a force specific.*

*Dynamics*

*linear*

*SDLL11E: Calculation of the Eigen frequencies of a thin circular ring.*

*Dynamics*

*non-linear*

*SDNX300A: Calculation of the linear temporal response of a piping.*

· **BAR**

*Statics*

*linear*

*SSLS110A [V3.01.110]: Analyze of a system of 3 bars out of U under actual weight.*

*Statics*

*non-linear*

*SSLS111B [V6.02.111]: Analyze of three elastoplastic bars perfect Von Mises.*

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**Code\_Aster** ®

Version

7.4

Titrate:

Modelings **DIS\_T** and **DIS\_TR**

Date:

03/06/05

Author (S):

**J.M. PROIX, F. LEBOUVIER** Key

:

U3.11.02-E Page

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Organization (S): EDF-R & D /AMA, DeltaCAD

**Instruction manual**

**U3.11 booklet: Mechanical elements of structure 1D**

**Document: U3.11.02**

**Modelings DIS\_T and DIS\_TR**

**Summary:**



*This document describes for modelings DIS\_T and DIS\_TR:*

- *degrees of freedom carried by the finite elements which support modeling,*
- *the related meshes supports,*
- *supported loadings,*
- *nonlinear possibilities,*
- *case-tests implementing modelings.*

*Two modelings DIS\_T and DIS\_TR allow the representation of discrete elements of translation and of translation-rotation.*

*They are usable for three-dimensional problems in linear and nonlinear mechanical analysis.*

*Instruction manual*

*U3.11 booklet: Mechanical elements of structure 1D*

*HT-66/05/004/A*

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Modelings DIS\_T and DIS\_TR*

*Date:*

*03/06/05*

*Author (S):*

*J.M. PROIX, F. LEBOUVIER Key*

*:*

*U3.11.02-E Page*

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*1 Discretization*

*1.1*

*Degrees of freedom*

*For two modelings into three-dimensional the degrees of freedom of discretization are, in each node of the mesh support, three components of displacement of translation or six components (three translations and three rotations).*

## ***Finite element***

***Degrès of freedom (with each node top)***

***DIS\_T***

***DX***

***DY***

***DZ***

***DIS\_TR***

***DX***

***DY***

***DZ***

***DRX***

***DRY***

***DRZ***

### ***1.2***

***Net support of the matrices of rigidity***

***The meshes support of the discrete elements, in displacement formulation, are segments with two nodes SEG2 or of specific meshes POII confused with a node:***

***Modeling Nets Element***

***finished***

***Remarks***

***DIS\_T POII***

***MECA\_DIS\_T\_N***

***SEG2***

***MECA\_DIS\_T\_L***

***DIS\_TR POII***

***MECA\_DIS\_TR\_N***

***SEG2***

***MECA\_DIS\_TR\_L***

***For meshes POII, the efforts are calculated starting from the differences of the degrees of freedom of the node***

***mesh with the fixed reference mark, while for meshes SEG2, they are calculated from differences of ddl between the two nodes.***

## 2 *Assignment of the characteristics*

*For these discrete elements, it is necessary to affect geometrical characteristics which are complementary to the data of grid. The definition of these data is carried out with order AFFE\_CARA\_ELEM associated with the key words following factors:*

- **DISCRETE**

*Allows to define and affect the values of the matrices of rigidity, mass or damping.  
Supported modelings: DIS\_T, DIS\_TR*

- **ORIENTATION**

*Allows to define and affect a local reference mark.  
Supported modelings: DIS\_T, DIS\_TR*

### *3 Loadings supported*

- **“GRAVITY”**

*Allows to apply a loading of the gravity type.  
Supported modelings: DIS\_T, DIS\_TR*

*Instruction manual*

*U3.11 booklet: Mechanical elements of structure 1D  
HT-66/05/004/A*

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**Code\_Aster** ®

Version

7.4

Titrate:

Modelings **DIS\_T** and **DIS\_TR**

Date:

03/06/05

Author (S):

**J.M. PROIX, F. LEBOUVIER** Key

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## **4 Possibilities**

### **non-linear**

#### **4.1**

##### **Law of behaviors**

Laws of behaviors specific to these modelings, usable under **COMP\_INCR** in **STAT\_NON\_LINE**, **DYNA\_NON\_LINE** and **DYNA\_TRAN\_EXPLI** are as follows (cf [U4.51.11]):

**/“ASSE\_CORN”**

Supported modeling: **DIS\_TR**

**/“WEAPON”**

Supported modeling: **DIS\_TR**

**/“DIS\_CHOC”**

Supported modelings: **DIS\_T**, **DIS\_TR**

**/“DIS\_CONTACT”**

Supported modelings: **DIS\_T**, **DIS\_TR**

**/“ELAS”**

Supported modelings: **2D\_DIS\_T**, **2D\_DIS\_TR**

In addition to the assignment of characteristics (**AFFE\_CARA\_ELEM**), the use of modelings **DIS\_T** and **DIS\_TR** with **STAT\_NON\_LINE/DYNA\_NON\_LINE/DYNA\_TRAN\_EXPLI** implies to define characteristics material (via **DEFI\_MATERIAU** and **AFFE\_MATERIAU**).

With *DIS\_CONTACT* and *DIS\_CHOC*, the elastic matrix is calculated with the characteristic of stiffness defined in *AFFE\_CARA\_ELEM*, while the tangent matrix is calculated via the behavior *DIS\_CONTACT* or *DIS\_CHOC*.

## 4.2 Deformations

Deformations available, used in the relations of behavior under the key word *DEFORMATION* for operators *STAT\_NON\_LINE*, *DYNA\_NON\_LINE* and *DYNA\_TRAN\_EXPLI* are  
(Cf [U4.51.11]):

*/"SMALL"*

The deformations used for the relation of behavior are the linearized deformations calculated on the initial geometry.

*/"PETIT\_REAC"*

The deformations used in the incremental relation of behavior are the deformations linearized calculated on the reactualized geometry.

*Instruction manual*

*U3.11 booklet: Mechanical elements of structure 1D*

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*Titrate:*

*Modelings DIS\_T and DIS\_TR*

*Date:*

*03/06/05*

*Author (S):*

*J.M. PROIX, F. LEBOUVIER Key*

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*5*

*Examples of implementation: case-test*

*· DIS\_T*

**Statics**

**linear**

**SSLL100B [V3.01.100]: Analyze static linear of a formed structure of right beams and curves subjected to a loading of inflection.**

**Statics**

**non-linear**

**SSNL118A [V6.02.118]: Analyze static non-linear of a bar subjected to a field of speed of wind.**

**Dynamics**

**linear**

**SDLD02A [V2.01.002]: Seek frequencies and modes of vibration of a structure mechanics made up of masses and springs.**

**Dynamics**

**non-linear**

**SDND102B [V5.01.102]: Seismic response of a system masses non-linear spring multi supported.**

**· DIS\_TR**

**Statics**

**linear**

**SSLX100D [V3.05.100]: Analyze of a beam in inflection of which the model is composed of one mix modeling 3D, Coque and Beam.**

**Statics**

**non-linear**

**SSNL102A [V6.02.102]: Analyze non-linear behaviour of an assembly of angles subjected to a two-dimensional loading of traction and moment.**

**Dynamics**

**linear**

**SDLD02C [V2.01.002]: Seek frequencies and modes of vibration of a structure mechanics made up of masses and springs.**

**Dynamics**

**non-linear**

**SDND102B [V5.01.102]: Seismic response of a system masses non-linear spring multi supported.**

**Instruction manual**

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**HT-66/05/004/A**

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**Code\_Aster ®**

**Version**

**7.4**

**Titrate:**

## ***Modelings CABLE and CABLE\_POULIE***

***Date:***

***01/06/05***

***Author (S):***

***J.M. PROIX, F. LEBOUVIER Key***

***:***

***U3.11.03-E Page***

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***Organization (S): EDF-R & D /AMA, DeltaCAD***

***Instruction manual***

***U3.11 booklet: Mechanical elements of structure 1D***

***Document: U3.11.03***

## ***Modelings CABLE and CABLE\_POULIE***

***Summary:***

***This document describes for modelings CABLE and CABLE\_POULIE:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported loadings,***

- *nonlinear possibilities,*
- *case-tests implementing modelings.*

*Modelings CABLE and CABLE\_POULIE correspond to elements of bar written specifically for to take into account great displacements (cf [R3.08.02] and [R3.08.04]).*

*They are not usable for problems of linear mechanical analysis.*

*Instruction manual*

*U3.11 booklet: Mechanical elements of structure 1D*

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Modelings CABLE and CABLE\_POULIE*

*Date:*

*01/06/05*

*Author (S):*

*J.M. PROIX, F. LEBOUVIER Key*

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*1 Discretization*

*1.1*

*Degrees of freedom*

*For these two modelings the degrees of freedom of discretization are, in each node of the mesh support, three components of displacement of translation.*

*Finite element*

*Degrees of freedom (with each node top)*

*CABLE DX*

*DY*

*DZ*



**CABLE\_POULIE DX**  
**DY**  
**DZ**

## **1.2**

### ***Net support of the matrices of rigidity***

***The meshes support of the finite elements, in displacement formulation, are segments with two nodes  
SEG2:***

***Modeling Nets Element  
finished  
Remarks***

***CABLE SEG2  
MECABL2  
CABLE\_POULIE SEG3  
MEPOUL1***

## **2**

### ***Assignment of the characteristics***

***For these modelings it is necessary to affect geometrical characteristics which are  
complementary to the data of grid. The definition of these data is carried out with  
order AFFE\_CARA\_ELEM associated with the key word following factor:***

***· CABLE  
Allows to define and affect a constant section.***

### ***3 Loadings supported***

***The loadings available are as follows:***

***· “CONTACT”  
Allows to define the zones subjected to conditions of contact.  
Supported modeling: CABLE***

· **“FORCE\_POUTRE”**

*Allows to apply linear forces*

*Supported modeling: CABLE*

· **“INTE\_ELEC”**

*Allows to apply the force of LAPLACE acting on a principal driver, due to presence of a secondary driver not necessarily right compared to this driver the main thing.*

*Supported modeling: CABLE*

*Instruction manual*

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*Code\_Aster ®*

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*7.4*

*Titrate:*

*Modelings CABLE and CABLE\_POULIE*

*Date:*

*01/06/05*

*Author (S):*

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· **“GRAVITY”**

*Allows to apply a loading of the gravity type.*

*Supported modelings: CABLE, CABLE\_POULIE*

· **“TEMP\_CALCULEE”**

*Allows to apply a thermal loading.*

*Supported modelings: CABLE, CABLE\_POULIE*

*Note:*

· *Possible following Charge in the case of a loading of the type FORCE\_POUTRE.*

· *Possible Contact between beam and surface [R5.03.50].*

**4 Possibilities**

## ***non-linear***

### **4.1**

#### ***Laws of behaviors***

***The law of behavior specific to these modelings, usable under COMP\_ELAS in STAT\_NON\_LINE and DYNA\_NON\_LINE are as follows (cf [U4.51.11]):***

***/“CABLE”***

***Supported modeling: CABLE***

### **4.2 Deformations**

***No linear calculation is possible with these modelings (calculations are necessarily done in great displacements).***

***The deformations used in the relation of behavior are the deformations of GREEN\_LAGRANGE: key word “GREEN” under DEFORMATION (cf [U4.51.11]).***

## **5**

### ***Examples of implementation: case-tests***

#### ***· CABLE***

##### ***Statics***

##### ***non-linear***

***SSNL100A [V6.02.100]: This test simulates the installation of a cable with two ranges. The cable is fixed at***

***one of its ends, passes on a fast pulley towards the other end and rests in sound medium on a pulley placed at the bottom of a mobile suspension.***

##### ***Dynamics***

##### ***non-linear***

***SDNL100A [V5.02.100]: This test simulates the movement of a heavy bar articulated with one not fixed by one of its ends, free elsewhere and oscillating with great amplitude in vertical plane.***

#### ***· CABLE\_POULIE***

##### ***Statics***

##### ***non-linear***

***SSNL100A [V6.02.100]: This test simulates the installation of a cable with two ranges. The cable is fixed at***

***one of its ends, passes on a fast pulley towards the other end and rests in sound medium on a pulley placed at the bottom of a mobile suspension.***

## ***Instruction manual***

***U3.11 booklet: Mechanical elements of structure 1D  
HT-66/05/004/A***

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***Code\_Aster*** ®

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***7.4***

***Titrate:***

***Modelings CABLE and CABLE\_POULIE***

***Date:***

***01/06/05***

***Author (S):***

***J.M. PROIX, F. LEBOUVIER Key***

***:***

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**Code\_Aster** ®

**Version**

**7.4**

**Titrate:**

**Modelings POU\_D\_TG, POU\_D\_TGM**

**Date:**

**17/06/05**

**Author (S):**

**J.L. FLEJOU, F. LEBOUVIER Key**

**:**

**U3.11.04-F Page**

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**Organization (S): EDF-R & D /AMA, DeltaCAD**

**Instruction manual**

**U3.11 booklet: Mechanical elements of structure 1D**

**Document: U3.11.04**

**Modelings POU\_D\_TG, POU\_D\_TGM**

**Summary:**

*This document describes for modelings POU\_D\_TG and POU\_D\_TGM*

- *degrees of freedom carried by the finite elements which support modeling,*
- *the related meshes supports,*
- *supported loadings,*
- *nonlinear possibilities,*
- *case-tests implementing modelings*

*Modeling POU\_D\_TG corresponds to a formulation of elements of beams of fascinating Timoshenko in count a modeling of the warping of the section (cf [R3.08.03]).*

*Modeling POU\_D\_TGM is based on the same formulation and makes it possible to take into account one nonlinear behavior of multifibre type.*

*They are usable for problems of beams in isotropic linear mechanical analysis and in elastoplasticity.*

*Instruction manual*

*U3.11 booklet: Mechanical elements of structure 1D*

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*Code\_Aster ®*

*Version*

*7.4*

*Titrate:*

*Modelings POU\_D\_TG, POU\_D\_TGM*

*Date:*

*17/06/05*

*Author (S):*

*J.L. FLEJOU, F. LEBOUVIER Key*

*:*

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*1 Discretization*

*1.1*

*Degrees of freedom*

*The degrees of freedom are, in each node of the mesh support, the six components of displacement (three translations and three rotations) more one component (GRX) relating to warping of section compared to neutral fibre (cf [R3.08.03]).*

### ***Finite element***

***Degrees of freedom (with each node top)***

*POU\_D\_TG DX*

*DY*

*DZ*

*DRX*

*DRY*

*DRZ*

*GRX*

## ***1.2***

***Net support of the matrices of rigidity***

*The meshes support of the finite elements, in displacement formulation, are segments with two nodes SEG2:*

***Modeling Nets Element***

***finished***

***Remarks***

*POU\_D\_TG SEG2*

*MECA\_POU\_D\_TG*

*POU\_D\_TGM SEG2*

*MECA\_POU\_D\_TGM*

## ***2***

***Assignment of the characteristics***

*For these elements of structures 1D, it is necessary to affect geometrical characteristics which are complementary to the data of grid. The definition of these data is carried out with order AFFE\_CARA\_ELEM associated with the key words following factors:*

### ***· BEAM***

*Allows to define and affect the characteristics of the cross section.*

*Supported modelings: POU\_D\_TG, POU\_D\_TGM*

### ***· ORIENTATION***

*Allows to lay down and affect the orientation of the principal axes of inertia around fibre neutral.*

*Supported modelings: POU\_D\_TG, POU\_D\_TGM*

### **3 Loadings supported**

*The loadings specific, available in AFFE\_CHAR\_MECA are as follows:*

#### **· “CONTACT”**

*Allows to define the zones subjected to conditions of contact.*

*Supported modelings: POU\_D\_TG, POU\_D\_TGM*

#### **· “EPSI\_INIT”**

*Allows to apply a loading of initial deformation.*

*Supported modeling: POU\_D\_TG*

*Instruction manual*

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### **Code\_Aster ®**

*Version*

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*Titrate:*

*Modelings POU\_D\_TG, POU\_D\_TGM*

*Date:*

*17/06/05*

*Author (S):*

*J.L. FLEJOU, F. LEBOUVIER Key*

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#### **· “FORCE\_POUTRE”**

*Allows to apply linear forces*

*Supported modelings: POU\_D\_TG, POU\_D\_TGM*

#### **· “GRAVITY”**

*Allows to apply a loading of the gravity type.*

*Supported modelings: POU\_D\_TG, POU\_D\_TGM*

#### **· “TEMP\_CALCULEE”**



*Allows to apply a thermal loading.*

*Supported modelings: POU\_D\_TG, POU\_D\_TGM*

## **4 Possibilities**

### **non-linear**

#### **4.1**

##### **Laws of behaviors**

*Laws of behaviors specific to these modelings, usable under COMP\_INCR in STAT\_NON\_LINE, DYNA\_NON\_LINE and DYNA\_TRAN\_EXPLI are as follows (cf [U4.51.11]):*

***/“VMIS\_POU\_LINE”***

***/“VMIS\_CINE\_LINE”***

*Supported modeling: POU\_D\_TG*

*Supported modeling: POU\_D\_TGM*

***/“VMIS\_POU\_FLEJOU”***

***/“VMIS\_ISOT\_LINE”***

*Supported modeling: POU\_D\_TG*

*Supported modeling: POU\_D\_TGM*

***/“VMIS\_ISOT\_TRAC”***

*Supported modeling: POU\_D\_TGM*

***/“GRAN\_IRRA\_LOG”***

*Supported modeling: POU\_D\_TGM*

##### **Note:**

*It is possible for these modelings using a monodimensional state of stresses to use the behaviors 3D, for that it is necessary to use key word ALGO\_ID (METHODE= “DEBORST”).*

#### **4.2 Deformations**

*Deformations available, used in the relations of behavior under the key word DEFORMATION for operators STAT\_NON\_LINE and DYNA\_NON\_LINE are (cf [U4.51.11]):*

***/“SMALL”***

*The deformations used for the relation of behavior are the linearized deformations.*

***/“PETIT\_REAC”***

*The increments of deformations used in the incremental relation of behavior are them*

*linearized deformations of the increment of displacement in the reactualized geometry.*

**Note:**

*Attention, the calculation of the deformations using PETIT\_REAC is only one approximation of the assumption of great displacements. It requires to carry out very small increments of loading. To correctly take into account great displacements, and especially them great rotations, it is recommended to use modeling POU\_D\_T\_GD.*

*Instruction manual*

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**Code\_Aster** ®

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*Titrate:*

*Modelings POU\_D\_TG, POU\_D\_TGM*

*Date:*

*17/06/05*

*Author (S):*

*J.L. FLEJOU, F. LEBOUVIER Key*

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**5**

***Examples of implementation: case-test***

**· POU\_D\_TG**

*Statics*

*linear*

*SSLL102D [V3.01.102]: Analyze of a beam fixed at an end and subjected to unit efforts at the other end.*

*Statics*

*non-linear*

*SSNL106A [V6.02.106]: Analyze of a right beam embedded at an end and subjected to a displacement in traction and inflection at the other end, with a law of behavior elastoplastic or linear work hardening.*

*Dynamics*

*linear*

*SDLL01B [V2.02.01]: Seek frequencies of vibration and modes associated with one*

*short beam on simple supports.*

*Dynamics*

*non-linear*

*SSNL106I [V6.02.106]: Analyze of a right beam embedded at an end and subjected to one displacement in traction and inflection at the other end, with a law of behavior elastoplastic or linear work hardening. The analysis was carried out with the operator of nonlinear dynamics.*

*· POU\_D\_TGM*

*Statics*

*non-linear*

*SSNL122A [V6.01.122]: Analyze of a beam multifibre embedded at an end and subjected to a force at the other end.*

*Dynamics*

*linear*

*SDLL132A [V2.02.132]: Seek frequencies of vibration and clean modes associated of a frame.*

*Instruction manual*

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**Code\_Aster** ®

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7.4

*Titrate:*

*Modeling POU\_D\_T\_GD*

*Date:*

01/06/05

*Author (S):*

**J.L. FLEJOU, F. LEBOUVIER** *Key*

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

***Instruction manual***

***U3.11 booklet: Mechanical elements of structure 1D***

***Document: U3.11.05***

***Modeling POU\_D\_T\_GD***

***Summary:***

***This document describes for modeling POU\_D\_T\_GD:***

- *degrees of freedom carried by the finite elements which support modeling,*
- *the related meshes supports,*
- *supported loadings,*
- *nonlinear possibilities,*
- *case-tests implementing modeling.*

*Modeling POU\_D\_T\_GD corresponds to a formulation of elements of beams of fascinating Timoshenko in count great displacements and great rotations (cf [R5.03.40]).*

*It is usable for problems of three-dimensional beams in isotropic mechanical analysis and in linear elastic behavior.*

*Instruction manual*

*U3.11 booklet: Mechanical elements of structure 1D*

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Modeling POU\_D\_T\_GD*

*Date:*

*01/06/05*

*Author (S):*

*J.L. FLEJOU, F. LEBOUVIER Key*

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*1 Discretization*

*1.1*

*Degrees of freedom*

*The degrees of freedom are, in each node of the mesh support, the six components of displacement (three translations and three rotations).*

*Finite element*

*Degrees of freedom (with each node top)*

***POU\_D\_T\_GD DX  
DY  
DZ  
DRX  
DRY  
DRZ***

## ***1.2 Net support of the matrices of rigidity***

***The meshes support of the finite elements, in displacement formulation, are segments with two nodes  
SEG2:***

***Modeling Nets Element  
finished  
Remarks***

***POU\_D\_T\_GD SEG2  
MECA\_POU\_D\_T\_GD***

## ***2 Assignment of the characteristics***

***For these elements of structures 1D, it is necessary to affect geometrical characteristics which  
are complementary to the data of grid. The definition of these data is carried out with  
order AFFE\_CARA\_ELEM associated with the key words following factors:***

***· BEAM  
Allows to define and affect the characteristics of the cross section.***

***· ORIENTATION  
Allows to define and affect the principal axes of the cross sections of the elements of  
beam type.***

## ***3 Loadings supported***

***The loadings specific, available in AFFE\_CHAR\_MECA are as follows:***

***· “EPSI\_INIT”  
Allows to apply a loading of initial deformation.***

***· “FORCE\_POUTRE”***

*Allows to apply linear forces.*

· **“GRAVITY”**

*Allows to apply a loading of the gravity type.*

· **“TEMP\_CALCULEE”**

*Allows to apply a thermal loading.*

· **“INTE\_ELEC”**

*Allows to apply the force of LAPLACE acting on a principal driver, due to presence of a secondary driver not necessarily right compared to this driver the main thing.*

*Instruction manual*

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**Version**

**7.4**

**Titrate:**

**Modeling POU\_D\_T\_GD**

**Date:**

**01/06/05**

**Author (S):**

**J.L. FLEJOU, F. LEBOUVIER Key**

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**4 Possibilities**

**non-linear**

**4.1**

**Law of behaviors**

**The law of behavior specific to this modeling, usable under COMP\_ELAS in**

**STAT\_NON\_LINE and DYNA\_NON\_LINE are relation ELAS\_POUTRE\_GR (cf [U4.51.11]).**

**4.2 Deformations**

*Only deformation "GREEN\_GR" allowing to treat the beams in great displacements and in great rotations is available (cf [U4.51.11]). Deformations used in the relation of behavior are the deformations of GREEN-LAGRANGE.*

**5**

***Examples putting work modeling: case-test***

*· Non-linear Statique*

*SSNL103A [V6.02.103]: Calculation of the static deformation in great displacements and large rotations of a beam fixed at an end and subjected to one bending moment to the other end.*

*· Non-linear Dynamique*

*SDNL103A [V5.02.103]: Analyze response of a gantry embedded in feet and subjected to one force dynamic applied in the middle of its span and perpendicular to its plan.*

*Instruction manual*

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*Titrate:*

*Modeling POU\_D\_T\_GD*

*Date:*

*01/06/05*

*Author (S):*

***J.L. FLEJOU, F. LEBOUVIER*** Key

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***Code\_Aster*** ®

*Version*

*7.4*

*Titrate:*

*Modelings TUYAU\_3M and TUYAU\_6M*

*Date:*

*01/06/05*

*Author (S):*

***J.L. FLEJOU, F. LEBOUVIER*** *Key*

*:*

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

***Instruction manual  
U3.11 booklet: Mechanical elements of structure 1D  
Document: U3.11.06***

***Modelings TUYAU\_3M and TUYAU\_6M***

***Summary:***

***This document describes for modelings TUYAU\_3M and TUYAU\_6M:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported loadings,***
- non-linear possibilities,***
- case-tests implementing modelings.***

***Modelings TUYAU\_3M and TUYAU\_6M correspond to a formulation of linear elements of piping right-hand side or curve, which are based on a kinematics of beam of Timoshenko for displacements and them***

***rotations of average fibre and on a kinematics of hull for the deformations of the transverse section (ovalization, warping, swelling). These transverse deformations are broken up into series of Fourier. Modeling TUYAU\_3M takes into account 3 modes to the maximum, while modeling TUYAU\_6M takes into account 6 modes of Fourier.***

***These modelings are usable for problems of three-dimensional pipings in mechanical analysis linear or not linear and in small displacements.***

***Instruction manual  
U3.11 booklet: Mechanical elements of structure 1D  
HT-66/05/004/A***

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***Code\_Aster ®***

***Version***

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***Titrate:***

***Modelings TUYAU\_3M and TUYAU\_6M***

***Date:***

***01/06/05***

***Author (S):***

***J.L. FLEJOU, F. LEBOUVIER Key***

***:***

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***1 Discretization***

***1.1***

***Degrees of freedom***

***The degrees of freedom are, in each node of the mesh support:***

- six components of displacement of average fibre (three translations and three rotations),***
- three degrees of freedom corresponding to modes 0 and 1,***
- for each mode of Fourier 6 degrees of freedom (U corresponds to warping, V with orthoradial displacement, W with radial displacement).***

***Finite element***

***Degrees of freedom (with each node top) Remarks***

***TUYAU\_3M DX***

***DY***

***DZ***

***DRX***

***DRY***

***DRZ***

***W0***

***W11***

***W01***

***UI2***

***VI2***

***WI2***

***UO2***

**VO2**

**WO2**

**mode 2**

**UI3**

**VI3**

**WI3**

**UO3**

**VO3**

**WO3**

**mode 3**

**TUYAU\_6M DX**

**DY**

**DZ**

**DRX**

**DRY**

**DRZ**

**W0**

**W11**

**W01**

**UI2**

**VI2**

**WI2**

**UO2**

**VO2**

**WO2**

**mode 2**

**UI3**

**VI3**

**WI3**

**UO3**

**VO3**

**WO3**

**mode 3**

**UI4**

**VI4**

**WI4**

**UO4**

**VO4**

**WO4**

**mode 4**

UI5  
VI5  
WI5  
UO5  
VO5  
WO5  
mode 5  
UI6  
VI6  
WI6  
UO6  
VO6  
WO6  
mode 6

## **1.2**

### ***Net support of the matrices of rigidity***

*The meshes support of the finite elements, in displacement formulation, are segments with 3 or 4 nodes.*

#### ***Modeling Nets Element finished Remarks***

*TUYAU\_3M SEG3 MET3SEG3*

*SEG4  
MET3SEG4*

*TUYAU\_6M SEG3 MET6SEG3*

*Instruction manual  
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*Date:*

01/06/05

*Author (S):*

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## **2**

### **Assignment of the characteristics**

*For these elements of structures 1D, it is necessary to affect geometrical characteristics which are complementary to the data of grid. The definition of these data is carried out with order AFFE\_CARA\_ELEM associated with the key words following factors:*

#### **· BEAM**

*Allows to define and affect the characteristics of the cross section.*

*Supported modelings: TUYAU\_3M, TUYAU\_6M*

#### **· ORIENTATION**

*Allows to define and affect a generator.*

*Supported modelings: TUYAU\_3M, TUYAU\_6M*

#### **· MASSIVE**

*Optional, allows to define and affect a direction of growth (necessary only in the case of a law of behavior ASSE\_COMBU).*

*Supported modelings: TUYAU\_3M, TUYAU\_6M*

## **3 Loadings supported**

*The loadings available are as follows:*

#### **· “FORCE\_POUTRE”**

*Allows to apply linear forces*

*Supported modelings: TUYAU\_3M, TUYAU\_6M*

#### **· “FORCE TUYAU”**

*Allows to apply a pressure in the pipe.*

*Supported modelings: TUYAU\_3M, TUYAU\_6M*

#### **· “GRAVITY”**

Allows to apply a loading of the gravity type.  
Supported modelings: TUYAU\_3M, TUYAU\_6M

· **“TEMP\_CALCULEE”**

Allows to apply a thermal loading.  
Supported modelings: TUYAU\_3M, TUYAU\_6M

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**4 Possibilities  
non-linear**

**4.1  
Law of behaviors**

All the laws of behaviors available in *C\_PLAN* are usable under *COMP\_INCR* in *STAT\_NON\_LINE* and *DYNA\_NON\_LINE* (cf [U4.51.11]).

**4.2 Deformations**

**Only the linearized deformations “SMALL” key word under DEFORMATION are available in relations of behavior (cf [U4.51.11]).**

## ***Examples of implementation: case-tests***

### ***· TUYAU\_3M***

*Statics*

*linear*

***FORMA01E [V7.15.100]: Analyze of a piping comprising an elbow embedded with one end and subjected to a force at the other end.***

***SSLL106A [V3.01.106]: Quasi-static analysis of a pipe right embedded at an end and subjected to a traction, 2 efforts sharp, 2 bending moments and a torsion with the other end. One applies moreover one internal pressure, a linear force distributed and one thermal dilation.***

*Statics*

*non-linear*

***SSNL117A [V6.02.117]: Elastoplastic analysis of an elbow embedded at an end and subjected to a loading of inflection in its plan at the other end.***

*Dynamics*

*linear*

***SDLL14A [V2.02.014]: Seek Eigen frequencies and modes associated with one bent piping.***

*Dynamics*

*non-linear*

***SDNL113A: Elastoplastic dynamic response of a piping in the shape of subjected quadrant with a seismic loading.***

### ***· TUYAU\_6M***

*Statics*

*linear*

***SSLL106C [V3.01.106]: Quasi-static analysis of a pipe right embedded at an end and subjected to a traction, 2 efforts sharp, 2 bending moments and a torsion with the other end. One applies moreover one internal pressure, a linear force distributed and one thermal dilation.***

*Statics*

*non-linear*

***HSNV100D [V7.22.100]: Analyze thermoplastic in simple traction of a right pipe.***

*Dynamics*

*linear*

***SDLL14B [V2.02.014]: Seek Eigen frequencies and modes associated with one bent piping.***

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**Code\_Aster** ®

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*Titrate:*

**Modeling POU\_D\_EM**

*Date:*

17/06/05

*Author (S):*

**J.L. FLEJOU, F. LEBOUVIER** Key

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

***Instruction manual***

***U3.11 booklet: Mechanical elements of structure 1D***

***Document: U3.11.07***

***Modeling POU\_D\_EM***

***Summary:***

***Modeling POU\_D\_EM corresponds to the formulation of elements of multifibre beam (beam of section heterogeneous divided into several fibres).***

***They are usable for three-dimensional problems in linear and nonlinear mechanical analysis.***

***Instruction manual***

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***Code\_Aster ®***

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***Titrate:***

***Modeling POU\_D\_EM***

***Date:***

***17/06/05***

***Author (S):***

***J.L. FLEJOU, F. LEBOUVIER Key***

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***1 Discretization***

***1.1***

***Degrees of freedom***

***For the modeling of multifibre beam into three-dimensional the degrees of freedom of discretization are,***

***in each node of the mesh support, six components of displacement (three translations and three rotations). These nodes are supposed to describe a segment of average fibre of the beam.***

***Finite element***

***Degrees of freedom (with each node top)***

***POU\_D\_EM***

***DX***

***DY***

***DZ***

***DRX***

***DRY***

***DRZ***

***1.2***

***Net support of the matrices of rigidity***

***The meshes support of the finite elements, in displacement formulation, are segments with two nodes SEG2:***

***Modeling Nets Element***

***finished***

***Remarks***

***POU\_D\_EM SEG2***

***MECA\_POU\_D\_EM***

***1.3***

***Net support of the loadings***

***As for the traditional elements of beam (POU\_D\_E), all loadings applicable to elements of multifibre beam are treated by direct discretization on the mesh support of the element in displacement formulation.***

***No mesh support of loading is thus necessary for the edge of the elements of beam or of bar.***

***1.4***

***Principal characteristics of modeling***

***Modeling POU\_D\_EM is based on the resolution of a problem of beam for which each definite section is divided into several fibres.***

***Each fibre behaves then like a beam of Euler, i.e. the sections remain right and perpendicular to average fibre (assumption of great twinge).***

***The section can be of an unspecified form.***

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Date:

17/06/05

Author (S):

**J.L. FLEJOU, F. LEBOUVIER** Key

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2

## **Assignment of the characteristics**

*For this element of structures 1D, it is necessary to affect geometrical characteristics which are complementary to the data of grid. The definition of these data is carried out with order **AFFE\_CARA\_ELEM** associated with the key words following factors:*

### **· AFFE\_SECT**

*Allows to associate a plane grid of section an element beam.*

### **· AFFE\_FIBRE**

*Allows to associate a section made up of one or more specific fibres an element beam.*

### **· BEAM**

*Allows to associate a geometrical characteristic of torsion an element beam.*

### **· ORIENTATION**

*Allows “to turn” the plane grid of the section around the axis of the beam.*

## **Remarks on the characteristics of modeling:**

*1) Within the framework of modeling of a multifibre type, there are two “levels” of modeling. It y with the modeling known as “longitudinal” which will be represented by a beam (support geometrical SEG2) and a modeling planes section (perpendicular to the SEG2).*

*Operand **AFFE\_SECT** makes it possible to associate a plane grid of section an element beam.*

*Operand **AFFE\_FIBRE** makes it possible to associate a section made up of one or more specific fibres (defined by their position and surfaces) with an element beam.*

2) In general in the plane modeling of the section, several materials cohabit. By example, in a section concrete reinforced, there are at the same time concrete and reinforcements. In it case there, operator **CREA\_MAILLAGE** makes it possible to duplicate support E.F so that there is not that only one material by support.

3) The operand

**BEAM** is used to affect a geometrical characteristic of torsion (**JX**)

who cannot be calculated starting from the plane grid of the section. If the value is used **GENERAL** for the key word **SECTION** of the operand **BEAM**, it is necessary to give the characteristics (**CARA**) With, **IY** and **IZ** in addition to **JX** because operator **AFPE\_CARA\_ELEM** waits at least these four characteristics for a traditional beam.

Values (**VALE**) data with **A**, **IY** and **IZ** are not used by element **POU\_D\_EM**, because they are calculated starting from the plane grid of the section. On the other hand a checking of coherence of the information (**SURFACE** and **INERTIA**) provided on the one hand by **A**, **IY**, **IZ** and of other

leaves by key words **AFPE\_SECT** and **AFPE\_FIBRE** is carried out. The criterion of error is based on the error relating and is compared either with the default value or to that given by the user via key words **PREC\_AIRE** and **PREC\_INERTIE**. (Cf orders **AFPE\_CARA\_ELEM** key words **PREC\_AIRE** and **PREC\_INERTIE** of the operand **BEAM**).

4) The operand

**ORIENTATION** is used in general “to turn” the plane grid of the section around the axis of beam (**CARA** “**ANGL\_VRIL**”). Indeed, by defect, axis **X** (horizontal) plane grid of the section is confused with the axis there beam (see [Figure 3-a]).

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*Y*

*P*

*y*

*X*

*X*

*P*

*Z*

*P*

*Element beam*

*Grid section*

***Appear 3-a: Orientation by defect of the plane grid compared to the element beam***

### ***3 Loadings supported***

*The loadings available are as follows:*

· ***“FORCE\_POUTRE”***

*Allows to apply linear forces.*

· ***“GRAVITY”***

*Allows to apply a loading of the gravity type.*

· ***“ROTATION”***

*Allows to define the number of revolutions and the vector of rotation.*

· ***“TEMP\_CALCULEE”***

*Allows to apply a thermal loading.*

## **4 Possibilities**

### **non-linear**

#### **4.1**

##### **Law of behaviors**

Laws of behaviors specific to this modeling, usable under *COMP\_INCR* in *STAT\_NON\_LINE* and *DYNA\_NON\_LINE* are as follows (cf [U4.51.11]):

**/"CORR\_ACIER"**

**/"LABORD\_1D"**

**/"PINTO\_MENEGOTTO"**

**/"VMIS\_CINE\_LINE"**

**/"VMIS\_ISOT\_LINE"**

**/"VMIS\_ISOT\_TRAC"**

**/"GRAN\_IRRA\_LOG"**

Moreover, it is possible for this modeling, which uses a monodimensional state of stresses to use the behaviors 3D by using key word *ALGO\_1D* (*METHOD = DEBORST*).

#### **4.2 Deformations**

Only the linearized deformations "*SMALL*" key word under *DEFORMATION* are available in relations of behavior (cf [U4.51.11]).

##### **Instruction manual**

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**Examples of implementation: case-tests**

**· Linear Statique**

**SSLL111A [V3.01.111]: Static response of a concrete beam reinforced (section in T) with one linear behavior subjected to three successive loading cases: a specific force, the weight clean and a rise in temperature.**

**· Non-linear Statique**

**SSNL119A [V6.02.119]: Deflection test 3 points, static response of a reinforced concrete beam (rectangular section) with a nonlinear behavior of Borderie.**

**· Linear Dynamique**

**SDLL130B [V2.02.130]: Seismic response of a reinforced concrete beam (rectangular section) to linear behavior.**

**· Non-linear Dynamique**

**SDNL130A [V5.02.130]: Seismic response of a reinforced concrete beam (rectangular section) to nonlinear behavior.**

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**Modeling POU\_D\_EM**

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**J.L. FLEJOU, F. LEBOUVIER Key**

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Modelings DKT - DST - Q4G*

*Date:*

*01/06/05*

*Author (S):*

*X. DESROCHES, F. LEBOUVIER Key*

*:*

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

***Instruction manual***  
***U3.12 booklet: Mechanical elements of structure 2D***  
***Document: U3.12.01***

***Modelings DKT - DST - Q4G***

***Summary:***

***This document describes for modelings DKT - DST - Q4G:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported loadings,***
- nonlinear possibilities,***
- case-tests implementing modelings.***

***They are usable for problems of plate into three-dimensional [R3.07.03] in mechanical analysis linear for all modelings and in nonlinear material for modeling DKT only. Their use for problems of hull is usually allowed by considering that the plan of the element is comparable to a tangent facet with the average layer of the hull (attention, only the plane facets are allowed).***

***Thermomechanical calculations are chained starting from the finite elements of thermal hulls (see [U3.22.01]).***

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***Code\_Aster*** ®

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***Modelings DKT - DST - Q4G***

*Date:*

*01/06/05*

*Author (S):*

*X. DESROCHES, F. LEBOUVIER Key*

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## *1 Discretization*

### *1.1*

#### *Degrees of freedom*

*For three modelings of plate into three-dimensional the degrees of freedom of discretization are, in each node of the mesh support six components of displacement (three translations and three rotations) with the nodes tops of the mesh support. These nodes are supposed to describe a facet tangent with the average layer of the hull.*

#### *Finite element*

*Degrès of freedom (with each node top)*

*DKT/DKQ*

*DX*

*DY*

*DZ*

*DRX*

*DRY*

*DRZ*

*DST/DSQ*

*DX*

*DY*

*DZ*

*DRX*

*DRY*

*DRZ*

*Q4G (Q4)*

*DX*

*DY*

*DZ*

*DRX*

*DRY*

*DRZ*

## **1.2**

### ***Net support of the matrices of rigidity***

***The meshes support of the finite elements, in displacement formulation, can be triangles or quadrangles. In this last case, the meshes are supposed to be plane (4 nodes tops coplanar):***

#### ***Modeling Nets Element***

***finished***

***Remarks***

***DKT TRIA3***

***MEDKTR3***

***QUAD4***

***MEDKQU4***

***DST TRIA3***

***MEDSTR3***

***QUAD4***

***MEDSQU4***

***Q4G (Q4)***

***QUAD4 MEQ4QU4***

## **1.3**

### ***Net support of the loadings***

***All the loadings applicable to the facets of the elements of plate are treated by discretization direct on the mesh support of the element in displacement formulation.***

***No mesh support of loading is thus necessary for the faces of the elements of plates.***

***For the applicable loadings on the edges of the elements of plate, a mesh support of the type SEG2 is usable:***

#### ***Modeling Nets Element***

***finished***

***Remarks***

***DKT SEG2***

***MEBODKT***

***DST SEG2***

**MEBODST**  
**Q4G (Q4)**  
**SEG2 MEBOQ4G**

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**2**  
**Assignment of the characteristics**

**For these elements of plate or hulls, it is necessary to affect characteristics geometrical which is complementary to the data of grid. The definition of these data is carried out with order AFFE\_CARA\_ELEM associated with the key word following factor:**

**· HULL**  
**Allows to define and affect on the meshes, the thickness, the coefficient of shearing, offsetting,...**

**For the study of structures comprising of multi-layer materials it is necessary to affect them characteristics of each layer (thickness, type of material) and their stacking (orientation of fibres). The definition of these data is carried out with the order DEFI\_COQU\_MULT.**

**3 Loadings**  
**supported**

*The loadings available are as follows:*

· **FORCE\_ARETE**

*Allows to apply linear forces.*

*Supported modelings: DKT, DST, Q4G*

· **FORCE\_COQUE**

*Allows to apply surface efforts.*

*Supported modelings: DKT, DST, Q4G*

· **GRAVITY**

*Allows to define the acceleration and the direction of gravity.*

*Supported modelings: DKT, DST, Q4G*

· **PRES\_REP**

*Allows to apply surface efforts.*

*Supported modelings: DKT, DST, Q4G*

· **TEMP\_CALCULEE**

*Allows to apply a thermal loading of origin.*

*Supported modelings: DKT, DST, Q4G*

· **EPSI\_INIT**

*Allows to apply a loading of initial deformation.*

*Supported modelings: DKT, DST, Q4G*

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## **4 Possibilities non-linear**

**For modeling DKT only.**

### **4.1 Law of behaviors**

**Only modeling "DKT" has non-linear possibilities. Laws of behaviors specific to this modeling, usable under COMP\_INCR in STAT\_NON\_LINE and DYNA\_NON\_LINE are the relations of behavior in plane constraints available with modelings "AXIS" and "C\_PLAN". These relations are to be used with the key word ALGO\_C\_PLAN = 'DEBORST' (cf [U4.51.11]).**

### **4.2 Deformations**

**Deformations available, used in the relations of behavior under the key word DEFORMATION for operators STAT\_NON\_LINE and DYNA\_NON\_LINE are (cf [U4.51.11]):**

**/"SMALL"**

**The deformations used for the relation of behavior are the deformations linearized.**

**/"PETIT\_REAC"**

**The increments of deformations used in the incremental relation of behavior are linearized deformations of the increment of displacement in the reactualized geometry.**

**Note:**

**Attention, the calculation of the deformations using PETIT\_REAC is only one approximation of assumptions of great displacements. It requires to carry out very small increments of loading. To correctly take into account great displacements, and especially them great rotations, it is recommended to use modeling COQUE\_3D, with DEFORMATION='GREEN\_GR'.**

## **5 List cases tests available**

**· DKT  
Statics  
linear  
FORMA01B [V7.15.100]: Analyze of a piping comprising an elbow subjected to one**

*specific force and with an internal pressure.*

*SSLS100A [V3.03.100]: Plate circular embedded on its contour, subjected to one uniform pressure, with a normal force and its actual weight.*

*Statics*

*non-linear*

*SSNL501C [V6.02.501]: Quasi-static analysis of a beam fixed to both ends, subjected to a uniform pressure, with an elastic material perfectly plastic.*

*Dynamics*

*linear*

*SDLS03C: Seek Eigen frequencies and modes associated with a plate rectangular thin in simple support on its edges.*

*Dynamics*

*non-linear*

*ELSA01D: Non-linear dynamic response of a piping in the shape of quadrant (elsa) subjected to a seismic loading.*

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*Modelings DKT - DST - Q4G*

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*· DST*

*Statics*

*linear*

*SSLS101F [V3.03.101]: Plate circular posed on the edge, subjected 3 loadings: actual weight, pressure and effort distributed constant.*

*HSL501A [V7.11.001]: Analyze of a thin square plate embedded on its contour*



*subjected to a heat gradient in the thickness.*

*Dynamics*

*linear*

*SDLS03A: Seek Eigen frequencies and modes associated with a plate rectangular thin in simple support on its edges.*

*· Q4G*

*Statics*

*linear*

*SLS101H [V3.03.101]: Plate circular posed on the edge under 3 loadings: weight clean, pressure and effort distributed constant.*

*HSL01B [V7.11.001]: Analyze of a thin square plate embedded on its contour subjected to a heat gradient in the thickness.*

*Dynamics*

*linear*

*SDLS03B: Seek Eigen frequencies and modes associated with a plate rectangular thin in simple support on its edges.*

*Instruction manual*

*U3.12 booklet: Mechanical elements of structure 2D*

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Modelings DKT - DST - Q4G*

*Date:*

*01/06/05*

*Author (S):*

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*Instruction manual*

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*Version*

7.4

*Titrate:*

*Modelings COQUE\_C\_PLAN, COQUE\_D\_PLAN, COQUE\_AXIS*

*Date:*

03/06/05

*Author (S):*

**X. DESROCHES, F. LEBOUVIER** *Key*

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

***Instruction manual***

***U3.12 booklet: Mechanical elements of structure 2D***

***Document: U3.12.02***

***Modelings COQUE\_C\_PLAN, COQUE\_D\_PLAN,  
COQUE\_AXIS***

***Summary:***

***This document describes for modelings COQUE\_C\_PLAN, COQUE\_D\_PLAN, COQUE\_AXIS:***

***· degrees of freedom carried by the finite elements which support modeling,***

- *the related meshes supports,*
- *supported loadings,*
- *nonlinear possibilities,*
- *case-tests implementing modelings.*

*Three thermoelastoplastic modelings COQUE\_C\_PLAN, COQUE\_D\_PLAN, COQUE\_AXIS correspond to a formulation resulting from the models 3D with a kinematics of hull [R3.07.02].*

*They are usable to model structures on average surface of particular geometry:*

- *hulls with symmetry of revolution around axis OY,*
- *cylindrical hulls with unspecified section invariant along axis OZ.*

*Thermomechanical calculations are chained starting from the finite elements of thermal hulls (see [U3.22.01]).*

*Instruction manual*

*U3.12 booklet: Mechanical elements of structure 2D*

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Modelings COQUE\_C\_PLAN, COQUE\_D\_PLAN, COQUE\_AXIS*

*Date:*

*03/06/05*

*Author (S):*

*X. DESROCHES, F. LEBOUVIER Key*

*:*

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*1 Discretization*

*1.1*

*Degrees of freedom*

*For three modelings of hull the degrees of freedom of discretization are, in each node of the mesh support, three components of displacement (two translations and a rotation). nodes are supposed to belong to the average surface of the hull.*

*Finite element*

***Degrees of freedom (with each node top)***

***METCSE3***

***DX***

***DY***

***DRZ***

***METDSE3***

***DX***

***DY***

***DRZ***

***MECXSE3***

***DX***

***DY***

***DRZ***

***1.2***

***Net support of the matrices of rigidity***

***The meshes support of the finite elements, in displacement formulation, are segments with three nodes:***

***Modeling Nets Element***

***finished***

***Remarks***

***COQUE\_C\_PLAN***

***SEG3***

***METCSE3***

***COQUE\_D\_PLAN***

***SEG3***

***METDSE3***

***COQUE\_AXIS***

***SEG3***

***MECXSE3***

## **1.3**

### ***Net support of the loadings***

***All the applicable loadings on the average surface of the elements of hull are treated by direct discretization on the mesh support of the element in displacement formulation.***

***No mesh support of loading is thus necessary for the faces of the elements of hulls.***

***For imposed displacements the meshes support are meshes reduced to a point.***

***For modeling COQUE\_C\_PLAN, the width of the hull (in direction Z) is by convention equalize with the unit. If one must model a width different from the unit, it is advisable to take it in count by modifying for example the loading.***

## **2**

### ***Assignment of the characteristics***

***For these elements of structures 2D, it is necessary to affect geometrical characteristics which are complementary to the data of grid. The definition of these data is carried out with order AFFE\_CARA\_ELEM associated with the key word following factor:***

***· HULL***

***Allows to define and affect on the meshes, the thickness, the coefficient of shearing, offsetting,...***

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***Titrate:***

***Modelings COQUE\_C\_PLAN, COQUE\_D\_PLAN, COQUE\_AXIS***

***Date:***

***03/06/05***

***Author (S):***

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***:***

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### **3 Loadings supported**

*The loadings available are as follows:*

· **“FORCE\_COQUE”**

*Allows to apply surface efforts.*

*Supported modelings: COQUE\_C\_PLAN, COQUE\_D\_PLAN, COQUE\_AXIS*

· **“PRES\_REP”**

*Allows to apply a pressure to a field of continuous medium.*

*Supported modelings: COQUE\_C\_PLAN, COQUE\_D\_PLAN, COQUE\_AXIS*

· **“TEMP\_CALCULEE”**

*Allows to apply a thermal loading.*

*Supported modelings: COQUE\_C\_PLAN, COQUE\_D\_PLAN, COQUE\_AXIS*

· **“ROTATION”**

*Allows to define the number of revolutions and the vector of rotation.*

*Supported modelings: COQUE\_C\_PLAN, COQUE\_D\_PLAN, COQUE\_AXIS*

· **“GRAVITY”**

*Allows to apply a loading of the gravity type.*

*Supported modelings: COQUE\_C\_PLAN, COQUE\_D\_PLAN, COQUE\_AXIS*

### **4 Possibilities non-linear**

#### **4.1**

##### **Law of behaviors**

*Laws of behaviors specific to these modelings, usable under COMP\_INCR in STAT\_NON\_LINE and DYNA\_NON\_LINE are the relations of behavior in plane constraints available with modelings “AXIS” and “C\_PLAN”. These relations are to be used with the key word ALGO\_C\_PLAN = ' DEBORST ' (cf [U4.51.11]).*

#### **4.2 Deformations**

*Only the linearized deformations “SMALL” key word under DEFORMATION are available in*

*relations of behavior (cf [U4.51.11]).*

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***Titrate:***

***Modelings COQUE\_C\_PLAN, COQUE\_D\_PLAN, COQUE\_AXIS***

***Date:***

***03/06/05***

***Author (S):***

***X. DESROCHES, F. LEBOUVIER*** Key

***:***

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***5***

***Examples of implementation: case-tests***

***· COQUE\_D\_PLAN***

***Statics***

***linear***

***SSLS114K [V3.03.114]: Quasi-static analysis of a cylindrical quarter of binding ring subjected to a pressure.***

***Statics***

***non-linear***

***SSNV115F [V6.04.115]: Elastoplastic non-linear quasi-static analysis of a sheet undulated with a law of behavior with criterion of Von Misès with linear work hardening, subjected has efforts of membrane and inflection.***

***Dynamics***

***linear***

***SDLS501B [V2.03.501]: Seek Eigen frequencies and modes associated with one iron corrugated into free-free.***

***· COQUE\_C\_PLAN***

***Statics***

***linear***

***SSLS114J [V3.03.114]: Quasi-static analysis of a cylindrical quarter of binding ring subjected to one pressure.***



**Statics**

**non-linear**

**SSNL501A [V6.02.501]: Analyze of a beam, made up of an elastic material perfectly plastic, embedded at the two ends and subjected to a uniform pressure.**

**Dynamics**

**linear**

**SDLL02C [V2.02.002]: Seek frequencies of vibration and modes associated with one hurred, embed-free beam folded up on itself.**

**· COQUE\_AXIS**

**Statics**

**linear**

**SSLS114I [V3.03.114]: Quasi-static analysis of a cylindrical quarter of binding ring subjected to one pressure.**

**Instruction manual**

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**Code\_Aster ®**

**Version**

**7.4**

**Titrate:**

**Modeling COQUE\_3D**

**Date:**

**01/06/05**

**Author (S):**

**X. DESROCHES, F. LEBOUVIER Key**

**:**

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**Organization (S): EDF-R & D /AMA, DeltaCAD**

***Instruction manual***

***U3.12 booklet: Mechanical elements of structure 2D***

***Document: U3.12.03***

***Modeling COQUE\_3D***

***Summary:***

*Modeling COQUE\_3D presented here corresponds to a formulation of general kinematics of hulls and plates, of Naghdi-Reissner type, where the generalized constraints are obtained starting from the laws of three-dimensional behavior of constitutive materials [R3.07.04]. Contrary to modelings DKT-DST, Q4G corresponding to the formulations of elements of plate developed by J.L. BATOZ [bib1] which use plane finite elements, modeling COQUE\_3D makes it possible to carry out structural analyses hulls of forms*

*unspecified, with a good approximation of the geometry. Moreover this modeling is able of to represent great rotations of the structures [R3.07.05] under the assumption of small deformations.*

*The degrees of freedom are displacements and the rotations, taken with the nodes of the elements.*

*The nonlinear behavior is discretized by P2 polynomials, which allows a precise calculation of constraints.*

*It is usable for problems of structures three-dimensional hulls in linear mechanical analysis and nonlinear.*

*This formulation also exists for problems of sections, or revolution. It rests on elements 1D: (see [U3.12.02]).*

*Thermomechanical calculations are chained starting from the finite elements of thermal hulls (see [U3.22.01]).*

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*Modeling COQUE\_3D*

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*:*  
*U3.12.03-D Page*  
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## *1 Discretization*

### *1.1* *Degrees of freedom*

*For modeling hull into three-dimensional the degrees of freedom of discretization are, in each node of the mesh support six components of displacement (three translations and three rotations) with the nodes tops and mediums on the sides of the mesh support. With the central node of the mesh support the degrees of freedom are reduced to only rotations. These nodes belong to the average layer of the hull.*

*Modeling*  
*Degrees of freedom (with each node)*  
*COQUE\_3D*  
*DX DY DZ DRX DRY DRZ*  
*DRX DRY DRZ only with the central node*

### *1.2* *Net support of the matrices of rigidity, mass...*

*The meshes support of the finite elements, in displacement formulation, can be triangles with 7 nodes or of the quadrangles with 9 nodes. These meshes are not supposed to be plane; they are created starting from grids in TRIA6 and QUAD8 by order CREA\_MAILLAGE (see [U4.23.02]).*

*Modeling Nets Element*  
*finished*  
*COQUE\_3D TRIA7 MEC3TR7H*  
*QUAD9*  
*MEC3QU9H*

## **1.3**

### ***Net support of the loadings***

***All the loadings applicable to the facets of the elements of hull are treated by discretization direct on the mesh support of the element in displacement formulation.***

***No mesh support of loading is thus necessary for the faces of the elements of hull.***

***For the applicable loadings on the edges of the elements of hull, a mesh support of the type SEG3 is usable:***

### ***Modeling Nets Element***

***finished***

***Remarks***

***COQUE\_3D SEG3 MEBOCQ3***

## **2**

### ***Assignment of the characteristics***

***For these elements of structures 2D 1/2, it is necessary to affect geometrical characteristics who are complementary to the data of grid. The definition of these data is carried out with order AFFE\_CARA\_ELEM associated with the key word following factor:***

#### ***· HULL***

***Allows to define and affect on the meshes, the thickness, the coefficient of shearing, offsetting,...***

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***Modeling COQUE\_3D***

***Date:***

***01/06/05***

***Author (S):***

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:  
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### **3 Loadings supported**

*The loadings available are as follows:*

· **“FORCE\_ARETE”**

*Allows to apply linear forces, with an edge of voluminal element.*

· **“FORCE\_COQUE”**

*Allows to apply surface efforts.*

· **“GRAVITY”**

*Allows to apply a loading of the gravity type.*

· **“TEMP\_CALCULEE”**

*Allows to apply a thermal loading.*

· **“PRES\_REP”**

*Allows to apply a pressure to a field of continuous medium.*

· **“ROTATION”**

*Allows to define the number of revolutions and the vector of rotation.*

### **4 Possibilities non-linear**

#### **4.1**

##### **Law of behaviors**

*All relations in constraints plane, usable under COMP\_INCR in STAT\_NON\_LINE, and DYNA\_NON\_LINE are available, like all the other relations 3D while using ALGO\_C\_PLAN = “DEBORST” (cf [U4.51.11]).*

#### **4.2 Deformations**

*Deformations available, used in the relations of behavior under the key word DEFORMATION for operators STAT\_NON\_LINE and DYNA\_NON\_LINE are (cf [U4.51.11]):*

**/“SMALL”**

*The deformations used for the relation of behavior are the deformations*

*linearized.*

*/“PETIT\_REAC”*

*The increments of deformations used in the incremental relation of behavior are linearized deformations of the increment of displacement in the reactualized geometry.*

*/“GREEN\_GR”*

*Allows to carry out calculations in great displacements and great rotations. deformations used in the relation of behavior are the deformations of GREEN-LAGRANGE.*

*Note:*

- Attention, the calculation of the deformations using PETIT\_REAC is only one approximation of assumptions of great displacements. It requires to carry out very small increments of loading. To correctly take into account great displacements, and especially them great rotations, it is recommended to use DEFORMATION=' GREEN\_GR'.*
- It is possible while using under the key word factor EXCIT (TYPE\_CHARGE=' SUIV') of to take into account a following pressure.*

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*5*

*Examples of implementation: case-tests*

*· Linear Statique*

***SSLP304C [V3.02.304]: Analyze of an orthotropic square plate subjected to a uniaxial traction out of the axes of orthotropism***

***· Non-linear Statique***

***HPLA100C [V7.01.100]: Thermoelastic analysis of a heavy hollow roll in uniform rotation.***

***· Linear Dynamique***

***SDLS01E [V2.03.01]: Calculation of the frequencies and the modes associated with inflection of a plate***

***square thin into free-free and embedded on an edge.***

## ***6 Bibliography***

***[1]***

***J.L. BATOZ, G. DHATT: Modeling of the structures by finite elements. Vol.2 - beams and plates - HERMES, PARIS, 1990.***

***Instruction manual***

***U3.12 booklet: Mechanical elements of structure 2D***

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***Code\_Aster ®***

***Version***

***7.3***

***Titrate:***

***Modeling ROASTS and GRILLE\_MEMBRANE***

***Date:***

***14/09/04***

***Author (S):***

***P. BADEL, C. CHAVANT Key***

***:***

***U3.12.04-B2 Page:***

***1/6***

***Organization (S): EDF-R & D /AMA***

***Instruction manual***  
***U3.12 booklet: Mechanical elements of structure 2D***  
***U3.12.04 document***

***Modeling ROASTS and GRILLE\_MEMBRANE***

***Summary:***

***This document describes for modelings ROASTS and GRILLE\_MEMBRANE:***

- degrees of freedom carried by the finite elements which support modeling,*
- the related meshes supports,*
- supported materials and loadings,*
- options of calculations for the elementary matrices and the post treatments,*
- nonlinear possibilities as well as the options of the breaking process if they exist.*

*Modeling ROASTS (Phenomenon: MECHANICS) corresponds to finite elements of which the meshes supports*

*are triangles with three nodes and is used to represent the reinforcements for modelings concrete reinforced with type hull. Indeed, it makes it possible to take into account the offsetting of the tablecloths of reinforcements compared to average layer.*

*Modeling GRILLE\_MEMBRANE (phenomenon: MECHANICS) corresponds to finite elements of which them*

*meshes supports are triangles with three nodes and quadrangles with four nodes and is used to represent them reinforcements for modelings concrete reinforced with massive type 3D. Indeed, it does not make it possible to take in*



*count offsetting and thus does not require a degree of freedom of rotation, useless in modeling 3D.*

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***P. BADEL, C. CHAVANT*** *Key*

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## ***1 Discretization***

### ***1.1***

#### ***Degrees of freedom***

##### ***Modeling***

##### ***Degrees of freedom***

***(with each node top)***

##### ***ROAST***

***DX: displacement following X***

***DY: displacement following Y***

***DZ: displacement following Z***

***DRX: rotation around X***

***DRY: rotation around Y***

***DRZ: rotation around Z***

## ***GRILLE\_MEMBRANE***

***DX: displacement following X***

***DY: displacement following Y***

***DZ: displacement following Z***

### ***1.2***

***Net support of the matrices of rigidity***

***The meshes support of the finite elements, in displacement formulation, are triangles.***

***Modeling Nets Element***

***finished***

***Remarks***

***ROAST TRIA3 MEGRDKT***

***GRILLE\_MEMBRANE TRIA3***

***MEGMTR3***

***GRILLE\_MEMBRANE QUAD4***

***MEGMQU4***

### ***1.3***

***Net support of the loadings***

***All the loadings applicable to the facets of the elements of grid are treated by discretization direct on the mesh support of the element in displacement formulation.***

***No mesh support of loading is thus necessary for the faces of the elements of grids.***

## ***2***

***Significance of the symbols***

***.  
corresponds to a functionality available***

***corresponds to a functionality which could exist but noncurrently available***

***Name of case corresponds to a test implementing the functionality***

***test***

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14/09/04

Author (S):

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**3**

***Assignment of the characteristics***

*One must assign characteristics to the elements ROASTS by using the key word ROASTS order AFFE\_CARA\_ELEM.*

***4 Materials supported***

***DEFI\_MATERIAU ROASTS  
GRILLE\_MEMBRANE***

*ELAS*

*SSNS100A*

*SSNS105A*

*PINTO\_MENEGOTTO*

*SSNS100C*

.

*ECRO\_LINE*

*SSNS100A*

*SSNS105A*

*ECRO\_LINE\_FO*

.

.

*CHABOCHE*

**5 Loadings  
supported**

**5.1**

**AFFE\_CHAR\_MECA**

**AFFE\_CHAR\_MECA**

**ROAST GRILLE\_MEMBRANE**

**Generals**

*DDL\_IMPO*

*SSLS109B*

*SSNS105A*

*LIAISON\_DDL*

.

.

*LIAISON\_OBLIQUE*

.

.

*FORCE\_NODALE*

*SSLS109B*

.

**AFFE\_CHAR\_MECA**

**ROAST GRILLE\_MEMBRANE**

**Remarks**

***private individuals***

*FORCE\_ELEC*

*IMPE\_FACE*

*INTE\_ELEC*

*GRAVITY*

.

*ROTATION*

*TEMP\_CALCULEE*

..

*EPSI\_INIT*

.

*VITE\_FACE*

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**5.2**

***AFFE\_CHAR\_MECA\_F***

***AFFE\_CHAR\_MECA\_F***

***ROAST GRILLE\_MEMBRANE***

***Generals***

***DDL\_IMPO***

·  
·  
*LIAISON\_DDL*

·  
·  
*LIAISON\_OBLIQUE*

·  
·  
*FORCE\_NODALE*

***AFFE\_CHAR\_MECA\_F***  
***ROAST GRILLE\_MEMB***  
*private individuals*

*FORCE\_ELEC*

*IMPE\_FACE*

*INTE\_ELEC*

*GRAVITY*

*ROTATION*

*TEMP\_CALCULEE*

*EPSI\_INIT*

*VITE\_FACE*

## ***6 Possibilities*** ***non-linear***

*The nonlinear behaviors for modelings GRID correspond to behaviors  
incrémentaux private individuals in STAT\_NON\_LINE:*

·  
*GRILLE\_ISOT\_LINE for plasticity with isotropic work hardening,*

·  
*GRILLE\_ISOT\_CINE for plasticity with kinematic work hardening linear Bi,*

*GRILLE\_PINTO\_MEN for the behavior of Pinto Menegotto.*

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14/09/04

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7

*Elementary calculations of matrices*

**OPTIONS**

**ROAST GRILLE\_MEMBRANE**

*elementary*

“AMOR\_MECA”

.

“FULL\_MECA”

..

“IMPE\_MECA”

“MASS\_MECA”

.

“MASS\_MECA\_DIAG”

“RAPH\_MECA”

..

“RIGI\_GEOM”



“RIGI\_MECA”

..

“RIGI\_MECA\_HYST”

.

“RIGI\_MECA\_TANG”

..

“RIGI\_ROTA”

## 8

### *Postprocessing of calculation*

#### *8.1 Options*

***CALC\_ELEM***

***ROAST GRILLE\_MEMBRANE***

“SIEF\_ELGA\_DEPL”

SSLS109B

“SIGM\_ELNO\_DEPL”

SSLS109B

“SIGM\_ELNO\_CART”

“EFGE\_ELNO\_DEPL”

SSLS109B

“EPSI\_ELNO\_DEPL”

SSLS109B

“DEGE\_ELNO\_DEPL”

SSLS109B

“EPOT\_ELEM\_DEPL”

.

“ECIN\_ELEM\_DEPL”

.

“VNOR\_ELEM\_DEPL”

.

“EFGE\_ELNO\_CART”

“SIEF\_ELNO\_ELGA”

SSNS100A ·  
“VARI\_ELNO\_ELGA”

· ·  
“SIGM\_ELNO\_COQU”  
SSNS100A

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## **8.2 Options**

**CALC\_CHAM\_ELEM**

**ROAST GRILLE\_MEMBRANE**

“SIEF\_ELGA\_DEPL”

·  
“SIGM\_ELNO\_DEPL”

·  
“SIGM\_ELNO\_CART”

“EFGE\_ELNO\_DEPL”

·  
“EPSI\_ELNO\_DEPL”

·  
“DEGE\_ELNO\_DEPL”

·

“EPOT\_ELEM\_DEPL”

.

“ECIN\_ELEM\_DEPL”

.

“EFGE\_ELNO\_CART”

### **8.3 Options**

**CALC\_NO**

**ROAST GRILLE\_MEMBRANE**

“FORC\_NODA”

SSLS109B SSNS105A

“REAC\_NODA”

“MASS\_INER”

.

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**Code\_Aster** ®

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7.4

*Titrate:*

*Modeling* **SHB8**

*Date:*

01/06/05

*Author (S):*

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

***Instruction manual  
U3.12 booklet: Mechanical elements of structure 2D  
Document: U3.12.05***

***Modeling SHB8***

***Summary:***

***This document describes for modeling SHB8:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported loadings,***
- non-linear possibilities,***
- case-tests implementing modeling.***

***This modeling corresponds to element SHB8-PS (developed by Alain Combescure, S. Baguet, INSA LYON) which is pressed on a mesh HEXA8. The element has 5 points of integration, distributed in the thickness.***

***It under-is integrated to have good performances. To avoid blockings the modes of hourglass are stabilized by the “Assumed strain method”. It functions into linear, nonlinear geometrical and material***

***(behavior VMIS\_ISOT\_TRAC only).***

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**Code\_Aster** ®

**Version**

**7.4**

**Titrate:**

**Modeling SHB8**

**Date:**

**01/06/05**

**Author (S):**

**X. DESROCHES, F. LEBOUVIER** Key

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**1 Discretization**

**1.1**

**Degrees of freedom**

**Modeling**

**Ddl with all the nodes**

**SHB8**

**DX, DY, DZ**

**1.2**

**Net support of the matrices of rigidity**

**For modeling SHB8, the meshes support of the finite elements are hexahedrons with 8 nodes.**

**Modeling Nets**

**Interpolation**

**in**

**displacements**

**SHB8 HEXA8**

**Linear**

**1.3**

**Net support of the surface loadings**

## ***Modeling***

### ***Net***

#### ***Interpolation in displacements***

### ***SHB8 QUAD4***

#### ***linear***

## ***2 Loadings***

### ***supported***

***The loadings available are as follows:***

- ***“FORCE\_ARETE”***

***Allows to apply linear forces, with an edge of voluminal element.***

- ***“FORCE\_FACE”***

***Allows to apply surface forces to a voluminal face of element.***

- ***“FORCE\_INTERNE”***

***Allows to apply voluminal forces.***

- ***“GRAVITY”***

***Allows to apply a loading of the gravity type.***

- ***“PRES\_REP”***

***Allows to apply a pressure to a field of continuous medium.***

## ***Instruction manual***

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***Date:***

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### **3 Possibilities** **non-linear**

#### **3.1** **Law of behavior**

**The law of behavior available under COMP\_INCR in STAT\_NON\_LINE is defined by the relation VMIS\_ISOT\_TRAC (cf [U4.51.11]).**

#### **3.2 Deformations**

**Deformations available, used in the relations of behavior under the key word DEFORMATION in STAT\_NON\_LINE are (cf [U4.51.11]):**

**/“SMALL”**

**The deformations used for the relation of behavior are the deformations linearized.**

**/“GREEN”**

**The deformations used in the relation of behavior are the deformations of GREEN\_LAGRANGE.**

### **4** **Examples of implementation: case-tests**

- Linear Statique**  
**SSLS124A [V3.03.124]: Quasi-static analysis of a beam in inflection, embedded with one end and subjected to a vertical force at the other end.**
- Non-linear Statique**  
**SSNS101A [V6.05.101]: Analyze static non-linear geometrical (breakdown) of a panel cylindrical under a specific force.**
- Linear Dynamique**  
**SDLS109H [V2.03.109]: Seek Eigen frequencies and modes associated with a ring cylindrical thick.**

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**Titrate:**

**Modelings AXIS, D\_PLAN, mechanical C\_PLAN**

**Date:**

**01/06/05**

**Author (S):**

**X. DESROCHES, F. LEBOUVIER**

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**Organization (S): EDF-R & D /AMA, DeltaCAD**

**Instruction manual**

**U3.13 booklet: Mechanical finite elements 2D**

**U3.13.01 document**

**Modelings AXIS, D\_PLAN, C\_PLAN**

**Summary:**

*Modelings AXIS, D\_PLAN, C\_PLAN (Phenomenon: MECHANICS) correspond to finite elements whose meshes supports are surface.*

*The assumptions of modeling are as follows:*

- *AXIS for the axisymetry (mode 0 of Fourier) according to the y axis,*
- *D\_PLAN for the plane deformations,*
- *C\_PLAN for the plane constraints.*

*This document described:*

- *degrees of freedom carried by the finite elements which support modeling,*
- *the related meshes supports,*
- *supported loadings,*
- *nonlinear possibilities,*
- *case-tests implementing modelings.*

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*Titrate:*

*Modelings AXIS, D\_PLAN, mechanical C\_PLAN*

*Date:*

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*Author (S):*

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*1 Discretization*

*1.1*

*Degrees of freedom*

*Modeling*

*Degrees of freedom*

*(with each node top)*

**AXIS**

***DX: corresponds to radial displacement***

***DY: corresponds to longitudinal displacement***

**D\_PLAN**

***DX: displacement following X***

***DY: displacement following Y***

**C\_PLAN**

***DX: displacement following X***

***DY: displacement following Y***

**1.2**

***Net support of the matrices of rigidity***

*The meshes support of the finite elements can be triangles or quadrangles. Elements are isoparametric.*

***Modelings Nets***

***Interpolation***

**AXIS**

**TRIA3**

**Linear**

**D\_PLAN**

**QUAD4**

**Bilinear**

**C\_PLAN**

**TRIA6**

**Quadratic**

**QUAD8**

**Serendip**

**QUAD9**

**Biquadratic**

**1.3**

***Net support of the loadings***

***Modelings Nets***

***Interpolation***

**AXIS**

**SEG2**

**Linear**

**D\_PLAN**

**or**

## *C\_PLAN SEG3*

### *Quadratic*

## **2 Loadings supported**

*The loadings available are as follows:*

### **· CONTACT**

*Allows to define the zones subjected to conditions of contact.*

*Supported modelings: AXIS, C\_PLAN, D\_PLAN*

### **· EPSI\_INIT**

*Allows to apply a loading of initial deformation.*

*Supported modelings: AXIS, C\_PLAN, D\_PLAN*

### **· FORCE\_CONTOUR**

*Allows to define linear forces at the edge of a field.*

*Supported modelings: AXIS, C\_PLAN, D\_PLAN*

### **· FORCE\_INTERNE**

*Allows to define voluminal forces.*

*Supported modelings: AXIS, C\_PLAN, D\_PLAN*

*Instruction manual*

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Modelings *AXIS, D\_PLAN, mechanical C\_PLAN*

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· **GRAVITY**

*Allows to define the acceleration and the direction of gravity.*

*Supported modelings: AXIS, C\_PLAN, D\_PLAN*

· **PRES\_REP**

*Allows to apply a pressure.*

*Supported modelings: AXIS, C\_PLAN, D\_PLAN*

· **TEMP\_CALCULEE**

*Allows to apply a thermal loading of origin.*

*Supported modelings: AXIS, C\_PLAN, D\_PLAN*

· **SECH\_CALCULEE**

*Allows to apply a loading resulting from fields of drying.*

*Supported modelings: AXIS, C\_PLAN, D\_PLAN*

· **HYDR\_CALCULEE**

*Allows to apply a loading obtained starting from fields of hydration and temperatures*

*Supported modelings: AXIS, C\_PLAN, D\_PLAN*

· **PRES\_CALCULEE**

*Allows to apply a pressure resulting from external software.*

*Supported modelings: AXIS, C\_PLAN, D\_PLAN*

· **EPSA\_CALCULEE**

*Allows to apply a loading of anelastic deformation.*

*Supported modelings: AXIS, C\_PLAN, D\_PLAN*

## · **ROTATION**

*Allows to define a number of revolutions and the direction of the vector of rotation.*

*Supported modelings: AXIS, C\_PLAN, D\_PLAN*

## **3**

### ***Nonlinear possibilities***

#### **3.1**

##### ***Laws of behaviors***

*Laws of behaviors (model traditional, model buildings with damage, models for the concrete,...), usable under COMP\_INCR or COMP\_ELAS in STAT\_NON\_LINE and DYNA\_NON\_LINE, under the key word RELATION, are described in details in the document "Behavior nonlinear" [U4.51.11].*

#### **3.2 Deformations**

*Deformations usable under COMP\_INCR or COMP\_ELAS in STAT\_NON\_LINE and DYNA\_NON\_LINE, under the key word DEFORMATION, are described in details in the document "Behavior nonlinear" [U4.51.11].*

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*Modelings AXIS, D\_PLAN, mechanical C\_PLAN*

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## **4**

### ***Examples of implementation: case-tests***

· **AXIS**

*Statics*

*linear*

*FORMA09B [V7.20.101]: Analyze thermo elastic of a tube right subjected to a cold shock.*

*SSLS07A [V3.03.007]: Analyze static linear of a thin cylinder subjected to a load axial uniform.*

*Nonlinear statics*

*SSNL129C [V6.02.129]*

*: Simulation of a tensile test*

*: validation of the laws of behavior “VISC\_ISOT\_TRAC” and “VISC\_ISOT\_LINE”.*

*Dynamics*

*linear*

*SDLS07B [V2.03.007]: Seek Eigen frequencies and modes associated with one thin spherical envelope.*

*Nonlinear dynamics*

*SDNV103B [V5.03.103]: Impact of a bar of TAYLOR: analyze impact rubbing of one bar elastoplastic on a rigid solid mass. Modeling includes/understands: contact, friction, elastoplasticity, great deformations.*

· **D\_PLAN**

*Statics*

*linear*

*SSLV100H [V3.04.100]: Analyze of a hollow roll subjected to an internal pressure, in plane deformations.*

*Nonlinear statics*

*SSNL129B [V6.02.129]*

*: Simulation of a tensile test*

*: validation of the laws of behavior “VISC\_ISOT\_TRAC” and “VISC\_ISOT\_LINE”.*

*Dynamics*

*linear*

*SDLS501A [V2.03.501]: Seek Eigen frequencies and modes associated with one iron corrugated into free-free.*

*Nonlinear dynamics*

*SDNV104A: Dynamic response of a rigid shoe rubbing subjected to a pressure and a force of recall.*

· **C\_PLAN**

*Statics*

*linear*

*SSLP101B [V3.02.101]: Analyze of a plate fissured in traction, calculation of the rate of restitution of energy in plane constraints.*

*Dynamics*

*linear*

*SDLL11G: Seek Eigen frequencies and modes associated with a circular ring thin into free-free.*

*Nonlinear statics*

*HSNV100B [V7.22.100]: Analyze of a cylinder in thermo plasticity subjected to an effort of simple traction.*

*Nonlinear dynamics*

*DEMO002A: Analyze dynamic nonlinear of a wing fissured with contact.*

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*Version*

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*Titrate:*

*Mechanical modeling **AXIS\_FOURIER***

*Date:*

01/06/05

*Author (S):*

**X. DESROCHES, F. LEBOUVIER** Key

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*Organization (S): EDF-R & D /AMA, DeltaCAD*



***Instruction manual  
U3.13 booklet: Mechanical finite elements 2D  
Document: U3.13.02***

***Mechanical modeling AXIS\_FOURIER***

***Summary:***

***This document describes for mechanical modeling AXIS\_FOURIER:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported loadings,***
- nonlinear possibilities,***
- case-tests implementing modeling.***

***Modeling AXIS\_FOURIER (Phenomenon: MECHANICS) corresponds to finite elements of which meshes***

***supports are plane and make it possible to model the longitudinal section of parts of revolution around the axis***

***OY, (in co-ordinates cylindrical (R, Z,)) and subjected to loadings of which the space distribution break up into Fourier series around this axis.***

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***Code\_Aster ®***

***Version***

***7.4***

***Titrate:***

***Mechanical modeling AXIS\_FOURIER***

***Date:***

***01/06/05***

***Author (S):***

***X. DESROCHES, F. LEBOUVIER Key***

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***U3.13.02-F Page***  
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## ***1 Discretization***

### ***1.1*** ***Degrees of freedom***

***Modeling***  
***Degrees of freedom***  
***(with each node top)***

***AXIS\_FOURIER***  
***DX: corresponds to radial displacement***

***DY: corresponds to longitudinal displacement***

***DZ: corresponds to ortho-radial displacement***

***DY (Z)***  
***DZ ()***  
***DX (R)***

### ***1.2*** ***Net support of the matrices of rigidity***

***Modeling Nets Interpolation***  
***Remarks***

***AXIS\_FOURIER TRIA3***  
***Linear***  
***QUAD4***  
***Bilinear***  
***TRIA6***  
***Quadratic***

***QUAD8***  
***Serendip***

**QUAD9**  
**Biquadratic**

**1.3**  
**Net support of the loadings**

**The grid must be carried out in the half-plane ( $X > 0$ ,  $Y$ ).**

**Modeling Nets Interpolation**  
**Remarks**

**AXIS\_FOURIER SEG2**  
**Linear or**

**Bilinear**  
**SEG3**  
**Quadratic,**

**Serendip or**

**Biquadratic**  
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**7.4**

**Titrate:**  
**Mechanical modeling AXIS\_FOURIER**

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**01/06/05**  
**Author (S):**  
**X. DESROCHES, F. LEBOUVIER Key**

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***U3.13.02-F Page***

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## ***2 Loadings supported***

***The loadings available are as follows:***

- ***“FORCE\_CONTOUR”***

***Allows to apply linear forces at the edge of a field 2D.***

- ***“FORCE\_INTERNE”***

***Allows to apply voluminal forces.***

- ***“GRAVITY”***

***Allows to apply a loading of the gravity type.***

- ***“PRES\_REP”***

***Allows to apply a pressure to a field of continuous medium.***

- ***“ROTATION”***

***Allows to define a number of revolutions and the direction of the vector of rotation.***

- ***“TEMP\_CALCULEE”***

***Allows to apply a thermal loading.***

## ***3 Possibilities non-linear***

***No non-linear possibility exists, this modeling can be used only with  
MECA\_STATIQUE or by a manual assembly.***

## ***4 Examples of implementation: case-tests***

- ***Linear Statique***

***HSLV304A [V7.14.304]: Analyze static of a cylinder subjected to a thermal loading  
decomposable in 2 harmonics.***

***SSLV303A [V3.04.303]: analyze static of a cylinder embedded under its actual and subjected weight  
with an internal pressure.***

***SSLV139A [V3.04.139]: Buckling of a circular plate subjected to a compressive force  
uniformly distributed on its contour.***

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***Code\_Aster*** ®

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***Titrate:***

***Mechanical modeling AXIS\_FOURIER***

***Date:***

***01/06/05***

***Author (S):***

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***Titrate:***

***Modelings 2D\_FLUIDE, 2D\_FLUI\_STRU, AXIS\_FLUIDE,...***

***Date:***

***01/06/05***

***Author (S):***

***NR. GREFFET, F. LEBOUVIER Key***

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***Organization (S): EDF-R & D /AMA, DeltaCAD***

***Instruction manual***  
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***Document: U3.13.03***

***Modelings 2D\_FLUIDE, 2D\_FLUI\_STRU,***  
***AXIS\_FLUIDE, AXIS\_FLUI\_STRU***

## **Summary:**

***This document describes for modelings 2D\_FLUIDE, 2D\_FLUI\_STRU, AXIS\_FLUIDE, AXIS\_FLUI\_STRU:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported loadings,***
- nonlinear possibilities,***
- case-tests implementing modelings.***

***Modelings 2D\_FLUIDE (elements in a plan) and 2D\_FLUI\_STRU (elements 1D of interaction fluid-structure) correspond to the formulation in 2D in linear assumption of the allowing coupled problem***

***the study of the vibratory behavior of a structure in the presence of a nonviscous, compressible fluid [R4.02.01]. Currently, the taking into account of the free face is not developed.***

***Modelings AXIS\_FLUIDE (elements in a plan) and AXIS\_FLUI\_STRU (elements 1D of interaction fluid-structure) correspond to the formulation in axisymetry in linear assumption of the coupled problem***

***allowing the study of the vibratory behavior of a structure in the presence of a nonviscous fluid, compressible [R4.02.01]. Currently, the taking into account of the free face is not developed.***

***Instruction manual***

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***Titrate:***

***Modelings 2D\_FLUIDE, 2D\_FLUI\_STRU, AXIS\_FLUIDE,...***

***Date:***

***01/06/05***

***Author (S):***

***NR. GREFFET, F. LEBOUVIER Key***

***:***

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## ***1 Discretization***

### ***1.1***

#### ***Degrees of freedom***

## ***Finished Elément***

***Degrees of freedom (with each node top)***

***MEFLTR3, MEFLTR6,***

***NEAR: pressure***

***MEFLQU4, MEFLQU8, MEFLQU9 PHI: potential of displacement***

***MEFLSE2, MEFLSE3***

***PHI: fluid potential of displacement***

***MEFSSE2, MEFSSE3***

***DX, DY: components of structure displacement***

***PHI: fluid potential of displacement***

***MEAXFLT3, MEAXFLT6,***

***NEAR: pressure***

***MEAXFLQ4, MEAXFLQ8,***

***PHI: potential of displacement***

***MEAXFLQ9***

***MEAXFLS2, MEAXFLS3***

***PHI: fluid potential of displacement***

***MEAXFSS2, MEAXFSS3***

***DX, DY: components of structure displacement***

***PHI: fluid potential of displacement***

## ***1.2***

***Net support of the matrices of rigidity***

***Modeling Nets Element***

***finished***

***Remarks***

***2D\_FLUIDE TRIA3***

***MEFLTR3***

***TRIA6***

***MEFLTR6***

***QUAD4***

***MEFLQU4***

***QUAD8 MEFLQU8***

***QUAD9 MEFLQU9***

***2D\_FLUI\_STRU SEG2 MEFSSE2***



*SEG3 MEFSSE3*

*AXIS\_FLUIDE TRIA3 MEAXFLT3*

*TRIA6 MEAXFLT6*

*QUAD4 MEAXFLQ4*

*QUAD8  
MEAXFLQ8*

*QUAD9 MEAXFLQ9*

*AXIS\_FLUI\_STRU SEG2  
MEAXFSS2*

*SEG3 MEAXFSS3*

### **1.3**

***Net support of the loadings***

***Modeling Nets Element  
finished***

***Remarks***

*2D\_FLUIDE SEG2 MEFLSE2*

*SEG3  
MEFLSE3*

*AXIS\_FLUIDE SEG2 MEAXFLS2*

*SEG3  
MEAXFLS3*

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## **Code\_Aster** ®

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7.4

Titrate:

Modelings **2D\_FLUIDE**, **2D\_FLUI\_STRU**, **AXIS\_FLUIDE**,...

Date:

01/06/05

Author (S):

**NR. GREFFET**, **F. LEBOUVIER** Key

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## **2 Loadings supported**

The supported loadings are as follows:

### **· VITE\_FACE**

Allows to specify the field normal speed real, vibratory imposed in loading on elements of border.

Supported modelings: **2D\_FLUIDE**, **AXIS\_FLUIDE**

### **· IMPE\_FACE**

Allows to specify the chart of normal impedance imposed in boundary condition on elements of border.

Supported modelings: **2D\_FLUIDE**, **AXIS\_FLUIDE**

### **· ONDE\_FLUI**

Allows to specify an amplitude of pressure of sinusoidal real incidental wave arriving normally with a face.

Supported modelings: **2D\_FLUIDE**, **AXIS\_FLUIDE**

## **3 Possibilities non-linear**

### **3.1**

#### **Laws of behaviors**

The only relation of behavior available in **DYNA\_NON\_LINE**, for modelings **2D\_FLUI\_STRU** and **AXIS\_FLUI\_STRU** under **COMP\_INCR** are **RELATION "ELAS"** (cf [U4.51.11]).

## 3.2 Deformations

*Only the linearized deformations “SMALL” key word under DEFORMATION are available in relations of behavior (cf [U4.51.11]).*

4

*Examples of implementation: case-tests*

· *2D\_FLUIDE*

*FDLV111B [V8.01.111]: Calculation of the absorption of a wave of pressure created by a piston, in a fluid column.*

· *AXIS\_FLUIDE*

*AHLV101C [V8.22.101]: Calculation of the acoustic field of pressure of the harmonic response of one guide rectilinear wave at anechoic exit, with rigid walls, whose propagation medium is of “normal” air, excited by a harmonically vibrating piston.*

· *2D\_FLUI\_STRU*

*FDLV111B [V8.01.111]: Calculation of the absorption of a wave of pressure created by a piston, in a fluid column.*

· *AXIS\_FLUI\_STRU*

*ADLV100C [V8.21.100]: Piston coupled to a fluid column: calculation in fluid coupling acoustics-structure of the first mode of a system fluide1 - piston fluid 2.*

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*Titrate:*

*Modelings 2D\_FLUIDE, 2D\_FLUI\_STRU, AXIS\_FLUIDE,...*

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*Titrate:*

*Modelings AXIS\_SI, D\_PLAN\_SI, mechanical C\_PLAN\_SI*

*Date:*

01/06/05

*Author (S):*

**J.P. LEFEBVRE, F. LEBOUVIER** *Key*

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

***Instruction manual***

***U3.13 booklet: Mechanical finite elements 2D***

***U3.13.05 document***

***Modelings AXIS\_SI, D\_PLAN\_SI, C\_PLAN\_SI***

***Summary:***

***Modelings AXIS\_SI, D\_PLAN\_SI, C\_PLAN\_SI (Phenomenon: MECHANICS) correspond to finite elements whose meshes supports are surface.***

**The suffix *\_SI* means: Under - Integrated: the integration of the terms relating to the laws of behavior is done**

**reduced way (diagram of points of Gauss of a nature less low than modeling with complete integration).**

**The assumptions of modeling are as follows:**

- **AXIS\_SI for the axisymetry (mode 0 of Fourier) according to the y axis,**
- **D\_PLAN\_SI for the plane deformations,**
- **C\_PLAN\_SI for the plane constraints.**

**This document describes for modelings:**

- **degrees of freedom carried by the finite elements which support modeling,**
- **the related meshes supports,**
- **supported loadings,**
- **nonlinear possibilities,**
- **case-tests implementing modelings.**

**Instruction manual**

**U3.13 booklet: Mechanical finite elements 2D**

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**Code\_Aster ®**

**Version**

**7.4**

**Titrate:**

**Modelings AXIS\_SI, D\_PLAN\_SI, mechanical C\_PLAN\_SI**

**Date:**

**01/06/05**

**Author (S):**

**J.P. LEFEBVRE, F. LEBOUVIER Key**

**:**

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**1 Discretization**

**1.1**

**Degrees of freedom**

**Modeling**

**Degrees of freedom**

**(with each node top)**

## ***AXIS\_SI***

***DX: corresponds to radial displacement***

***DY: corresponds to longitudinal displacement***

## ***D\_PLAN\_SI***

***DX: displacement following X***

***DY: displacement following Y***

## ***C\_PLAN\_SI***

***DX: displacement following X***

***DY: displacement following Y***

## ***1.2***

### ***Net support of the matrices of rigidity***

***The meshes support of the finite elements can be triangles or quadrangles. Elements are isoparametric. Only the element which is pressed on mesh QUAD8 under is integrated.***

### ***Modelings Nets***

#### ***Interpolation integration***

#### ***AXIS\_SI***

#### ***TRIA3***

#### ***Linear***

#### ***complete***

#### ***D\_PLAN\_SI***

#### ***QUAD4***

#### ***Bilinear***

#### ***reduced***

#### ***C\_PLAN\_SI***

#### ***TRIA6***

#### ***Quadratic***

#### ***complete***

#### ***QUAD8***

#### ***Serendip***

#### ***reduced***

#### ***QUAD9***

#### ***Biquadratic***

#### ***complete***

## ***1.3***

### ***Net support of the loadings***

### ***Modelings Nets***

#### ***Interpolation***

**AXIS\_SI**  
**SEG2**  
**Linear**  
**D\_PLAN\_SI**

**or**  
**C\_PLAN\_SI**  
**SEG3**  
**Quadratic**

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**Code\_Aster** ®  
**Version**  
**7.4**

**Titrate:**  
**Modelings AXIS\_SI, D\_PLAN\_SI, mechanical C\_PLAN\_SI**

**Date:**  
**01/06/05**

**Author (S):**  
**J.P. LEFEBVRE, F. LEBOUVIER Key**

**:**  
**U3.13.05-C Page**  
**: 3/4**

**2 Loadings**  
**supported**

**The loadings available are as follows:**

· **TEMP\_CALCULEE**  
**Allows to apply a thermal loading of origin.**  
**Supported modelings: AXIS\_SI, C\_PLAN\_SI, D\_PLAN\_SI**

· **SECH\_CALCULEE**  
**Allows to apply a loading obtained starting from fields of drying.**  
**Supported modelings: AXIS\_SI, C\_PLAN\_SI, D\_PLAN\_SI**

· **HYDR\_CALCULEE**  
**Allows to apply a loading obtained starting from fields of hydration and temperatures.**  
**Supported modelings: AXIS\_SI, C\_PLAN\_SI, D\_PLAN\_SI**



· **PRES\_CALCULEE**

*Allows to apply a pressure resulting from external software.*

*Supported modelings: AXIS\_SI, C\_PLAN\_SI, D\_PLAN\_SI*

· **EPSA\_CALCULEE**

*Allows to apply a loading of anelastic deformation.*

*Supported modelings: AXIS\_SI, C\_PLAN\_SI, D\_PLAN\_SI*

· **EPSI\_INIT**

*Allows to apply a loading of initial deformation.*

*Supported modelings: AXIS\_SI, C\_PLAN\_SI, D\_PLAN\_SI*

· **GRAVITY**

*Allows to define the acceleration and the direction of gravity.*

*Supported modelings: AXIS\_SI, C\_PLAN\_SI, D\_PLAN\_SI*

· **ROTATION**

*Allows to define a number of revolutions and the direction of the vector of rotation.*

*Supported modelings: AXIS\_SI, C\_PLAN\_SI, D\_PLAN\_SI*

· **CONTACT**

*Allows to define the zones subjected to conditions of contact.*

*Supported modelings: AXIS\_SI, C\_PLAN\_SI, D\_PLAN\_SI*

· **FORCE\_CONTOUR**

*Allows to define linear forces at the edge of a field.*

*Supported modelings: AXIS\_SI, C\_PLAN\_SI, D\_PLAN\_SI*

· **FORCE\_INTERNE**

*Allows to define voluminal forces.*

*Supported modelings: AXIS\_SI, C\_PLAN\_SI, D\_PLAN\_SI*

· **PRES\_REP**

*Allows to apply a pressure.*

*Supported modelings: AXIS\_SI, C\_PLAN\_SI, D\_PLAN\_SI*

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

## ***Modelings AXIS\_SI, D\_PLAN\_SI, mechanical C\_PLAN\_SI***

***Date:***

***01/06/05***

***Author (S):***

***J.P. LEFEBVRE, F. LEBOUVIER Key***

***:***

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### ***3 Possibilities***

***non-linear***

#### ***3.1***

***Laws of behaviors***

***Laws of behaviors (model traditional, model buildings with damage, models for the concrete and the grounds,...), usable under COMP\_INCR or COMP\_ELAS in STAT\_NON\_LINE***

***and DYNA\_NON\_LINE, under the key word RELATION, are described in details in the document “Behavior nonlinear” [U4.51.11].***

#### ***3.2 Deformations***

***Deformations usable under COMP\_INCR or COMP\_ELAS in STAT\_NON\_LINE and***

***DYNA\_NON\_LINE, under the key word DEFORMATION, are described in details in the document “Behavior nonlinear” [U4.51.11].***

## ***4***

***Examples of implementation: case-tests***

***· AXIS\_SI***

***Statics***

***non-linear***

***SSNA113A [V6.01.113]: Analyze of an axisymmetric test-tube notched with a law of behavior of the two-speed type subjected “VISC\_ISOT\_TRAC” of loading.***

***Nonlinear dynamics***

***SDNV103B [V5.03.103]: Impact of a bar of Taylor: analyze impact rubbing of one bar elastoplastic on a rigid solid mass. Modeling includes/understands: contact, friction, elastoplasticity and great deformations.***

***· D\_PLAN\_SI***

***Statics***

**non-linear**

**SSNP123A [V6.03.123]: Analyze of a notched rectangular plate consisted of one elastoplastic material with isotropic work hardening, subjected to a traction at its ends.**

**Statics**

**non-linear**

**CENTE01A [V1.02.001]: Probability calculus of rupture per cleavage of a test-tube of impact strength (test-tube of Charpy) impacted by a hammer at a speed of 5m/s.**

**SSNP117A [V6.03.117], SSNP122A [V6.03.122]: Model of Rousselier**

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**Version**

**6.4**

**Titrate:**

**Modelings D\_PLAN\_GRAD\_EPSI, mechanical C\_PLAN\_GRAD\_EPSI**

**Date:**

**27/06/03**

**Author (S):**

**P. Key BADEL**

**:**

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**Organization (S): EDF-R & D /AMA**

**Instruction manual**

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### ***U3.13.06 document***

***Modelings D\_PLAN\_GRAD\_EPSI,  
C\_PLAN\_GRAD\_EPSI***

#### ***Summary:***

***Modelings D\_PLAN\_GRAD\_EPSI, C\_PLAN\_GRAD\_EPSI (Phenomenon: MECHANICS)  
correspond to***

***finite elements whose meshes supports are surface. These modelings enrich the finite elements  
surface traditional of mechanics by adding degrees of freedom of generalized deformations  
allowing to carry out nonlocal calculations, the regularization utilizing the gradient of the  
deformations***

***(from where the name of modeling), for more details to see document [R5.04.02].***

***The assumptions of modeling are as follows:***

- D\_PLAN\_GRAD\_EPSI for the plane deformations,***
- C\_PLAN\_GRAD\_EPSI for the plane constraints.***

***Instruction manual***

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***Code\_Aster ®***

***Version***

***6.4***

***Titrate:***

***Modelings D\_PLAN\_GRAD\_EPSI, mechanical C\_PLAN\_GRAD\_EPSI***

***Date:***

***27/06/03***

***Author (S):***

***P. Key BADEL***

***:***

***U3.13.06-A Page***

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***1 Discretization***

## **1.1**

### ***Degrees of freedom***

#### ***Modeling***

#### ***Degrees of freedom***

***(with each node top)***

#### ***D\_PLAN***

***DX: displacement following X***

***DY: displacement following Y***

***EPXX: generalized deformation XX***

***EPYY: generalized deformation YY***

***EPZZ: generalized deformation ZZ***

***EPXY: generalized deformation XY***

#### ***C\_PLAN***

***DX: displacement following X***

***DY: displacement following Y***

***EPXX: generalized deformation XX***

***EPYY: generalized deformation YY***

***EPZZ: generalized deformation ZZ***

***EPXY: generalized deformation XY***

#### ***Modeling***

#### ***Degrees of freedom***

***(with each node medium)***

#### ***D\_PLAN***

***DX: displacement following X***

***DY: displacement following Y***

#### ***C\_PLAN***

***DX: displacement following X***

***DY: displacement following Y***

## **1.2**

### ***Net support of the matrices of rigidity***

***The meshes support of the finite elements can be quadratic triangle or quadrangles: displacements are interpolated with an order higher than the deformations generalized. One indicates in the column interpolation of the table following the couples of interpolation (displacements/deformations generalized). The elements are isoparametric.***

#### ***Modelings Nets***

#### ***Interpolation***

***D\_PLAN***

***TRIA6***

***Quadratic/linear***

***C\_PLAN***

***QUAD8***

***Serendip/bi-linear***

***1.3***

***Net support of the loadings***

***Modeling does not require a boundary condition specific to the generalized deformations (boundary condition natural), one thus uses for the meshes support of the loading modeling D\_PLAN or C\_PLAN (cf [U3.13.01]).***

***2***

***Significance of the symbols***

***·***  
***corresponds to a functionality available***

***·***  
***corresponds to a functionality which could exist but noncurrently available***

***Name of corresponds to a test implementing the functionality***  
***case-test***

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***Code\_Aster ®***

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***6.4***

***Titrate:***

***Modelings D\_PLAN\_GRAD\_EPSI, mechanical C\_PLAN\_GRAD\_EPSI***

***Date:***

***27/06/03***

***Author (S):***

***P. Key BADEL***

***:***

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***3 Materials***  
***supported***

**DEFI\_MATERIAU**  
**D\_PLAN\_GRAD\_EPSI**  
**C\_PLAN\_GRAD\_EPSI**

*% general elastic Behaviors*

**ELAS**  
**SSNV131B**

*% general nonlinear mechanical Behaviors*

**ECRO\_LINE**  
**SSNV131B**  
**BETON\_ECRO\_LINE**

**MAZARS**

*The case of the nonlinear operators is approached further.*

**4 Loadings**  
**supported**

*The loadings are to be affected on a modeling 3D, cf [§1.3].*

**5 Possibilities**  
**non-linear**

*This modeling has direction only into non-linear.*

**5.1**  
**STAT\_NON\_LINE**

**COMP\_INCR**  
**RELATION**  
**D\_PLAN\_GRAD\_EPSI**  
**C\_PLAN\_GRAD\_EPSI**

**ENDO\_FRAGILE**  
**SSNV131B**

**ENDO\_ISOT\_BETON**

**MAZARS**

.

**COMP\_INCR**  
**DEFORMATION**  
**D\_PLAN\_GRAD\_EPSI**  
**C\_PLAN\_GRAD\_EPSI**

**“SMALL”**  
**SSNV131B**

**5.2**  
**DYNA\_NON\_LINE**

**COMP\_INCR**  
**RELATION**  
**D\_PLAN\_GRAD\_EPSI**  
**C\_PLAN\_GRAD\_EPSI**

**ENDO\_FRAGILE**

.

**ENDO\_ISOT\_BETON**

.

**MAZARS**

.

**COMP\_INCR**  
**DEFORMATION**  
**D\_PLAN\_GRAD\_EPSI**  
**C\_PLAN\_GRAD\_EPSI**

**“SMALL”**

.

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**Code\_Aster** ®  
**Version**  
**6.4**



***Titrate:***

***Modelings D\_PLAN\_GRAD\_EPSI, mechanical C\_PLAN\_GRAD\_EPSI***

***Date:***

***27/06/03***

***Author (S):***

***P. Key BADEL***

***:***

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***6***

***Postprocessing of calculation***

***6.1 Option***

***CALC\_ELEM***

***D\_PLAN\_GRAD\_EPSI***

***C\_PLAN\_GRAD\_EPSI***

***ECIN\_ELEM\_DEPL***

***.***

***ENEL\_ELGA***

***.***

***ENEL\_ELNO\_ELGA***

***.***

***EPME\_ELGA\_DEPL***

***.***

***EPME\_ELNO\_DEPL***

***.***

***EPOT\_ELEM\_DEPL***

***.***

***EPSI\_ELGA\_DEPL***

***.***

***EPSI\_ELNO\_DEPL***

***.***

***EQUI\_ELGA\_EPME***

***.***

***EQUI\_ELGA\_EPSI***

***.***

***EQUI\_ELGA\_SIGM***

***.***

***EQUI\_ELNO\_EPME***

•  
***EQUI\_ELNO\_EPSI***

•  
***EQUI\_ELNO\_SIGM***

•  
***SIEF\_ELGA\_DEPL***

•  
***SIEF\_ELNO\_ELGA***

•  
***VARI\_ELNO\_ELGA***

## ***6.2 Option***

***CALC\_CHAM\_ELEM***

***D\_PLAN\_GRAD\_EPSI***

***C\_PLAN\_GRAD\_EPSI***

***ECIN\_ELEM\_DEPL***

***EPOT\_ELEM\_DEPL***

•  
***ENEL\_ELGA***

•  
***ENEL\_ELNO\_ELGA***

•  
***EPSI\_ELNO\_DEPL***

•  
***EQUI\_ELGA\_EPSI***

•  
***EQUI\_ELGA\_SIGM***

•  
***EQUI\_ELNO\_EPSI***

•  
***EQUI\_ELNO\_SIGM***

•  
***SIEF\_ELGA\_DEPL***

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**Version**

**6.4**

**Titrate:**

**Modelings D\_PLAN\_GRAD\_EPSI, mechanical C\_PLAN\_GRAD\_EPSI**

**Date:**

**27/06/03**

**Author (S):**

**P. Key BADEL**

**:**

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**6.3 Option**

**CALC\_NO**

**D\_PLAN\_GRAD\_EPSI**

**C\_PLAN\_GRAD\_EPSI**

**FORC\_NODA'**

**.**

**REAC\_NODA'**

**.**

**ENEL\_NOEU\_ELGA'**

**.**

**EPME\_NOEU\_DEPL'**

**.**

**EPSI\_NOEU\_DEPL'**

**.**

**EQUI\_NOEU\_EPME'**

**.**

**EQUI\_NOEU\_EPSI'**

**.**

**EQUI\_NOEU\_SIGM'**

**.**

**SIEF\_NOEU\_ELGA'**

**.**

**VARI\_NOEU\_ELGA'**

**.**

**6.4 Option**  
**POST\_ELEM**

**D\_PLAN\_GRAD\_EPSI**  
**C\_PLAN\_GRAD\_EPSI**  
**MASS\_INER**

.

**ENER\_POT**

.

**ENER\_CIN**

**ENER\_TOTALE**

.

**ENER\_ELAS**

.

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**Code\_Aster** ®  
**Version**  
**6.4**

**Titrate:**  
**Modelings D\_PLAN\_GRAD\_EPSI, mechanical C\_PLAN\_GRAD\_EPSI**

**Date:**  
**27/06/03**

**Author (S):**  
**P. Key BADEL**

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**Code\_Aster** ®

*Version*

7.4

*Titrate:*

**Modelings** *AXIS\_INCO, D\_PLAN\_INCO*

*Date:*

01/06/05

*Author (S):*

**S. MICHEL-PONNELLE, F. LEBOUVIER** *Key*

:

*U3.13.07-D Page*

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*Organization (S):* **EDF-R & D /AMA, DeltaCAD**

***Instruction manual***

***U3.13 booklet: Mechanical finite elements 2D***

***Document: U3.13.07***

**Modelings** *AXIS\_INCO, D\_PLAN\_INCO*

***Summary:***

***This document describes for modelings AXIS\_INCO, D\_PLAN\_INCO:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported loadings,***
- non-linear possibilities,***
- case-tests implementing modelings.***

***This modeling is based on finite elements adapted to the treatment of the problems quasi-incompressible. It is essential to carry out calculations of limiting analysis with the law of Norton-***

***Hoff and is also useful for the studies presenting of strong plastic deformations for which traditional formulation in displacement appears insufficient (oscillation of the constraints). The formulation used***

***is a formulation with 3 fields: displacement-pressure-swelling [R6.03.05], usable with all them behaviors written in incremental form. Modelings are supported by plane meshes of degree 2 (TRIA6 and QUAD8).***

***Instruction manual***

***U3.13 booklet: Mechanical finite elements 2D***

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***Code\_Aster ®***

***Version***

***7.4***

***Titrate:***

***Modelings AXIS\_INCO, D\_PLAN\_INCO***

***Date:***

***01/06/05***

***Author (S):***

***S. MICHEL-PONNELLE, F. LEBOUVIER Key***

***:***

***U3.13.07-D Page***

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***1 Discretization***

***1.1***

***Degrees of freedom***

***Modeling***

***Ddl with all the nodes***

***Ddl only with the nodes***

***tops***

***D\_PLAN\_INCO***

***DX, DY***

***CLOSE (\*), GONF***

***AXIS\_INCO***

***DX, DY***

***CLOSE (\*), GONF***

***\* no kinematic condition can be imposed on the degree of freedom NEAR.***

***1.2***

***Net support of the matrices of rigidity***

***The meshes support of the finite elements can be triangles, or quadrangles (degree 2) for modelings D\_PLAN\_INCO and AXIS\_INCO.***

***Modeling Nets Interpolation***

***Interpolation***

***in displacement***

***in pressure and***

***swelling***

***Linear D\_PLAN\_INCO TRIA6 Quadratic***

***QUAD8***

***Quadratic Linear***

***Linear AXIS\_INCO TRIA6 Quadratic***

***QUAD8***

***Quadratic Linear***

***1.3***

***Net support of the surface loadings***

***Modeling***

***Net***

***Interpolation in displacements***

***D\_PLAN\_INCO and***

***SEG3***

***Quadratic***

***AXIS\_INCO***



## **2 Loadings supported**

**The loadings available are as follows:**

**· “CONTACT”**

**Allows to define the zones subjected to conditions of contact.**

**Supported modelings: D\_PLAN\_INCO, AXIS\_INCO**

**· “FORCE\_CONTOUR”**

**Allows to apply linear forces at the edge of a field 2D.**

**Supported modelings: D\_PLAN\_INCO, AXIS\_INCO**

**· “FORCE\_INTERNE”**

**Allows to apply voluminal forces.**

**Supported modelings: D\_PLAN\_INCO, AXIS\_INCO**

**· “GRAVITY”**

**Allows to apply a loading of the gravity type.**

**Supported modelings: D\_PLAN\_INCO, AXIS\_INCO**

**· “PRES\_REP”**

**Allows to apply a pressure to a field of continuous medium.**

**Supported modelings: D\_PLAN\_INCO, AXIS\_INCO**

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**Code\_Aster ®**

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**Titrate:**

**Modelings AXIS\_INCO, D\_PLAN\_INCO**

**Date:**

**01/06/05**

**Author (S):**

**S. MICHEL-PONNELLE, F. LEBOUVIER Key**

**:**

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### **3 Possibilities**

#### ***non-linear***

***Attention, this modeling is accessible only starting from STAT\_NON\_LINE. It cannot be used with MECA\_STATIQUE or by a manual assembly.***

#### **3.1**

##### ***Laws of behaviors***

***All the laws of behavior usable on meshes of continuous mediums have a physical direction for these modelings and are easily affected as from the moment when they are accessible from COMP\_INCR in STAT\_NON\_LINE (cf [U4.51.11]).***

***A law of behavior is specific to this modeling (dedicated to the calculation of limiting load, cf [R7.07.01]):***

***/“NORTON\_HOFF”***

***Supported modelings: D\_PLAN\_INCO, AXIS\_INCO***

#### **3.2 Deformations**

***Deformations available, used in the relations of behavior under the key word DEFORMATION for operators STAT\_NON\_LINE and DYNA\_NON\_LINE are (cf [U4.51.11]):***

***/“SMALL”***

***The deformations used for the relation of behavior are the deformations linearized.***

***/“SIMO\_MIEHE”***

***Allows to carry out calculations in great plastic deformations.***

#### **3.3**

##### ***Method of Newton***

***For the resolution of the problem by the method of Newton-Raphson, the elastic matrix is not available. It is thus necessary to use under the key word NEWTON for operators STAT\_NON\_LINE and DYNA\_NON\_LINE (cf [U4.51.11]):***

***/PREDICTION = “TANGENT”***

*The phase of prediction is carried out with the tangent matrix.*

*/MATRIX = "TANGENT"*

*The matrix used for the iterations total is the tangent matrix.*

*Note:*

*The formulation used leads to nonpositive matrices and the current solveurs do not know to solve always well the linear systems which are associated for them. In the event of difficulty of convergence, it can thus be useful to test the other solveurs available in the code or them other methods of renumérotations (cf [U4.50.01]).*

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*Version*

*7.4*

*Titrate:*

*Modelings AXIS\_INCO, D\_PLAN\_INCO*

*Date:*

*01/06/05*

*Author (S):*

*S. MICHEL-PONNELLE, F. LEBOUVIER Key*

*:*

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*4*

*Examples of implementation: case-tests*

*· AXIS\_INCO*

*Incompressible elasticity:*

*SSLV130D [V3.04.130]: analyze of a hollow roll subjected to an internal pressure. material has a Poisson's ratio equal to 0.4999.*

*Limiting example of analysis:*

*SSNV146A [V6.04.146]: spherotoric bottom tank*

· ***D\_PLAN\_INCO***

***Elastoplastic material:***

***SSNP123B [V6.03.123]: Analyze of a notched rectangular plate consisted of one elastoplastic material with isotropic work hardening which is subjected to a traction with its ends.***

***Limiting example of analysis:***

***SSNV124A [V6.04.146]: calculation of load limits of a rectangular plate***

***Instruction manual***

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***Code\_Aster*** ®

***Version***

***6.3***

***Titrate:***

***Modelings D\_PLAN\_HM, D\_PLAN\_HHM, D\_PLAN\_THM, D\_PLAN\_THH...***

***Date:***

***04/11/02***

***Author (S):***

***C. CHAVANT Key***

***:***

***U3.13.08-C1 Page:***

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***Organization (S): EDF-R & D /AMA***

***Instruction manual***

***U3.13 booklet: Mechanical finite elements 2D***

## ***U3.13.08 document***

***Modelings D\_PLAN\_HM, D\_PLAN\_HHM,  
D\_PLAN\_THM, D\_PLAN\_THH, D\_PLAN\_THHM,  
AXIS\_HM, AXIS\_HHM, AXIS\_THM, AXIS\_THH,  
AXIS\_THHM***

### ***Summary:***

***This document describes for modelings D\_PLAN and AXIS into thermo\_hydro\_mecanic:***

- degrees of freedom carried by the finite elements which support modeling,*
- the related meshes supports,*
- supported materials and loadings,*
- options of calculations for the elementary matrices and the post treatments,*
- nonlinear possibilities as well as the options of the breaking process if they exist.*

***Modelings D\_PLAN\_HM, D\_PLAN\_HHM, D\_PLAN\_THM, D\_PLAN\_THH, D\_PLAN\_THHM,  
AXIS\_HM,  
AXIS\_HHM, AXIS\_THM, AXIS\_THH, AXIS\_THHM, (Phenomenon: MECHANICS) correspond to  
elements  
stop whose meshes supports are surface.***

***Instruction manual***

***U3.13 booklet: Mechanical finite elements 2D***

***HT-66/02/003/A***

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***Code\_Aster*** ®

***Version***

***6.3***

***Titrate:***

***Modelings D\_PLAN\_HM, D\_PLAN\_HHM, D\_PLAN\_THM, D\_PLAN\_THH...***

***Date:***

***04/11/02***

***Author (S):***

***C. CHAVANT Key***

***:***

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## ***1 Discretization***

### ***1.1***

#### ***Degrees of freedom***

***DX, DY indicate the degrees of freedom of displacement.***

***PRE1 and PRE2 indicate two degrees of freedom of pressure, whose precise significance depends on laws of behavior used. TEMP indicates the temperature.***

#### ***Modeling***

##### ***Degrees of freedom***

***(with each node top)***

***D\_PLAN\_HM***

***DX, DY, PRE1***

***AXIS\_HM***

***D\_PLAN\_HHM***

***DX, DY, PRE1, PRE2***

***AXIS\_HHM***

***D\_PLAN\_THM***

***DX, DY, PRE1, TEMP***

***AXIS\_THM***

***D\_PLAN\_THH***

***PRE1, PRE2, TEMP***

***AXIS\_THH***

***D\_PLAN\_THHM***

***DX, DY, PRE1, PRE2, TEMP***

***AXIS\_THHM***

### ***1.2***

#### ***Net support of the matrices of rigidity***

***The meshes support of the finite elements can be tetrahedrons, pyramids, prisms or hexaèdres. The elements are isoparametric.***

#### ***Modeling Nets***

##### ***Interpolation***

##### ***Remarks***

***D\_PLAN\_HM***

***QUAD8***

*Serendip 8 nodes in  
Pressure of a node medium  
AXIS\_HM*

*bilinear displacement on 4  
is the average of the nodes  
nodes in pressure  
tops of the segment*

*D\_PLAN\_HHM  
QUAD8*

*Serendip 8 nodes in  
Pressures of a node  
AXIS\_HHM*

*bilinear displacement on 4  
medium are the averages of  
nodes in pressure  
nodes tops of the segment*

*D\_PLAN\_THM  
QUAD8*

*Serendip 8 nodes in  
Pressure and the temperature  
AXIS\_THM*

*bilinear displacement on 4  
of a node medium are  
nodes in pressure and  
average of the nodes tops  
temperature*

*segment  
D\_PLAN\_THH*

*QUAD8  
Bilinear on 4 nodes in  
Pressures and*

*AXIS\_THH  
pressure and temperature  
temperature of a node medium  
are the average of the nodes  
tops of the segment*

*D\_PLAN\_THHM  
QUAD8*

*Serendip 8 nodes in  
Pressures and  
AXIS\_THHM*

*bilinear displacement on 4  
temperature of a node medium*

*nodes in pressure and  
are the average of the nodes  
temperature*

*tops of the segment*

*D\_PLAN\_HM*

*TRIA6*

*Quadratic in displacement*

*Pressure of a node medium*

*AXIS\_HM*

*linear in pressure*

*is the average of the nodes*

*tops of the segment*

*D\_PLAN\_HHM*

*TRIA6*

*Quadratic in displacement*

*Pressures of a node*

*AXIS\_HHM*

*linear in pressure*

*medium are the averages of*

*nodes tops of the segment*

*D\_PLAN\_THM*

*TRIA6*

*Quadratic in displacement*

*Pressure and the temperature*

*AXIS\_THM*

*linear in pressure and*

*of a node medium are*

*temperature*

*average of the nodes tops*

*segment*

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6.3

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Date:

04/11/02

Author (S):



**C. CHAVANT Key**

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*D\_PLAN\_THH*

*TRIA6*

*Linear*

*Pressures and*

*AXIS\_THH*

*temperature of a node medium*

*are the average of the nodes*

*tops of the segment*

*D\_PLAN\_THHM*

*TRIA6*

*Quadratic in displacement*

*Pressures and*

*AXIS\_THHM*

*linear in pressure and*

*temperature of a node medium*

*temperature*

*are the average of the nodes*

*tops of the segment*

*D\_PLAN\_HM*

*QUAD4*

*Bilinear*

*AXIS\_HM*

*D\_PLAN\_HHM*

*QUAD4*

*Bilinear*

*AXIS\_HHM*

*D\_PLAN\_THM*

*QUAD4*

*Bilinear*

*AXIS\_THM*

*D\_PLAN\_THH*

*QUAD4*

*Bilinear*

*AXIS\_THH*

*D\_PLAN\_THHM*

*QUAD4*

*Bilinear*

*AXIS\_THHM*

*D\_PLAN\_HM*  
*TRIA3*  
*Linear*  
*AXIS\_HM*  
*D\_PLAN\_HHM*  
*TRIA3*  
*Linear*  
*AXIS\_HHM*  
*D\_PLAN\_THM*  
*TRIA3*  
*Linear*  
*AXIS\_THM*  
*D\_PLAN\_THH*  
*TRIA3*  
*Linear*  
*AXIS\_THH*  
*D\_PLAN\_THHM*  
*TRIA3*  
*Linear*  
*AXIS\_THHM*

**1.3**  
***Net support of the loadings***

***Modeling Nets***  
***Interpolation***  
***Remarks***

*D\_PLAN\_HM*  
*SEG3*  
*Quadratic in displacement,*  
*The pressure of the node medium is*  
*AXIS\_HM*  
*linear in pressure*  
*the average of the nodes*  
*tops of the segment*  
*D\_PLAN\_HHM*  
*SEG3*  
*Quadratic in displacement,*  
*Pressures of the node medium*  
*AXIS\_HHM*  
*linear in pressure*  
*are the averages of the nodes*  
*tops of the segment*

*D\_PLAN\_THM*

*SEG3*

*Quadratic in displacement,  
Pressure and the temperature*

*AXIS\_THM*

*linear in pressure and*

*node medium are*

*temperature*

*average of the nodes tops*

*segment*

*D\_PLAN\_THH*

*SEG3*

*Linear*

*Pressures and*

*AXIS\_THH*

*temperature of the node medium*

*are the average of the nodes*

*tops of the segment*

*D\_PLAN\_THHM*

*SEG3*

*Quadratic in displacement,*

*Pressures and*

*AXIS\_THHM*

*linear in pressure and*

*temperature of the node medium*

*temperature*

*are the average of the nodes*

*tops of the segment*

*D\_PLAN\_HM*

*SEG2*

*Linear*

*AXIS\_HM*

*D\_PLAN\_HHM*

*SEG2*

*Linear*

*AXIS\_HHM*

*D\_PLAN\_THM*

*SEG2*

*Linear*

*AXIS\_THM*

*D\_PLAN\_THH*

*SEG2*

*Linear*

*AXIS\_THH*  
*D\_PLAN\_THHM*  
*SEG2*  
*Linear*  
*AXIS\_THHM*

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**Code\_Aster** ®

*Version*

6.3

*Titrate:*

*Modelings D\_PLAN\_HM, D\_PLAN\_HHM, D\_PLAN\_THM, D\_PLAN\_THH...*

*Date:*

04/11/02

*Author (S):*

**C. CHAVANT** Key

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## **2**

### ***Significance of the symbols***

.

*corresponds to a functionality available*

*Name of*

*corresponds to a test implementing the functionality*

*case-test*

*corresponds to a functionality which could exist but noncurrently available*

### **3 Materials**

#### ***supported***

***DEFI\_MATERIAU***

*D\_PLAN\_HM*

*D\_PLAN\_HHM*

*D\_PLAN\_THM*

*D\_PLAN\_THH*

*D\_PLAN\_THHM*

*AXIS\_HM*

*AXIS\_HHM*

*AXIS\_THM*

*AXIS\_THH*

*AXIS\_THHM*

*THM\_LIQU*

*WTNV113B WTNV112A WTNV109B*

.

*WTNV118A*

*THM\_GAZ*

*WTNV113A WTNV112A WTNV109B*

.

*WTNV118A*

*THM\_VAPE\_GAZ*

*WTNV112A*

*· WTNV118A*

*THM\_INIT*

*WTNV113A WTNV112A WTNV109B*

.

*WTNV118A*

*THM\_DIFFU*

*WTNV113A WTNV112A WTNV109B*

.

*WTNV118A*

*ELAS*

*WTNV113A WTNV112A WTNV109B*

.

*CJS*

.....

*ELAS\_THM*

*WTNV120A*

*WTNV118A*

*SURF\_ETAT\_SATU*

*WTNV120B*

*CAM\_CLAY\_THM*

.

*SURF\_ETAT\_NSAT*

WTNV118A

**4 Loadings  
supported**

**4.1**

**AFFE\_CHAR\_MECA**

*All elements*

*Remarks*

*of this note*

*DDL\_IMPO*

*WTNV113A*

*FACE\_IMPO*

.

*LIAISON\_DDL*

*WTNV109C*

*LIAISON\_OBLIQUE*

.

*LIAISON\_GROUP*

.

*LIAISON\_UNIF*

.

*LIAISON\_SOLIDE*

.

*LIAISON\_ELEM*

.

*LIAISON\_CHAM\_NO*

.

*GRAVITY*

.

*ROTATION*

*FORCE\_NODALE*

*WTNV120A*

*FORCE\_FACE*

*FORCE\_ARETE*

*FORCE\_INTERNE*

.

*PRES\_REP*

.

*EPSI\_INIT*

*FLUX\_THM\_REP*

*WTNV114A*

*PRES\_CALCULEE*

.

*EPSA\_CALCULEE*

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*Titrate:*

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*Date:*

04/11/02

*Author (S):*

**C. CHAVANT** Key

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**4.2**

***AFFE\_CHAR\_MECA\_F***

***All elements***

***Remarks***

***of this note***

*DDL\_IMPO*

.

*FACE\_IMPO*

.

*LIAISON\_DDL*

.

*LIAISON\_OBLIQUE*

.

*LIAISON\_GROUP*

.

*LIAISON\_UNIF*

.

*LIAISON\_SOLIDE*

.

*FORCE\_NODALE*

.

*FORCE\_FACE*

.

*FORCE\_ARETE*

*FORCE\_INTERNE*

.

*PRES\_REP*

.

*EPSI\_INIT*

*FLUX\_THM\_REP*

.

## ***5 Possibilities***

### ***non-linear***

#### ***5.1***

***STAT\_NON\_LINE***

*COMP\_INCR*

*RELATION*

*D\_PLAN\_HM*

*D\_PLAN\_HHM*

*D\_PLAN\_THM*

*D\_PLAN\_THH*

*D\_PLAN\_THHM*

*AXIS\_HM*

*AXIS\_HHM*

*AXIS\_THM*

*AXIS\_THH*

*AXIS\_THHM*

*KIT\_HM*

*WTNV113A*



*KIT\_HHM*  
*WTNV112A*

*KIT\_THM*  
*WTNV109B*

*KIT\_THH*  
.  
*KIT\_THHM*  
*WTNV118A*

**6**  
*Elementary calculations of matrices*

***OPTIONS Remarks***

“*RIGI\_MECA\_TANG*”  
.  
“*FULL\_MECA*”  
.  
“*RAPH\_MECA*”  
.

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*Version*

6.3

*Titrate:*

*Modelings D\_PLAN\_HM, D\_PLAN\_HHM, D\_PLAN\_THM, D\_PLAN\_THH...*

*Date:*

04/11/02

*Author (S):*

***C. CHAVANT*** *Key*

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## ***Postprocessing of calculation***

### ***7.1 Options***

#### ***CALC\_ELEM***

##### ***OPTIONS Remarks***

***“SIEF\_ELNO\_ELGA”***

***WTNV109C***

***Except for***

***elements having***

***for support of the TRIA6***

***“VARI\_ELNO\_ELGA”***

***.***

***“EPSI\_ELNO\_DEPL”***

***“EPSI\_ELGA\_DEPL”***

### ***7.2 Options***

#### ***CALC\_NO***

##### ***D\_PLAN***

##### ***Remarks***

***“FORC\_NODA”***

***.***

***If***

***FORC\_NODA is***

***called from***

***REAC\_NODA***

***only terms of***

***mechanics are***

***calculated***

***“REAC\_NODA”***

***.***

***Only terms of***

*mechanics are  
calculated*

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**Code\_Aster** ®

Version

7.4

Titrate:

*Modeling 2D\_DIS\_T and 2D\_DIS\_TR*

Date:

03/06/05

Author (S):

**J.M. PROIX, F. LEBOUVIER** Key

:

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Organization (S): *EDF-R & D /AMA, DeltaCAD*

**Instruction manual**

**U3.13 booklet: Mechanical finite elements 2D**

**Document: U3.13.09**

**Modelings 2D\_DIS\_T and 2D\_DIS\_TR**

**Summary:**

***This document describes for modelings 2D\_DIS\_T, 2D\_DIS\_TR (cf [R5.03.17]):***

- *degrees of freedom carried by the finite elements which support modeling,*
- *the related meshes supports,*
- *supported loadings,*
- *nonlinear possibilities,*
- *case-tests implementing modelings.*

*Modeling 2D\_DIS\_T allows the representation of discrete elements of translation one or two nodes.  
Modeling 2D\_DIS\_TR allows the representation of discrete elements of translation and rotation one  
or  
two nodes.*

*They are usable for two-dimensional problems in linear mechanical analysis or not linear.*

*Instruction manual*

*U3.13 booklet: Mechanical finite elements 2D*

*HT-66/05/004/A*

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*Code\_Aster ®*

*Version*

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*Titrate:*

*Modeling 2D\_DIS\_T and 2D\_DIS\_TR*

*Date:*

*03/06/05*

*Author (S):*

*J.M. PROIX, F. LEBOUVIER Key*

*:*

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*1 Discretization*

*1.1*

*Degrees of freedom*

*The degrees of freedom of discretization are, in each node of the mesh support, both  
components of displacement of translation and rotation.*

*Finite element*

*Degrees of freedom (with each node top)*

*2D\_DIS\_T*

*DX*

**DY**

**2D\_DIS\_TR**

**DX**

**DY**

**DRZ**

**1.2**

***Net support of the matrices of rigidity***

***The meshes support of the discrete elements, in displacement formulation, are segments with two nodes SEG2 or of specific meshes POI1 confused with a node:***

***Modeling Nets Element  
finished***

***Remarks***

***2D\_DIS\_T POI1***

***MECA\_2D\_DIS\_T\_N***

***SEG2***

***MECA\_2D\_DIS\_T\_L***

***2D\_DIS\_TR POI1***

***MECA\_2D\_DIS\_TR\_N***

***SEG2***

***MECA\_2D\_DIS\_TR\_L***

***With regard to meshes POI1, the efforts intern are calculated starting from the differences of degrees of freedom of the mesh with the reference mark fixes (as if this discrete node were attached to a reference mark fixed).***

***For meshes SEG2, the efforts are calculated starting from the differences of the degrees of freedom carried by each of the 2 nodes.***

**2**

## ***Assignment of the characteristics***

***For these discrete elements, it is necessary to affect geometrical characteristics which are complementary to the data of grid. The definition of these data is carried out with order AFFE\_CARA\_ELEM associated with the key words following factors:***

### ***· DISCRETE***

***Allows to define and affect the values of the matrices of rigidity, mass or damping.  
Supported modelings: 2D\_DIS\_T, 2D\_DIS\_TR***

### ***· ORIENTATION***

***Allows to define and affect a local reference mark.  
Supported modelings: 2D\_DIS\_T, 2D\_DIS\_TR***

***Instruction manual***

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***Code\_Aster ®***

***Version***

***7.4***

***Titrate:***

***Modeling 2D\_DIS\_T and 2D\_DIS\_TR***

***Date:***

***03/06/05***

***Author (S):***

***J.M. PROIX, F. LEBOUVIER Key***

***:***

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***3 Loadings***

***supported***

***The supported loading is as follows:***

### ***· “GRAVITY”***

***Allows to apply a loading of the gravity type.  
Supported modelings: 2D\_DIS\_T, 2D\_DIS\_TR***

## ***Possibilities not - linear***

***Only modeling 2D\_DIS\_T being pressed on a mesh with 2 nodes is usable with STAT\_NON\_LINE and DYNA\_NON\_LINE. It is only in this case that one uses DEFI\_MATERIAU.***

### ***4.1***

#### ***Law of behavior***

***Laws of behaviors specific to these modelings, usable under COMP\_INCR in STAT\_NON\_LINE and DYNA\_NON\_LINE the following ones (cf [U4.51.11]):***

***/“DIS\_GOUJ2E\_ELAS”***

***Supported modeling: 2D\_DIS\_T (Mesh SEG2)***

***/“DIS\_GOUJ2E\_PLAS”***

***Supported modeling: 2D\_DIS\_T (Mesh SEG2)***

***/“ELAS”***

***Supported modelings: 2D\_DIS\_T, 2D\_DIS\_TR***

***In addition to the assignment of characteristics (AFFE\_CARA\_ELEM) the use of modelings DIS\_T and DIS\_TR with STAT\_NON\_LINE/DYNA\_NON\_LINE/DYNA\_TRAN\_EXPLI implies to define characteristics material (AFFE\_MATERIAU).***

### ***4.2 Deformations***

***Deformations available, used in the relations of behavior under the key word DEFORMATION for operators STAT\_NON\_LINE and DYNA\_NON\_LINE are (cf [U4.51.11]):***

***/“SMALL”***

***The deformations used for the relation of behavior are the linearized deformations calculated on the initial geometry.***

***Supported modeling: 2D\_DIS\_TR (Mesh SEG2)***

***/“PETIT\_REAC”***

***The deformations used in the incremental relation of behavior are the deformations linearized calculated on the reactualized geometry.***

***Supported modeling: 2D\_DIS\_TR (Mesh SEG2)***

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***Titrate:***

***Modeling 2D\_DIS\_T and 2D\_DIS\_TR***

***Date:***

***03/06/05***

***Author (S):***

***J.M. PROIX, F. LEBOUVIER Key***

***:***

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***5***

***Examples of implementation: case-tests***

***· 2D\_DIS\_T***

***Statics***

***linear***

***SSLL108A [V3.01.108]: Analyze response of a bar, modelled by 10 elements discrete (Meshs SEG2) subjected to a loading of traction.***

***Statics***

***non-linear***

***ZZZZ120A: Calculation of an assembly Pin-Attaches without top of support, with a law of elastoplastic behavior of Von Mises representing the local behavior of a net of pin of threaded assembly.***

***Dynamics***

***linear***

***SDLD02E [V2.01.002]: Seek frequencies of vibration and modes associated with one mechanical structure made up of masses and springs.***

***Dynamics***

***non-linear***

***SDNV104A: Dynamic response of a rigid shoe rubbing subjected to a pressure and one force of recall.***

***· 2D\_DIS\_TR***

***Dynamics***

***linear***

***SDLD02F [V2.01.002]: Seek frequencies of vibration and modes associated with one mechanical structure made up of masses and springs.***

***Instruction manual***

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**Code\_Aster** ®

**Version**

**7.4**

**Titrate:**

**Modeling D\_PLAN\_ABSO**

**Date:**

**01/06/05**

**Author (S):**

**G. DEVESA, F. LEBOUVIER Key**

**:**

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**Organization (S): EDF-R & D /AMA, DeltaCAD**

**Instruction manual**

**U3.13 booklet: Mechanical finite elements 2D**

**Document: U3.13.12**

**Modeling D\_PLAN\_ABSO**

## **Summary:**

*This document describes for modeling D\_PLAN\_ABSO:*

- *degrees of freedom carried by the finite elements which support modeling,*
- *the related meshes supports,*
- *supported loadings,*
- *nonlinear possibilities,*
- *case-tests implementing modeling.*

*Modeling D\_PLAN\_ABSO (Phenomenon: MECHANICS) corresponds to finite elements of which meshes supports are linear. They make it possible to take into account the condition of absorbing border of sections solids, studied in plane deformations.*

*Instruction manual*

*U3.13 booklet: Mechanical finite elements 2D*

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**Code\_Aster** ®

*Version*

*7.4*

*Titrate:*

*Modeling D\_PLAN\_ABSO*

*Date:*

*01/06/05*

*Author (S):*

*G. DEVESA, F. LEBOUVIER Key*

*:*

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## **1 Discretization**

### **1.1**

#### **Degrees of freedom**

#### **Modeling**

#### **Degrees of freedom (with each node top)**

## ***D\_PLAN\_ABSO***

***DX: displacement following X***

***DY: displacement following Y***

### ***1.2***

***Meshs supports of the matrices of rigidity***

***The meshs supports of the finite elements are segments. The elements are isoparametric.***

## ***Modeling Nets Interpolation***

***Remarks***

***Linear D\_PLAN\_ABSO SEG2***

***SEG3***

***quadratic***

### ***1.3***

***Meshs supports of the loadings***

***The same ones as previously.***

## ***2 Loadings***

***supported***

***The loading available is as follows:***

***· “ONDE\_PLANE”***

***Allows to impose a seismic loading by plane wave.***

## ***3 Possibilities***

***non-linear***

### ***3.1***

***Laws of behaviors***

***The only relation of behavior, available under DYNA\_NON\_LINE, for this modeling, under COMP\_INCR is relation “ELAS”.***

### ***3.2 Deformations***

***Only the linearized deformations “SMALL” key word under DEFORMATION are available.***

4

***Example of implementation: case-test***

***· Non-linear Dynamique***

***SDLV120B [V2.04.120]: Analyze propagation of a wave of compression in a bar infinite rubber band (absorption of the wave at the border of the grid).***

***Instruction manual***

***U3.13 booklet: Mechanical finite elements 2D***

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***Code\_Aster ®***

***Version***

***7.4***

***Titrate:***

***Modeling 2D\_FLUI\_ABSO***

***Date:***

***03/06/05***

***Author (S):***

***G. DEVESA, F. LEBOUVIER Key***

***:***

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***Organization (S): EDF-R & D /AMA, DeltaCAD***

***Instruction manual***

***U3.13 booklet: Mechanical finite elements 2D***

***Document: U3.13.13***

## ***Modeling 2D\_FLUI\_ABSO***

### ***Summary:***

***This document describes for modeling 2D\_FLUI\_ABSO:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported loadings,***
- nonlinear possibilities,***
- case-tests implementing modeling.***

***Modeling 2D\_FLUI\_ABSO (Phenomenon: MECHANICS) corresponds to finite elements of which meshes supports are linear. They make it possible to take into account the condition of absorbing border of sections fluid volumes, moving plane.***

### ***Instruction manual***

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***Code\_Aster ®***

***Version***

***7.4***

***Titrate:***

***Modeling 2D\_FLUI\_ABSO***

***Date:***

***03/06/05***

***Author (S):***

***G. DEVESA, F. LEBOUVIER Key***

***:***

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## ***1 Discretization***

### ***1.1***

#### ***Degrees of freedom***

##### ***Modeling***

***Degrees of freedom (with each node top)***

***2D\_FLUI\_ABSO***

***NEAR: pressure***

***PHI: fluid potential of displacement***

### ***1.2***

***Net support of the matrices of rigidity***

***The meshes supports of the finite elements are segments. The elements are isoparametric.***

##### ***Modeling Nets Interpolation***

***Remarks***

***linear 2D\_FLUI\_ABSO SEG2***

***SEG3***

***quadratic***

### ***1.3***

***Net support of the loadings***

***The same ones as previously.***

## ***2 Loadings***

***supported***

***No specific loading is supported by this modeling.***

## ***3 Possibilities***

***non-linear***

***In the case of a calculation with operator DYNA\_NON\_LINE, it is necessary to use the key word RELATION = "ELAS" as well as key word DEFORMATION=' PETIT' defined under the key word***

*COMP\_INCR.*

**4**

***Example of implementation: case-test***

*FDLV111B [V8.01.111]: Calculation of the absorption of a wave of pressure, created by a piston, in one fluid column.*

*Instruction manual*

*U3.13 booklet: Mechanical finite elements 2D*

*HT-66/05/004/A*

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***Code\_Aster*** ®

*Version*

*8.1*

*Titrate:*

*Modelings PLAN\_JOINT, AXIS\_JOINT, PLAN\_ELDI and AXIS\_ELDI*

*Date:*

*15/02/06*

*Author (S):*

***J. LAVERNE, F. LEBOUVIER*** *Key*

*:*

*U3.13.14-C Page*

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*Organization (S): EDF-R & D /AMA, DeltaCAD*



***Instruction manual  
U3.13 booklet: Mechanical finite elements 2D  
Document: U3.13.14***

***Modelings PLAN\_JOINT, AXIS\_JOINT,  
PLAN\_ELDI and AXIS\_ELDI***

***Summary:***

***This document describes for modelings PLAN\_JOINT, AXIS\_JOINT, PLAN\_ELDI and  
AXIS\_ELDI:***

***.  
degrees of freedom carried by the finite elements which support modeling,***

***.  
the related meshes supports,***

***.  
supported loadings,***

***.  
nonlinear possibilities,***

***.  
case-tests implementing modelings.***

***Modelings PLAN\_JOINT and AXIS\_JOINT (Phenomenon: MECHANICS) correspond to elements  
stop of joint, they are QUAD4 degenerated into SEG2 modelling the lips of a crack. Such elements  
stop can support the laws of behavior CZM\_EXP\_REG (law of cohesive forces of Barenblatt type:  
to see Doc. [R7.02.11]) and JOINT\_BA.***

***Modelings PLAN\_ELDI and AXIS\_ELDI (Phenomenon: MECHANICS) correspond to elements  
with***

***internal discontinuity, they are voluminal elements (QUAD4) crossed by a discontinuity. It allow  
also to model the opening of a crack. Such finite elements can support only one law of  
behavior: CZM\_EXP (law of cohesive forces of Barenblatt type: to see Doc. [R7.02.12]).***

***Thereafter, symbol XXX corresponds to “PLAN” or “AXIS”.***

***Instruction manual  
U3.13 booklet: Mechanical finite elements 2D  
HT-62/06/004/A***

**Code\_Aster** ®

**Version**

**8.1**

**Titrate:**

**Modelings PLAN\_JOINT, AXIS\_JOINT, PLAN\_ELDI and AXIS\_ELDI**

**Date:**

**15/02/06**

**Author (S):**

**J. LAVERNE, F. LEBOUVIER Key**

**:**

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## **1 Discretization**

### **1.1**

**Degrees of freedom**

**Modeling**

**Degrees of freedom (with each node top)**

**XXX\_JOINT**

**DX: displacement following X**

**DY: displacement following Y**

**XXX\_ELDI**

**DX: displacement following X**

**DY: displacement following Y**

### **1.2**

**Net support of the matrices of rigidity**

**The meshes supports of the finite elements are quadrangles. The elements are isoparametric.**

**Modeling Nets Interpolation**

**Remarks**

**Linear XXX\_JOINT QUAD4**

**Linear XXX\_ELDI QUAD4**

## **2 Possibilities**

## ***non-linear***

### ***2.1***

#### ***Law of behaviors***

***Laws of behaviors specific to these modelings, usable under COMP\_INCR in STAT\_NON\_LINE and DYNA\_NON\_LINE are as follows (cf [U4.51.11]):***

***/“CZM\_EXP\_REG”***

***Supported modelings: PLAN\_JOINT, AXIS\_JOINT***

***/“CZM\_EXP”***

***Supported modelings: PLAN\_ELDI, AXIS\_ELDI***

***/“JOINT\_BA”***

***Supported modelings: PLAN\_JOINT, AXIS\_JOINT***

### ***2.2 Deformations***

***Only the linearized deformations “SMALL” key word under DEFORMATION are available in relations of behavior (cf [U4.51.11]).***

#### ***Instruction manual***

***U3.13 booklet: Mechanical finite elements 2D***

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**Code\_Aster** ®

Version

8.1

Titrate:

Modelings *PLAN\_JOINT*, *AXIS\_JOINT*, *PLAN\_ELDI* and *AXIS\_ELDI*

Date:

15/02/06

Author (S):

**J. LAVERNE**, **F. LEBOUVIER** Key

:

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**3**

**Examples of implementation: case-tests**

.

**PLAN\_JOINT**

Statics

non-linear

*SSNP118A [V6.03.118]: Case-test of validation of the element joint plane 2D with a law of behavior of the type CZM\_EXP\_REG.*

*SSNP128A [V6.03.128]: Validation of the element with internal discontinuity and law CZM\_EXP on a plane plate.*

*SSNP126A [V6.03.126]: Case-test of validation of the law of behavior JOINT\_BA (connection steel-concrete) with an element of joint plane 2D.*

.

**AXIS\_JOINT**

Statics

non-linear

*SSNA112A [V6.01.112]: Test of wrenching carried out by Borderie & Pijaudier - Pooch for the study of the steel-concrete connection with the law of behavior JOINT\_BA.*

*SSNA115A [V6.01.115]*

*: Wrenching of a rigid reinforcement with elements with discontinuity.*

Instruction manual

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**Code\_Aster** ®

*Version*

*8.1*

*Titrate:*

*Modelings PLAN\_JOINT, AXIS\_JOINT, PLAN\_ELDI and AXIS\_ELDI*

*Date:*

*15/02/06*

*Author (S):*

*J. LAVERNE, F. LEBOUVIER Key*

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*Instruction manual*

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***Code\_Aster*** ®

*Version*

*7.4*

***Titrate:***  
***Modelings mechanical 3D and 3D\_SI***

***Date:***  
***01/06/05***

***Author (S):***  
***X. DESROCHES, F. LEBOUVIER Key***

***:***  
***U3.14.01-E Page***  
***: 1/4***

***Organization (S): EDF-R & D /AMA, DeltaCAD***

***Instruction manual***  
***U3.14 booklet: Mechanical finite elements 3D***  
***U3.14.01 document***

***Modelings mechanical 3D and 3D\_SI***

***Summary:***

***This document describes for mechanical modelings 3D and 3D\_SI:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***

- *supported loadings,*
- *nonlinear possibilities,*
- *case-tests implementing modeling.*

*Modelings 3D and 3D\_SI (Phenomenon: MECHANICS) correspond to finite elements of which meshes supports are voluminal.*

*The suffix \_SI means: Under - Integrated: the integration of the terms relating to the laws of behavior is done reduced way (diagram of points of Gauss of a nature less low than modeling with complete integration).*

*Instruction manual*

*U3.14 booklet: Mechanical finite elements 3D*

*HT-66/05/004/A*

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Modelings mechanical 3D and 3D\_SI*

*Date:*

*01/06/05*

*Author (S):*

*X. DESROCHES, F. LEBOUVIER Key*

*:*

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*1 Discretization*

*1.1*

*Degrees of freedom*

*Modeling*

*Degrees of freedom*

*(with each node top)*

*3D, 3D\_SI*

*DX: displacement following X*

***DY: displacement following Y***

***DZ: displacement following Z***

## ***1.2***

***Net support of the matrices of rigidity***

***The meshes support of the finite elements can be tetrahedrons, pyramids, prisms or hexaèdres. The elements are isoparametric.***

***Modeling Nets Interpolation***

***Remarks***

***3D, 3D\_SI***

***TETRA4***

***Linear***

***3D, 3D\_SI***

***TETRA10***

***Quadratic***

***3D, 3D\_SI***

***PYRAM5***

***Linear***

***3D, 3D\_SI***

***PYRAM13***

***Quadratic***

***3D, 3D\_SI***

***PENTA6***

***Bilinear***

***3D, 3D\_SI***

***PENTA15***

***Serendip***

***3D, 3D\_SI***

***HEXA8***

***Trilinear***

***3D HEXA20***

***Serendip integration***

***complete***

***3D\_SI HEXA20***

***Serendip integration***

***reduced***

***3D, 3D\_SI***

***HEXA27***

***Tri-quadratic***



## **1.3**

### ***Net support of the loadings***

#### ***Modeling Nets Interpolation***

##### ***Remarks***

*3D, 3D\_SI*

*TRIA3*

*Linear or*

*Bilinear*

*TRIA6*

*Quadratic or*

*Serendip*

*QUAD4*

*Bilinear*

*QUAD8*

*Serendip*

*QUAD9*

*Quadratic*

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*Titrate:*

*Modelings mechanical 3D and 3D\_SI*

*Date:*

*01/06/05*

*Author (S):*

***X. DESROCHES, F. LEBOUVIER*** *Key*

*:*

## **2 Loadings supported**

*The loadings available are as follows:*

### **· “CONTACT”**

*Allows to define the zones subjected to conditions of contact.*

*Supported modelings: 3D, 3D\_SI*

### **· “FORCE\_ARETE”**

*Allows to apply linear forces, with an edge of voluminal element.*

*Supported modelings: 3D, 3D\_SI*

### **· “FORCE\_FACE”**

*Allows to apply surface forces to a voluminal face of element.*

*Supported modelings: 3D, 3D\_SI*

### **· “FORCE\_INTERNE”**

*Allows to apply voluminal forces.*

*Supported modelings: 3D, 3D\_SI*

### **· “GRAVITY”**

*Allows to apply a loading of the gravity type.*

*Supported modelings: 3D, 3D\_SI*

### **· “PRES\_REP”**

*Allows to apply a pressure to a field of continuous medium.*

*Supported modelings: 3D, 3D\_SI*

### **· “TEMP\_CALCULEE”**

*Allows to apply a thermal loading.*

*Supported modelings: 3D, 3D\_SI*

### **· “SECH\_CALCULEE”**

*Allows to apply a field of drying.*

*Supported modelings: 3D, 3D\_SI*

### **· “HYDR\_CALCULEE”**

*Allows to apply a field of hydration and a field of temperature.*

*Supported modelings: 3D, 3D\_SI*

· **“EPSA\_CALCULEE”**

*Allows to apply a field of anelastic deformations resulting from external software.*

*Supported modelings: 3D, 3D\_SI*

· **“PRES\_CALCULEE”**

*Allows to apply a field of pressure resulting from external software.*

*Supported modelings: 3D, 3D\_SI*

*Instruction manual*

*U3.14 booklet: Mechanical finite elements 3D*

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*Titrate:*

*Modelings mechanical 3D and 3D\_SI*

*Date:*

*01/06/05*

*Author (S):*

*X. DESROCHES, F. LEBOUVIER Key*

*:*

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· **“EPSI\_INIT”**

*Allows to apply a field of initial deformation.*

*Supported modelings: 3D, 3D\_SI*

· **“ROTATION”**

*Allows to apply a number of revolutions and a vector of rotation.*

*Supported modelings: 3D, 3D\_SI*

· **“EFFE\_FOND”**

*Allows to calculate and apply the basic effect on a branch of piping subjected to one internal pressure.*

*Supported modelings: 3D, 3D\_SI*

**3 Possibilities**

***non-linear***

### **3.1**

#### ***Laws of behaviors***

*Laws of behaviors (model traditional, model buildings with damage, models for the concrete and the grounds,...), usable under COMP\_INCR or COMP\_ELAS in STAT\_NON\_LINE and DYNA\_NON\_LINE, under the key word RELATION, are described in details in the document “Behavior nonlinear” [U4.51.11].*

### **3.2 Deformations**

*Deformations usable under COMP\_INCR or COMP\_ELAS in STAT\_NON\_LINE and DYNA\_NON\_LINE, under the key word DEFORMATION, are described in details in the document “Behavior nonlinear” [U4.51.11].*

## **4**

### ***Examples of implementation: case-tests***

#### **· 3D**

*Statics*

*linear*

*FORMA01C [V7.15.100]: Quasi-static analysis of a piping comprising an elbow subjected to a specific force, an internal pressure and a thermal transient.*

*Statics*

*non-linear*

*HSNV121A: [V7.15.121]: Quasi-static analysis in great deformations of a bar under thermal loading subjected to a force of traction.*

*Dynamics*

*linear*

*SDLV100A [V2.04.100]: Seek frequencies and modes of inflection associated with one slim beam of variable rectangular section (embed-free).*

*Dynamics*

*non-linear*

*SDNV100A [V5.03.100]: Analyze transitory direct of a slim beam animated of one initial speed coming to run up against a rigid wall.*

#### **· 3D\_SI**

*Statics*

*non-linear*

*HSNV125D: Quasi-static analysis of a volume in traction subjected to a temperature variable and with a loading in shearing with a law of viscoplastic behavior (case-test n°2 PHI2AS “non-linear Behavior of materials”, 2000 Volume XXIV N°1).*

*Dynamics*

*non-linear*

*SDNV103A [V5.03.103]: Analyze impact of an elastoplastic bar of Taylor on one rigid solid mass. Modeling takes into account the contact with friction and one behavior elastoplasticity with great deformations.*

*Instruction manual*

*U3.14 booklet: Mechanical finite elements 3D*

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**Code\_Aster** ®

Version

7.4

Titrate:

*Modelings 3D\_FLUIDE, FLUI\_STRU, 2D\_FLUI\_PESA*

Date:

01/06/05

Author (S):

**NR. GREFFET, F. LEBOUVIER** Key

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

**Instruction manual**

**U3.14 booklet: Mechanical finite elements 3D**

**Document: U3.14.02**

**Modelings 3D\_FLUIDE, FLUI\_STRU,**

## **2D\_FLUI\_PESA**

### **Summary:**

***This document describes for modelings 3D\_FLUIDE, FLUI\_STRU, 2D\_FLUI\_PESA:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported loadings,***
- nonlinear possibilities,***
- case-tests implementing modelings.***

***Modelings 3D\_FLUIDE (elements of volume) and FLUI\_STRU (elements 2D of interaction fluid-structure)***

***correspond to the linear formulation of the coupled problem allowing the study of the vibratory behavior of one structure in the presence of a nonviscous, compressible fluid [R4.04.01]. The free face is taken into account***

***by modeling 2D\_FLUI\_PESA (surface elements).***

***Instruction manual***

***U3.14 booklet: Mechanical finite elements 3D***

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***Code\_Aster ®***

***Version***

***7.4***

***Titrate:***

***Modelings 3D\_FLUIDE, FLUI\_STRU, 2D\_FLUI\_PESA***

***Date:***

***01/06/05***

***Author (S):***

***NR. GREFFET, F. LEBOUVIER Key***

***:***

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***1 Discretization***

***1.1***

## ***Degrees of freedom***

### ***Finished Elément***

#### ***Degrees of freedom (with each node top)***

***MEFL\_... (3D\_FLUIDE)***

***NEAR: pressure***

***PHI: fluid potential of displacement***

***MEFL\_FACE... (3D\_FLUIDE)***

***PHI: fluid potential of displacement***

***MEFS\_... (FLUI\_STRU)***

***DX, DY, DZ: components of structure displacement***

***PHI: fluid potential of displacement***

***MEFP\_FACE... (2D\_FLUI\_PESA)***

***DZ: deflection of the free face***

***PHI: fluid potential of displacement***

## ***1.2***

### ***Net support of the matrices of rigidity***

#### ***Modeling Nets Element***

***finished***

***Remarks***

***3D\_FLUIDE TETRA4***

***MEFL\_TETRA4***

***TETRA10***

***MEFL\_TETRA10***

***PENTA6***

***MEFL\_PENTA6***

***PENTA15 MEFL\_PENTA15***

***HEXA8 MEFL\_HEXA8***

***HEXA20 MEFL\_HEXA20***

***HEXA27 MEFL\_HEXA27***

***FLUI\_STRU TRIA3***

***MEFS\_FACE3***

*TRIA6 MEFS\_FACE6*

*QUAD4 MEFS\_FACE4*

*QUAD8 MEFS\_FACE8*

*QUAD9 MEFS\_FACE9*

*2D\_FLUI\_PESA TRIA3 MEFP\_FACE3*

*TRIA6 MEFP\_FACE6*

*QUAD4 MEFP\_FACE4*

*QUAD8 MEFP\_FACE8*

*QUAD9 MEFP\_FACE9*

**Note:**

*The coupling with a structure with a grid in elements COQUE\_3D forces to net the interface fluid-structure with elements QUAD8 (and not QUAD9). The fluid massive field is thus with a grid in HEXA20 (and not HEXA27). Indeed, the coupling fluid-structure is done on the DDL of displacement only, for the solid.*

**1.3**

**Net support of the loadings**

**Modeling Nets Element  
finished**

**Remarks**

*3D\_FLUIDE TRIA3  
MEFL\_FACE3*



*TRIA6*  
*MEFL\_FACE6*

*QUAD4*  
*MEFL\_FACE4*

*QUAD8*  
*MEFL\_FACE8*

*QUAD9*  
*MEFL\_FACE9*

*Instruction manual*  
*U3.14 booklet: Mechanical finite elements 3D*  
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**Code\_Aster** ®

*Version*

7.4

*Titrate:*

*Modelings 3D\_FLUIDE, FLUI\_STRU, 2D\_FLUI\_PESA*

*Date:*

01/06/05

*Author (S):*

**NR. GREFFET, F. LEBOUVIER** *Key*

:

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**2 Loadings**  
**supported**

*The loadings available are as follows:*

· **GRAVITY**

*Allows to apply a loading of the gravity type.*

*Supported modeling: 2D\_FLUI\_PESA*

· **VITE\_FACE**

*Allows to specify the field speed vibratory imposed in loading on elements of border.*

*Supported modeling: 3D\_FLUIDE*

· **IMPE\_FACE**

*Allows to specify the chart of impedance imposed in boundary condition on elements of border.*

*Supported modeling: 3D\_FLUIDE*

· **“ONDE\_FLUI”**

*Allows to apply an amplitude of pressure of sinusoidal incidental wave arriving normally with a face.*

*Supported modeling: 3D\_FLUIDE*

### **3 Possibilities**

#### **non-linear**

#### **3.1**

##### **Laws of behaviors**

*The only relation of behavior available in DYNA\_NON\_LINE, for modeling FLUI\_STRU under COMP\_INCR is RELATION “ELAS” (cf [U4.51.11]).*

#### **3.2 Deformations**

*Only the linearized deformations “SMALL” key word under DEFORMATION are available in relations of behavior (cf [U4.51.11]).*

#### **4**

##### **Example of implementation: case-tests**

· **3D\_FLUIDE**

*AHLV100B [V8.22.100]: A rectilinear guide of wave at anechoic exit of which medium of propagation is “normal” air, is excited by a harmonically vibrating piston. Calculation consist in determining the field of acoustic pressure of the harmonic answer.*

*FDLV111A [V8.01.111]: Absorption of a wave of pressure created by a piston in a column fluid.*

· **FLUI\_STRUC**

*FDLV111A [V8.01.111]: Absorption of a wave of pressure created by a piston in a column fluid.*

*FDNV100A [V8.01.111]: Analyze shaking of a water tank with deformable wall rubber band.*

· **2D\_FLUI\_PESA**

*FDNV100A [V8.01.111]: Analyze shaking of a water tank with deformable wall*

***rubber band.***

***Instruction manual***

***U3.14 booklet: Mechanical finite elements 3D***

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***Code\_Aster*** ®

***Version***

***7.4***

***Titrate:***

***Modelings 3D\_FLUIDE, FLUI\_STRU, 2D\_FLUI\_PESA***

***Date:***

***01/06/05***

***Author (S):***

***NR. GREFFET, F. LEBOUVIER Key***

***:***

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***Instruction manual***

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**Code\_Aster** ®

*Version*

7.4

*Titrate:*

**Modeling 3D\_INCO**

*Date:*

01/06/05

*Author (S):*

**S. MICHEL-PONNELLE, F. LEBOUVIER** *Key*

:

*U3.14.06-D Page*

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

***Instruction manual***

***U3.14 booklet: Mechanical finite elements 3D***

***Document: U3.14.06***

***Modeling 3D\_INCO***

***Summary:***

*This document describes for modeling 3D\_INCO:*

- *degrees of freedom carried by the finite elements which support modeling,*
- *the related meshes supports,*
- *laws of behavior and loadings supported,*
- *non-linear possibilities,*
- *case-tests implementing modeling.*

*This modeling is based on finite elements adapted to the treatment of the problems quasi-incompressible. It is essential to carry out calculations of limiting analysis with the law of Norton-Hoff and is also useful for the studies presenting of strong plastic deformations for which traditional formulation in displacement appears insufficient (oscillation of the constraints). The formulation used*

*is a formulation with 3 fields: displacement-pressure-swelling [R6.03.05], usable with all them behaviors written in incremental form. Modeling 3D\_INCO has voluminal meshes supports and accept the TETRA10, the HEXA20, and the PENTA15.*

*Instruction manual*

*U3.14 booklet: Mechanical finite elements 3D*

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Modeling 3D\_INCO*

*Date:*

*01/06/05*

*Author (S):*

*S. MICHEL-PONNELLE, F. LEBOUVIER Key*

*:*

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*1 Discretization*

*1.1*

*Degrees of freedom*

*Modeling*

*Ddl with all the nodes*

*Ddl only with the nodes tops*

**3D**  
**DX, DY, DZ**  
**CLOSE (\*), GONF**

*\* no kinematic condition can be imposed on the degree of freedom NEAR.*

**1.2**  
**Net support of the matrices of rigidity**

*For modeling 3D, the meshes support of the finite elements can be tetrahedrons, hexaédres or of the prisms.*

**Modeling Nets**  
**Interpolation**  
**in**  
**Interpolation in**  
**displacements**  
**pressure and swelling**

**3D TETRA10**  
**Quadratic Linear**  
**HEXA20**  
**Quadratic Linear**  
**PENTA15**  
**Quadratic Linear**

**1.3**  
**Net support of the surface loadings**

**Modeling**  
**Net**  
**Interpolation in displacements**

**3D TRIA6**  
**Quadratic**  
**Quadratic QUAD8**

**2 Loadings**  
**supported**

*The loadings available under AFFE\_CHAR\_MECA\_ are as follows:*

· **“FORCE\_ARETE”**

*Allows to apply linear forces, with an edge of voluminal element.*

· **“FORCE\_FACE”**

*Allows to apply surface forces to a voluminal face of element.*

· **“FORCE\_INTERNE”**

*Allows to apply voluminal forces.*

· **“GRAVITY”**

*Allows to apply a loading of the gravity type.*

· **“PRES\_REP”**

*Allows to apply a pressure to a field of continuous medium.*

**Instruction manual**

**U3.14 booklet: Mechanical finite elements 3D**

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**Code\_Aster** ®

**Version**

**7.4**

**Titrate:**

**Modeling 3D\_INCO**

**Date:**

**01/06/05**

**Author (S):**

**S. MICHEL-PONNELLE, F. LEBOUVIER Key**

**:**

**U3.14.06-D Page**

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**3 Possibilities**

**non-linear**

**Attention, this modeling is accessible only starting from STAT\_NON\_LINE. It cannot be used with MECA\_STATIQUE or by a manual assembly.**

**3.1**

**Laws of behavior**



*All the laws of behavior usable on meshes of continuous mediums have a physical direction for these modelings and are easily affected as from the moment when they are accessible from COMP\_INCR in STAT\_NON\_LINE (cf [U4.51.11]).*

*Let us announce that a law of behavior is specific to this modeling (dedicated to the calculation of load limit, cf [R7.07.01]):*

*/“NORTON\_HOFF”*

### *3.2 Deformations*

*Deformations available, used in the relations of behavior under the key word DEFORMATION for operators STAT\_NON\_LINE, DYNA\_NON\_LINE and DYNA\_TRANS\_EXPLI are (Cf [U4.51.11]):*

*/“SMALL”*

*The deformations used for the relation of behavior are the deformations linearized.*

*/“SIMO\_MIEHE”*

*Allows to carry out calculations in great plastic deformations.*

### *3.3*

#### *Method of Newton*

*For the resolution of the problem by the method of Newton-Raphson, the elastic matrix is not available. It is thus necessary to use under the key word NEWTON for operators STAT\_NON\_LINE and DYNA\_NON\_LINE (cf [U4.51.11]):*

*/PREDICTION = “TANGENT”*

*The phase of prediction is carried out with the tangent matrix.*

*/MATRIX = “TANGENT”*

*The matrix used for the iterations total is the tangent matrix*

*Note:*

*The formulation used leads to nonpositive matrices and the current solveurs do not know*

*to solve always well the linear systems which are associated for them. In the event of difficulty of convergence, it can thus be useful to test the other solveurs available in the code or them other methods of renumérotations (cf [U4.50.01]).*

***Instruction manual***

***U3.14 booklet: Mechanical finite elements 3D***

***HT-66/05/004/A***

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***Code\_Aster ®***

***Version***

***7.4***

***Titrate:***

***Modeling 3D\_INCO***

***Date:***

***01/06/05***

***Author (S):***

***S. MICHEL-PONNELLE, F. LEBOUVIER Key***

***:***

***U3.14.06-D Page***

***: 4/4***

***4***

***Examples of implementation: case-tests***

***· Petites deformations:***

***SSLV130A [V3.04.130]: Analyze of a hollow roll into incompressible, subjected to a pressure intern.***

***· Grandes deformations:***

***SSNV112A [V6.04.112]: Analyze of a hollow roll into incompressible in great deformations, subjected to an internal radial displacement.***

***· Limiting Analyse:***

***SSNV124B [V6.04.124]: Determination of the load limits of a cube subjected to loadings on its edges.***

***Instruction manual***

***U3.14 booklet: Mechanical finite elements 3D***

***HT-66/05/004/A***

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**Code\_Aster** ®

**Version**

**6.3**

**Titrate:**

**Modeling 3D\_HM, 3D\_HHM, 3D\_THM, 3D\_THH, 3D\_THHM**

**Date:**

**04/11/02**

**Author (S):**

**C. CHAVANT Key**

**:**

**U3.14.07-C1 Page:**

**1/6**

**Organization (S): EDF-R & D /AMA**

**Instruction manual**

**U3.14 booklet: Mechanical finite elements 3D**

**U3.14.07 document**

**Modelings 3D\_HM, 3D\_HHM, 3D\_THM, 3D\_THH,  
3D\_THHM**

**Summary:**

*This document describes for modelings 3D\_HM, 3D\_HHM, 3D\_THM, 3D\_THH and 3D\_THHM:*

- degrees of freedom carried by the finite elements which support modeling,*
- the related meshes supports,*
- supported materials and loadings,*
- options of calculations for the elementary matrices and the post treatments,*
- nonlinear possibilities as well as the options of the breaking process if they exist.*

*Modelings 3D\_HM, 3D\_HHM, 3D\_THM, 3D\_THH, 3D\_THHM, (Phenomenon: MECHANICS) correspond to finite elements whose meshes supports are voluminal.*

*Instruction manual*

*U3.14 booklet: Mechanical finite elements 3D*

*HT-66/02/003/A*

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*Code\_Aster ®*

*Version*

*6.3*

*Titrate:*

*Modeling 3D\_HM, 3D\_HHM, 3D\_THM, 3D\_THH, 3D\_THHM*

*Date:*

*04/11/02*

*Author (S):*

*C. CHAVANT Key*

*:*

*U3.14.07-C1 Page:*

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*1 Discretization*

*1.1*

*Degrees of freedom*

*DX, DY and DZ indicate the degrees of freedom of displacement.*

*PRE1 and PRE2 indicate two degrees of freedom of pressure, whose precise significance depends on laws of behavior used. TEMP indicates the temperature.*

*Finite element*

*Degrees of freedom*

*3D\_HM*

***DX, DY, DZ, PRE1***  
***3D\_HHM***  
***DX, DY, DZ, PRE1, PRE2***  
***3D\_THM***  
***DX, DY, DZ, PRE1, TEMP***  
***3D\_THH***  
***PRE1, PRE2, TEMP***  
***3D\_THHM***  
***DX, DY, DZ, PRE1, PRE2, TEMP***

***1.2***  
***Net support of the matrices of rigidity***

***The meshes support of the finite elements can be only h xa dres. The elements are isoparametric.***

***Modeling Nets***  
***Interpolation***  
***Remarks***

***3D\_HM***  
***HEXA20***  
***Serendip 20 nodes in***  
***Pressure of a node medium***  
***trilinear displacement on 8***  
***is the average of the nodes***  
***nodes in pressure***  
***tops of the segment***

***3D\_HHM***  
***HEXA20***  
***Serendip 20 nodes in***  
***Pressures of a node medium***  
***trilinear displacement on 8***  
***are the averages of the nodes***  
***nodes in pressure***  
***tops of the segment***

***3D\_THM***  
***HEXA20***  
***Serendip 20 nodes in***  
***Pressure and the temperature***  
***trilinear displacement on 8***  
***of a node medium are***  
***nodes in pressure and***

*average of the nodes tops  
temperature  
segment  
3D\_THH  
HEXA20  
Trilinear on 8 nodes in  
Pressures and the temperature  
pressure and temperature  
of a node medium are  
average of the nodes tops  
segment  
3D\_THHM  
HEXA20  
Serendip 20 nodes in  
Pressures and the temperature  
trilinear displacement on 8  
of a node medium are  
nodes in pressure and  
average of the nodes tops  
temperature  
segment  
Instruction manual  
U3.14 booklet: Mechanical finite elements 3D  
HT-66/02/003/A*

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*Code\_Aster* ®

*Version*

*6.3*

*Titrate:*

*Modeling 3D\_HM, 3D\_HHM, 3D\_THM, 3D\_THH, 3D\_THHM*

*Date:*

*04/11/02*

*Author (S):*

*C. CHAVANT Key*

*:*

*U3.14.07-C1 Page:*

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*1.3*

*Net support of the loadings*

***Modeling Nets***

***Interpolation***

***Remarks***

***3D\_HM***

***QUAD8***

***Serendip 8 nodes in  
Pressure of a node medium  
bilinear displacement on 4  
is the average of the nodes  
nodes in pressure and  
tops of the segment  
temperature***

***3D\_HHM***

***QUAD8***

***Serendip 8 nodes in  
Pressures of a node medium  
bilinear displacement on 4  
are the averages of the nodes  
nodes in pressure  
tops of the segment***

***3D\_THM***

***QUAD8***

***Quadratic in displacement  
Pressure and the temperature  
linear in pressure and  
of a node medium are  
temperature  
average of the nodes tops  
segment***

***3D\_THH***

***QUAD8***

***Bilinear on 4 nodes in  
Pressures and the temperature  
pressure and temperature  
of a node medium are  
average of the nodes tops  
segment***

***3D\_THHM***

***QUAD8***

***Serendip 8 nodes in  
Pressures and the temperature  
bilinear displacement on 4***

*of a node medium are  
nodes in pressure and  
average of the nodes tops  
temperature  
segment*

**2**  
*Significance of the symbols*

*.  
corresponds to a functionality available*

*corresponds to a functionality which could exist but noncurrently available  
Name of case corresponds to a test implementing the functionality  
test*

**3 Materials**  
*supported*

*DEFI\_MATERIAU*

*3D\_HM*

*3D\_HHM*

*3D\_THM*

*3D\_THH*

*3D\_THHM*

*THM\_LIQU*

*SSNV134C WTNV112B WTNV109A*

*.  
.*

*THM\_GAZ*

*SSNV134C WTNV122B WTNV109A*

*.  
.*

*THM\_VAPE\_GAZ*

*WTNV112B*

*.  
.*

*THM\_INIT*

*SSNV134C WTNV112B WTNV109A*

*.  
.*



**THM\_DIFFU**  
**SSNV134C WTNV112B WTNV109A**

**ELAS**  
**SSNV134C WTNV112B WTNV109A**

**CJS**  
**SSNV134C**

**ELAS\_THM**

**WTNV115A**  
**SURF\_ETAT\_SATU**

**WTNV116A**  
**CAM\_CLAY\_THM**

**WTNV117A**  
**SURF\_ETAT\_NSAT**

**Instruction manual**  
**U3.14 booklet: Mechanical finite elements 3D**  
**HT-66/02/003/A**

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**Code\_Aster** ®  
**Version**  
**6.3**

**Titrate:**  
**Modeling 3D\_HM, 3D\_HHM, 3D\_THM, 3D\_THH, 3D\_THHM**

**Date:**  
**04/11/02**  
**Author (S):**  
**C. CHAVANT Key**

**:**  
**U3.14.07-C1 Page:**  
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***4 Loadings  
supported***

***4.1  
AFFE\_CHAR\_MECA***

***All elements  
Remarks  
of this note***

***DDL\_IMPO***

***SSNV134C***

***FACE\_IMPO***

***SSNV134C***

***LIAISON\_DDL***

***.***

***LIAISON\_OBLIQUE***

***.***

***LIAISON\_GROUP***

***.***

***LIAISON\_UNIF***

***.***

***LIAISON\_SOLIDE***

***.***

***LIAISON\_ELEM***

***.***

***LIAISON\_CHAM\_NO***

***.***

***GRAVITY***

***.***

***ROTATION***

***FORCE\_NODALE***

***.***

***FORCE\_FACE***

***FORCE\_ARETE***

***FORCE\_INTERNE***

***.***

***PRES\_REP***

***SSNV134C***

***EPSI\_INIT***

***FLUX\_THM\_REP***

***WTNV114C***

***PRES\_CALCULEE***

.

***EPSA\_CALCULEE***

***Instruction manual***

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***Code\_Aster*** ®

***Version***

***6.3***

***Titrate:***

***Modeling 3D\_HM, 3D\_HHM, 3D\_THM, 3D\_THH, 3D\_THHM***

***Date:***

***04/11/02***

***Author (S):***

***C. CHAVANT Key***

.

***U3.14.07-C1 Page:***

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***4.2***

***AFFE\_CHAR\_MECA\_F***

***All elements***

***Remarks***

***of this note***

***DDL\_IMPO***

.

***FACE\_IMPO***

.

***LIAISON\_DDL***

.

***LIAISON\_OBLIQUE***

.

**LIAISON\_GROUP**

.

**LIAISON\_UNIF**

.

**LIAISON\_SOLIDE**

.

**FORCE\_NODALE**

.

**FORCE\_FACE**

.

**FORCE\_ARETE**

**FORCE\_INTERNE**

.

**PRES\_REP**

.

**EPSI\_INIT**

**FLUX\_THM\_REP**

.

**5 Possibilities**

**non-linear**

**5.1**

**STAT\_NON\_LINE**

**COMP\_INCR**

**RELATION**

**3D\_HM**

**3D\_HHM**

**3D\_THM**

**3D\_THH**

**3D\_THHM**

**KIT\_HM**

**SSNV13**

**4C**

***KIT\_HHM***  
***WTNV112B***

***KIT\_THM***  
***WTNV109A***

***KIT\_THH***  
.

***KIT\_THHM***  
.

**6**  
***Elementary calculations of matrices***

***OPTIONS Remarks***

***“RIGI\_MECA\_TANG”***  
.

***“FULL\_MECA”***  
.

***“RAPH\_MECA”***  
.

***“FORC\_NODA”***

· ***If***

***FORC\_NODA is called from***

***REAC\_NODA***

***only the terms of mechanics are  
calculated***

***Instruction manual***

***U3.14 booklet: Mechanical finite elements 3D***

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***Code\_Aster*** ®

***Version***

**6.3**

***Titrate:***

***Modeling 3D\_HM, 3D\_HHM, 3D\_THM, 3D\_THH, 3D\_THHM***

**Date:**

**04/11/02**

**Author (S):**

**C. CHAVANT Key**

**:**

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**7**

***Postprocessing of calculation***

**7.1 Options**

**CALC\_ELEM**

**OPTIONS**

***All elements***

***Remarks***

***of this note***

**“SIEF\_ELNO\_ELGA”**

**SSNV134C**

**“VARI\_ELNO\_ELGA”**

**.**

**“EPSI\_ELNO\_DEPL”**

**“EPSI\_ELGA\_DEPL”**

**7.2 Options**

**CALC\_NO**

***All elements***

***Remarks***

***of this note***

**“FORC\_NODA”**

**· *If***

***FORC\_NODA is called from***

***REAC\_NODA***

***only the terms of mechanics are***

*calculated*  
**“REAC\_NODA”**

.

*Only the terms of mechanics are  
calculated*

*Instruction manual*  
*U3.14 booklet: Mechanical finite elements 3D*  
*HT-66/02/003/A*

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**Code\_Aster** ®

*Version*

7.4

*Titrate:*

*Modeling 3D\_ABSO*

*Date:*

01/06/05

*Author (S):*

**G. DEVESA, F. LEBOUVIER** *Key*

:

*U3.14.09-C Page*

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

***Instruction manual***

***U3.14 booklet: Mechanical finite elements 3D***

***Document: U3.14.09***

***Modeling 3D\_ABSO***

***Summary:***



*This document describes for modeling 3D\_ABSO:*

- *degrees of freedom carried by the finite elements which support modeling,*
- *the related meshes supports,*
- *supported loadings,*
- *nonlinear possibilities,*
- *case-tests implementing modelings.*

*Modeling 3D\_ABSO (Phenomenon: MECHANICS) corresponds to finite elements of which meshes supports are surface. They make it possible to take into account the condition of absorbing border of volumes solids.*

*Instruction manual*

*U3.14 booklet: Mechanical finite elements 3D*

*HT-66/05/004/A*

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Modeling 3D\_ABSO*

*Date:*

*01/06/05*

*Author (S):*

*G. DEVESA, F. LEBOUVIER Key*

*:*

*U3.14.09-C Page*

*: 2/2*

*1 Discretization*

*1.1*

*Degrees of freedom*

*Modeling*

*Degrees of freedom (with each node top)*

*3D\_ABSO*

*DX: displacement following X*

***DY: displacement following Y***

***DZ: displacement following Z***

## ***1.2***

***Meshs supports of the matrices of rigidity***

***The meshs supports of the finite elements can be quadrangles or triangles. Elements are isoparametric.***

***Modeling Nets Interpolation***

***Remarks***

***3D\_ABSO TRIA3***

***linear***

***TRIA6***

***quadratic***

***QUAD4***

***linear***

***QUAD8***

***quadratic***

***QUAD9***

## ***1.3***

***Meshs supports of the loadings***

***The same ones as previously.***

***2 Loadings***

***supported***

***The loading available is as follows:***

***· “ONDE\_PLANE”***

***Allows to impose a seismic loading by plane wave.***

***3 Possibilities***

***non-linear***

## ***3.1***

***Laws of behaviors***

***The only relation of behavior, available under DYNA\_NON\_LINE, for this modeling, under COMP\_INCR is relation “ELAS”.***

## **3.2 Deformations**

**Only the linearized deformations “SMALL” key word under DEFORMATION are available.**

**4**

**Examples of implementation: case-tests**

**· Non-linear Dynamique**

**SDLV120A [V2.04.120]: Analyze propagation of a wave of compression in a bar infinite rubber band (absorption of the wave at the border of the grid).**

**SDLV121A [V2.04.121]: Propagation, reflexion and absorption of a wave plane in a solid mass modelled in the shape of a column 1D.**

**Instruction manual**

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**Code\_Aster ®**

**Version**

**7.4**

**Titrate:**

**Modeling 3D\_FLUI\_ABSO**

**Date:**

**01/06/05**

**Author (S):**

**G. DEVESA, F. LEBOUVIER Key**

**:**

**U3.14.10-C Page**

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**Organization (S): EDF-R & D /AMA, DeltaCAD**

***Instruction manual***  
***U3.14 booklet: Mechanical finite elements 3D***  
***Document: U3.14.10***

***Modeling 3D\_FLUI\_ABSO***

***Summary:***

***This document describes for modeling 3D\_FLUI\_ABSO:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported loadings,***
- nonlinear possibilities,***
- case-tests implementing modeling.***

***Modeling 3D\_FLUI\_ABSO (Phenomenon: MECHANICS) corresponds to finite elements of which meshes***

***supports are surface. They make it possible to take into account the condition of absorbing border of volumes fluids.***

***Instruction manual***  
***U3.14 booklet: Mechanical finite elements 3D***  
***HT-66/05/004/A***

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***Code\_Aster*** ®

***Version***

***7.4***

***Titrate:***

***Modeling 3D\_FLUI\_ABSO***

***Date:***

***01/06/05***

*Author (S):*

*G. DEVESA, F. LEBOUVIER Key*

*:*

*U3.14.10-C Page*

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## *1 Discretization*

### *1.1*

#### *Degrees of freedom*

##### *Modeling*

*Degrees of freedom (with each node top)*

*3D\_FLUI\_ABSO*

*NEAR: pressure*

*PHI: fluid potential of displacement*

### *1.2*

#### *Net support of the matrices of rigidity*

*The meshes supports of the finite elements can be quadrangles or triangles. Elements are isoparametric.*

##### *Modeling Nets Interpolation*

###### *Remarks*

*linear 3D\_FLUI\_ABSO TRIA3*

*TRIA6*

*quadratic*

*QUAD4*

*linear*

*QUAD8*

*quadratic*

*QUAD9*

### *1.3*

#### *Net support of the loadings*

*The same ones as previously.*

*2 Loadings  
supported*

*AFFE\_CHAR\_MECA*

*3D\_FLUI\_ABSO  
Remarks*

*DDL\_IMPO  
FDLV111A*

*Instruction manual  
U3.14 booklet: Mechanical finite elements 3D  
HT-66/05/004/A*

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*Code\_Aster ®  
Version  
7.4*

*Titrate:  
Modeling 3D\_FLUI\_ABSO*

*Date:  
01/06/05  
Author (S):  
G. DEVESA, F. LEBOUVIER Key*

*:  
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*3 Possibilities  
non-linear*

*3.1  
Laws of behaviors*

*The only relation of behavior available for this modeling is RELATION “ELAS” (under  
COMP\_INCR) in DYNA\_NON\_LINE (cf [U4.51.11]).*

## ***3.2 Deformations***

***Only the linearized deformations “SMALL” key word under DEFORMATION are available in relations of behavior (cf [U4.51.11]).***

### ***4 Examples of implementation: case-tests***

***FDLV111A [V8.01.111]: Absorption of a wave of pressure in a fluid column***

***Instruction manual  
U3.14 booklet: Mechanical finite elements 3D  
HT-66/05/004/A***

---

***Code\_Aster ®  
Version  
7.4***

***Titrate:  
Modeling 3D\_FLUI\_ABSO***

***Date:  
01/06/05  
Author (S):  
G. DEVESA, F. LEBOUVIER Key  
:  
U3.14.10-C Page  
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*Instruction manual*

*U3.14 booklet: Mechanical finite elements 3D*

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*Code\_Aster* ®

*Version*

*6.4*

*Titrate:*

*Mechanical modeling 3D\_GRAD\_EPSI*

*Date:*

*27/06/03*

*Author (S):*

*P. Key BADEL*

*:*

*U3.14.11-A Page*

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*Organization (S): EDF-R & D /AMA*



***Instruction manual***  
***U3.14 booklet: Mechanical finite elements 3D***  
***U3.14.11 document***

***Modeling 3D\_GRAD\_EPSI***

***Summary:***

***This document describes for mechanical modeling 3D\_GRAD\_EPSI:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported materials and loadings,***
- options of calculations for the elementary matrices and the post treatments accessible to the user,***
- nonlinear possibilities as well as the options of the breaking process if they exist.***

***Modeling 3D\_GRAD\_EPSI (Phenomenon: MECHANICS) corresponds to finite elements of which meshes supports are voluminal. This modeling enriches the finite elements 3D traditional by mechanics in adding degrees of freedom of generalized deformations allowing to carry out nonlocal calculations, regularization utilizing the gradient of the deformations (from where the name of modeling), for more details to see document [R5.04.02].***

***Instruction manual***  
***U3.14 booklet: Mechanical finite elements 3D***  
***HT-66/03/002/A***

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***Code\_Aster*** ®

***Version***

***6.4***

***Titrate:***

***Mechanical modeling 3D\_GRAD\_EPSI***

***Date:***

***27/06/03***

***Author (S):***

***P. Key BADEL***

:  
*U3.14.11-A Page*  
: 2/6

## ***1 Discretization***

### ***1.1*** ***Degrees of freedom***

***Modeling***  
***Degrees of freedom***  
***(with each node top)***

***3D\_GRAD\_EPSI***  
***DX: displacement following X***

***DY: displacement following Y***

***DZ: displacement following Z***

***EPXX: generalized deformation XX***

***EPYY: generalized deformation YY***

***EPZZ: generalized deformation ZZ***

***EPXY: generalized deformation XY***

***EPXZ: generalized deformation XZ***

***EPYZ: generalized deformation YZ***

***Degrees of freedom***  
***(with each node medium)***

***DX: displacement following X***

***DY: displacement following Y***

***DZ: displacement following Z***

### ***1.2*** ***Net support of the matrices of rigidity***

*The meshes support of the finite elements can be tetrahedrons, pyramids, prisms or quadratic hexahedrons: displacements are interpolated with an order higher than them deformations generalized. One indicates in the column interpolation of the table following the couples of interpolation (displacements/generalized deformations). The elements are isoparametric.*

### *Modeling Nets Interpolation*

#### *Remarks*

*3D\_GRAD\_EPSI TETRA10*

*Quadratic/linear*

*3D\_GRAD\_EPSI PYRAM13*

*Quadratic/linear*

*3D\_GRAD\_EPSI PENTA15*

*Serendip/bi-linear*

*3D\_GRAD\_EPSI HEXA20*

*Trilinear Serendip/*

### *1.3*

#### *Net support of the loadings*

*Modeling does not require a boundary condition specific to the generalized deformations (boundary condition natural), one thus uses for the meshes support of the loading modeling 3D (cf [U3.14.01]).*

### *2*

#### *Significance of the symbols*

*·*  
*corresponds to a functionality available*

*·*  
*corresponds to a functionality which could exist but not currently available*

#### *Name of*

*corresponds to a test implementing the functionality case-test*

#### *Instruction manual*

*U3.14 booklet: Mechanical finite elements 3D*

*HT-66/03/002/A*

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*Code\_Aster ®*

*Version*

*6.4*

***Titrate:***

***Mechanical modeling 3D\_GRAD\_EPSI***

***Date:***

***27/06/03***

***Author (S):***

***P. Key BADEL***

***:***

***U3.14.11-A Page***

***: 3/6***

***3 Materials  
supported***

***DEFI\_MATERIAU  
3D\_GRAD\_EPSI***

***% general elastic Behaviors***

***ELAS***

***SSNV157A***

***% general nonlinear mechanical Behaviors***

***ECRO\_LINE***

***SSNV157A***

***BETON\_ECRO\_LINE***

***SSNV157D***

***MAZARS***

***SSNV157E***

***The case of the nonlinear operators is approached further.***

***4 Loadings  
supported***

***The loadings are to be affected on a modeling 3D, cf [§1.3].***

***5 Possibilities  
non-linear***

*This modeling has direction only into non-linear.*

## **5.1**

**STAT\_NON\_LINE**

**COMP\_INCR RELATION**

**3D\_GRAD\_EPSI**

**ENDO\_FRAGILE**

**SSNV157A**

**ENDO\_ISOT\_BETON**

**SSNV157D**

**MAZARS SSNV157E**

**COMP\_INCR DEFORMATION**

**3D\_GRAD\_EPSI**

**“SMALL”**

**SSNV157A**

## **5.2**

**DYNA\_NON\_LINE**

**COMP\_INCR RELATION**

**3D\_GRAD\_EPSI**

**ENDO\_FRAGILE**

.

**ENDO\_ISOT\_BETON**

.

**MAZARS**

.

**COMP\_INCR DEFORMATION**

**3D\_GRAD\_EPSI**

**“SMALL”**

.

**Instruction manual**

**U3.14 booklet: Mechanical finite elements 3D**  
**HT-66/03/002/A**

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**Code\_Aster** ®

**Version**

**6.4**

**Titrate:**

**Mechanical modeling 3D\_GRAD\_EPSI**

**Date:**

**27/06/03**

**Author (S):**

**P. Key BADEL**

**:**

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**6**

**Postprocessing of calculation**

**6.1 Option**

**CALC\_ELEM**

**3D\_GRAD\_EPSI**

**ECIN\_ELEM\_DEPL**

**.**

**ENEL\_ELGA**

**.**

**ENEL\_ELNO\_ELGA**

**.**

**EPME\_ELGA\_DEPL**

**.**

**EPME\_ELNO\_DEPL**

**.**

**EPOT\_ELEM\_DEPL**

**.**

**EPSI\_ELGA\_DEPL**

**.**

**EPSI\_ELNO\_DEPL**

**.**

*EQUI\_ELGA\_EPME*

.

*EQUI\_ELGA\_EPSI*

.

*EQUI\_ELGA\_SIGM*

.

*EQUI\_ELNO\_EPME*

.

*EQUI\_ELNO\_EPSI*

.

*EQUI\_ELNO\_SIGM*

.

*SIEF\_ELGA\_DEPL*

.

*SIEF\_ELNO\_ELGA*

.

*VARI\_ELNO\_ELGA*

.

## *6.2 Option*

*CALC\_CHAM\_ELEM*

*3D\_GRAD\_EPSI*

*ECIN\_ELEM\_DEPL*

*EPOT\_ELEM\_DEPL*

.

*ENEL\_ELGA*

.

*ENEL\_ELNO\_ELGA*

.

*EPSI\_ELNO\_DEPL*

.

*EQUI\_ELGA\_EPSI*

.

*EQUI\_ELGA\_SIGM*

.

*EQUI\_ELNO\_EPSI*

.

*EQUI\_ELNO\_SIGM*

.

***SIEF\_ELGA\_DEPL***

.

***Instruction manual***

***U3.14 booklet: Mechanical finite elements 3D***

***HT-66/03/002/A***

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**Code\_Aster** ®

Version

6.4

Titrate:

*Mechanical modeling 3D\_GRAD\_EPSI*

Date:

27/06/03

Author (S):

**P. Key BADEL**

:

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**6.3 Option**

**CALC\_NO**

**3D\_GRAD\_EPSI**

*FORC\_NODA'*

.

*REAC\_NODA'*

.

*ENEL\_NOEU\_ELGA'*

.

*EPME\_NOEU\_DEPL'*

.

*EPSI\_NOEU\_DEPL'*

.

*EQUI\_NOEU\_EPME'*

.

*EQUI\_NOEU\_EPSI'*

.

*EQUI\_NOEU\_SIGM'*

.

*SIEF\_NOEU\_ELGA'*

.

*VARI\_NOEU\_ELGA'*

.

**6.4 Option**  
**POST\_ELEM**

**3D\_GRAD\_EPSI**

*MASS\_INER*

.

*ENER\_POT*

.

*ENER\_CIN*

*ENER\_TOTALE*

.

*ENER\_ELAS*

.

*Instruction manual*

*U3.14 booklet: Mechanical finite elements 3D*

*HT-66/03/002/A*

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**Code\_Aster** ®

*Version*

6.4

*Titrate:*

*Mechanical modeling 3D\_GRAD\_EPSI*

*Date:*

27/06/03

*Author (S):*

**P. Key BADEL**

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*Instruction manual*

*U3.14 booklet: Mechanical finite elements 3D*

*HT-66/03/002/A*

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***Code\_Aster*** ®

*Version*

*7.4*

*Titrate:*

*Modelings HULL, COQUE\_PLAN, COQUE\_AXIS*

*Date:*

*01/06/05*

*Author (S):*

***C. DURAND, F. LEBOUVIER***

*Key:*

*U3.22.01-E Page*

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

***Instruction manual***

***U3.22 booklet: Thermal elements of structure 2D***

***U3.22.01 document***

***Modelings HULL, COQUE\_PLAN, COQUE\_AXIS -  
THERMAL phenomenon***

***Summary:***

***This document describes for thermal modelings of the axisymmetric and plane elements:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported loadings,***
- nonlinear possibilities,***
- case-tests implementing modelings.***

***Modeling HULL of the THERMAL Phenomenon [R3.11.01] is usable to treat the equations of heat in mediums with average layer in linear thermal analysis. One can use it like the first calculation of a thermomechanical chaining with the corresponding machine elements.***

***Instruction manual***

***U3.22 booklet: Thermal elements of structure 2D***

***HT-66/05/004/A***

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***Code\_Aster ®***

***Version***

***7.4***

***Titrate:***

***Modelings HULL, COQUE\_PLAN, COQUE\_AXIS***

**Date:**

**01/06/05**

**Author (S):**

**C. DURAND, F. LEBOUVIER**

**Key:**

**U3.22.01-E Page**

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## **1 Discretization**

### **1.1**

#### **Degrees of freedom**

**The degrees of freedom are the temperatures *TEMP* (temperature on the average surface of the hull), *TEMP\_INF* (temperature on the lower surface of the hull), and *TEMP\_SUP* (temperature on upper surface of the hull).**

### **1.2**

#### **Meshes support of the matrices of rigidity**

#### **Modeling Nets Element**

**finished**

**Remarks**

**HULL TRIA3**

**THCOTR3**

**nodes with 3 co-ordinates X, y, Z**

**TRIA6**

**THCOTR6**

**TRIA7**

**THCOTR7**

**QUAD4**

**THCOQU4**

**QUAD8**

**THCOQU8**

**QUAD9**

**THCOQU9**

**COQUE\_PLAN SEG3**

**THCPSE3 nodes with 2 co-ordinates X, y**

**COQUE\_AXIS**  
**SEG3**  
**THCASE3**

*For THCOTRI, only the 3 tops are exploited to define the local geometry (tangent plan, normal). For THCOQUI, one considers that the element is plane and its tangent plan is defined by defect by 3 of the 4 tops of the element.*

**1.3**

**Net support of the loadings**

*All the loadings applicable to the facets of the elements of hull are treated by discretization direct on the mesh support of the element in temperature formulation.*

*No mesh support of loading is thus necessary for the faces of the elements of hulls.*

*For the applicable loadings on the edges of the elements of hull or plate of modeling - hull, a mesh support of the type SEG2 or SEG3 must be used.*

**Modeling Nets Element**

**finished**

**Remarks**

*HULL SEG2*

*THCOSE2 with TRIA3 and QUAD4*

*HULL SEG3*

*THCOSE3 with TRIA6 or TRIA7 and*

*QUAD8 or QUAD9*

*For the imposed temperatures, the meshes support are meshes reduced to a point.*

**2**

**Assignment of the characteristics**

*For these elements of thermal structures, it is necessary to affect characteristics geometrical which is complementary to the data of grid. The definition of these data is carried out with order AFFE\_CARA\_ELEM associated with the key word following factor:*

**· HULL**

*Allows to define and affect the thickness on the meshes.*

*Instruction manual*

*U3.22 booklet: Thermal elements of structure 2D*

HT-66/05/004/A

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**Code\_Aster** ®

Version

7.4

Titrate:

Modelings *HULL*, *COQUE\_PLAN*, *COQUE\_AXIS*

Date:

01/06/05

Author (S):

**C. DURAND, F. LEBOUVIER**

Key:

U3.22.01-E Page

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### **3 Loadings supported**

*The loadings available are as follows:*

#### **· FLUX\_REP**

*Allows to apply normal flows to faces of elements of hulls to the faces  $\pm$ .*

*Supported modelings: HULL, COQUE\_PLAN, COQUE\_AXIS*

#### **· EXCHANGE**

*Allows to apply conditions of exchange with an outside temperature with faces of hulls on the faces  $\pm$ .*

*Supported modelings: HULL, COQUE\_PLAN, COQUE\_AXIS*

### **4 Possibilities**

#### **non-linear**

*Nothing.*

### **5 Possibilities**

#### **transients**

*Only modeling HULL makes it possible to deal with the evolutionary problems of thermics.*

## 6

### **Examples of implementation: case-test**

#### **· HULL**

*Stationary linear thermics*

*HPLA100C [V7.01.100]: Analyze of a heavy thermoelastic hollow roll in rotation uniform. In this modeling, one carries out a chained thermoelastic calculation and a calculation thermoelastoplastic without plastic evolution.*

*TPLS100A [V4.03.100]: Analyze thermal in stationary regime of an infinite plate subjected to a couple of antisymmetric heat flows on its two half-faces.*

*Transitory linear thermics*

*TTLL01M [V4.21.001]: Analyze thermal linear transient of an infinite wall subjected to a shock thermics.*

#### **· COQUE\_PLAN**

*Stationary linear thermics*

*HPLA100B [V7.01.100]: Analyze of a heavy thermoelastic hollow roll in rotation uniform. In this modeling, one carries out a chained thermoelastic calculation and a calculation thermoelastoplastic without plastic evolution.*

*TPLS100B [V4.03.100]: Analyze thermal in stationary regime of an infinite plate subjected to a couple of antisymmetric heat flows on its two half-faces.*

*Instruction manual*

*U3.22 booklet: Thermal elements of structure 2D*

*HT-66/05/004/A*

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**Code\_Aster** ®

Version

7.4

Titrate:

*Modelings HULL, COQUE\_PLAN, COQUE\_AXIS*

Date:

01/06/05

Author (S):

**C. DURAND, F. LEBOUVIER**

Key:

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*Instruction manual  
U3.22 booklet: Thermal elements of structure 2D  
HT-66/05/004/A*

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***Code\_Aster*** ®

*Version*

*7.4*

*Titrate:*

***Modelings AXIS, PLAN, AXIS\_DIAG and PLAN\_DIAG***

*Date:*

*01/06/05*

*Author (S):*

***C. DURAND, F. LEBOUVIER*** *Key*

*:*

*U3.23.01-E Page*

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***Organization (S): EDF-R & D /AMA, DeltaCAD***

***Instruction manual  
U3.23 booklet: Thermal finite elements 2D  
Document: U3.23.01***

***Modelings AXIS, PLAN, AXIS\_DIAG  
and PLAN\_DIAG***

***Summary:***

***This document describes for modelings of thermics of the axisymmetric and plane elements:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported materials and loadings,***
- nonlinear possibilities,***
- case-tests implementing modelings.***

***Axisymmetric and plane modelings (Phenomenon: THERMICS) correspond to finite elements whose meshes supports are surface.***

***Modelings AXIS\_DIAG and PLAN\_DIAG cover the same possibilities as AXIS and PLAN and in differ that for a calculation from thermics where the thermal matrix of mass is then diagonalisée.***

***Instruction manual  
U3.23 booklet: Thermal finite elements 2D  
HT-66/05/004/A***

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***Code\_Aster ®***

**Version**

**7.4**

**Titrate:**

**Modelings AXIS, PLAN, AXIS\_DIAG and PLAN\_DIAG**

**Date:**

**01/06/05**

**Author (S):**

**C. DURAND, F. LEBOUVIER Key**

**:**

**U3.23.01-E Page**

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**1 Discretization**

**1.1**

**Degrees of freedom**

**Modeling**

**Degrees of freedom**

**(with each node top)**

**AXIS, AXIS\_DIAG, PLAN,**

**TEMP: corresponds to the temperature**

**PLAN\_DIAG**

**1.2**

**Net support of the matrices of rigidity**

**The meshes support of the finite elements can be triangles or quadrilaterals. The elements are isoparametric.**

**Modeling Nets**

**Interpolation**

**Remarks**

**AXIS (\_DIAG) - PLANE (\_DIAG)**

**TRIA3**

**Linear**

**AXIS (\_DIAG) - PLANE (\_DIAG)**

**QUAD4**

**Linear**

**AXIS (\_DIAG) - PLANE (\_DIAG)**

## **TRIA6**

**Quadratic**

**AXIS - PLAN**

**QUAD8**

**Serendip**

**AXIS (\_DIAG) - PLANE (\_DIAG)**

**QUAD9**

**Quadratic**

## **1.3**

**Net support of the loadings**

**Modeling Nets**

**Interpolation**

**Remarks**

**AXIS (\_DIAG) - PLANE (\_DIAG)**

**SEG2**

**Linear**

**AXIS (\_DIAG) - PLANE (\_DIAG)**

**SEG3**

**Quadratic**

**2 Loadings**

**supported**

**The loadings available are as follows:**

**· SOURCE**

**Allows to apply voluminal sources to a field 2D.**

**Supported modelings: AXIS (\_DIAG), PLAN (\_DIAG)**

**· FLUX\_REP**

**Allows to apply normal flows to sides of elements 2D.**

**Supported modelings: AXIS (\_DIAG), PLAN (\_DIAG)**

**· EXCHANGE**

**Allows to apply conditions of exchange with an outside temperature at sides elements 2D.**

**Supported modelings: AXIS (\_DIAG), PLAN (\_DIAG)**

**· ECHANGE\_PAROI**

**Allows to apply conditions of exchange between two walls.**

**Supported modelings: AXIS (\_DIAG), PLAN (\_DIAG)**

**Instruction manual**

**U3.23 booklet: Thermal finite elements 2D**  
**HT-66/05/004/A**

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**Code\_Aster** ®

**Version**

**7.4**

**Titrate:**

**Modelings** *AXIS, PLAN, AXIS\_DIAG and PLAN\_DIAG*

**Date:**

**01/06/05**

**Author (S):**

**C. DURAND, F. LEBOUVIER** Key

**:**

**U3.23.01-E Page**

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**· GRAD\_TEMP\_EPSI**

*Allows to apply a presumed uniform variation in temperature “initial” in the element.*

*Supported modelings: AXIS (\_DIAG), PLAN (\_DIAG)*

**· CONVECTION**

*Allows to take into account the terms of transport of heat by convection, for*

*THER\_NON\_LINE\_MO only.*

*Supported modelings: AXIS, PLAN*

**· RADIATION**

*Allows to take into account ad infinitum radiated flow.*

*Supported modelings: AXIS (\_DIAG), PLAN (\_DIAG)*

**3 Possibilities**

**non-linear**

**Two operators are available for the study of non-linear behaviors:**

**· THER\_NON\_LINE [U4.54.02]:** *this operator allows, in hover or in transient, of to solve the problems of:*

*Standard non-linear thermics: material depend on the temperature, conditions with limits (radiation and nonlinear imposed flow),*

*Non-linear thermics with calculation of the hydration of the concrete,*

*Drying of the concrete.*

**· THER\_NON\_LINE\_MO [U4.54.03]:** *this operator allows to solve the equation of heat*

*stationary in a mobile reference frame related to a loading and moving in a direction and at a given speed.*

## **4**

*Examples of implementation: case-tests*

### **4.1 Thermics**

#### **· AXIS**

*Stationary linear thermics*

*TPLA07A [V4.01.007]: Analyze thermal of an orthotropic hollow roll subjected to different boundary conditions (imposed flow, convection, linear variation of the temperatures external).*

*Stationary non-linear thermics*

*TPNA01A [V4.41.001]: Analyze thermal of a hollow roll subjected to a convectif exchange on the interior wall and with a radiation ad infinitum on the external wall.*

*Transitory linear thermics*

*TTLV01B [V4.25.001]: Analyze thermal linear transient of a full sphere subjected to a heat transfer by convection.*

*Transitory non-linear thermics*

*TTNA200A: case-test of not-regression*

#### **· PLANE**

*Stationary linear thermics*

*TPLL100B [V4.02.100]: Analyze thermal of an anisotropic plane wall subjected to one temperature imposed and on a flow.*

*Stationary non-linear thermics*

*TPNL300A [V4.42.300]: Analyze thermal unidimensional of a wall subjected to one temperature imposed on the internal wall and on an exchange by radiation on the wall external (Test NAFEMS).*

*Instruction manual*

*U3.23 booklet: Thermal finite elements 2D*

*HT-66/05/004/A*

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**Code\_Aster** ®

**Version**

**7.4**

**Titrate:**

**Modelings AXIS, PLAN, AXIS\_DIAG and PLAN\_DIAG**

**Date:**

**01/06/05**

**Author (S):**

**C. DURAND, F. LEBOUVIER Key**

**:  
U3.23.01-E Page**

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***Transitory linear thermics***

***TTLP100B [V4.23.100]: Calculate linear transitory thermal response of two plates separated by a play in which a transfer of heat between the walls is carried out.***

***Transitory non-linear thermics***

***TTNL02A [V4.22.002]: Simulation of a liquid/solid phase shift while introducing via the voluminal enthalpy latent heat of fusion.***

***Nonlinear stationary thermics with mobile loading***

***TPLV102A [V4.04.102]: Transport of heat by convection and conduction in one square cavity.***

**· *AXIS\_DIAG***

***Transitory linear thermics***

***TTLV100A [V4.25.100]: Analyze thermal linear transient of a presumedly infinite pipe in which one imposes a cold thermal shock using a limiting condition of exchange.***

**· *PLAN\_DIAG***

***Transitory linear thermics***

***TLLL100A [V4.21.100]: Analyze thermal linear transient of an infinite plane wall to which one impose a cold thermal shock using a limiting condition of exchange.***

***Transitory non-linear thermics***

***TTNL02C [V4.22.002]: Simulation of a liquid/solid phase shift while introducing via the voluminal enthalpy latent heat of fusion.***

## **4.2 Hydration**

**· *AXIS***

***TTNL03B [V4.22.003]: simulation of an adiabatic test: analyze behavior thermo-hydrating of freshly-mixed a concrete sample plunged in a calorimeter, the catch being carried out with release of heat.***

## **4.3 Drying**

**· *AXIS***

***HSNA102A [V7.20.102]: Validation of the calculation of the drying of the concrete, it acts of a case test axisymmetric where the water concentration is applied directly to the external wall.***

**· *AXIS\_DIAG***

***HSNA102D [V7.20.102]: Validation of the calculation of the drying of the concrete, it acts of a case test***

***axisymmetric where the water concentration is applied directly to the external wall.***

***Instruction manual***

***U3.23 booklet: Thermal finite elements 2D***

***HT-66/05/004/A***

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**Code\_Aster** ®

*Version*

7.4

*Titrate:*

***Thermal modeling AXIS\_FOURIER***

*Date:*

01/06/05

*Author (S):*

***X. DESROCHES, F. LEBOUVIER*** Key

:

*U3.23.02-E Page*

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

***Instruction manual***

***U3.23 booklet: Thermal finite elements 2D***

***Document: U3.23.02***

***Thermal modeling AXIS\_FOURIER***

***Summary:***

***This document describes for thermal modeling AXIS\_FOURIER:***

- *degrees of freedom carried by the finite elements which support modeling,*
- *the related meshes supports,*
- *supported materials and loadings,*
- *nonlinear possibilities,*
- *case-tests implementing modeling.*

*Modeling AXIS\_FOURIER (Phenomenon: THERMICS) corresponds to finite elements of which meshes*

*supports are plane and make it possible to model the longitudinal section of parts of revolution around the axis*

*OZ (in cylindrical co-ordinates) subjected to boundary conditions of which the space distribution break up into Fourier series around this axis.*

*Instruction manual*

*U3.23 booklet: Thermal finite elements 2D*

*HT-66/05/004/A*

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Thermal modeling AXIS\_FOURIER*

*Date:*

*01/06/05*

*Author (S):*

*X. DESROCHES, F. LEBOUVIER* Key

*:*

*U3.23.02-E Page*

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*1 Discretization*

*1.1*

*Degrees of freedom*

*Modeling*

*Degrees of freedom*

*(with each node top)*

*AXIS\_FOURIER*

***TEMP: corresponds to the temperature***

***1.2***

***Net support of the matrices of rigidity***

***Modeling Nets Interpolation***

***Remarks***

***AXIS\_FOURIER TRIA3***

***Linear***

***QUAD4***

***Bilinear***

***TRIA6***

***Quadratic***

***QUAD8***

***Serendip***

***QUAD9***

***Biquadratic***

***1.3***

***Net support of the loadings***

***Modeling Nets Interpolation***

***Remarks***

***AXIS\_FOURIER SEG2***

***Linear or***

***Bilinear***

***SEG3***

***Quadratic,***

***Serendip or***

***Biquadratic***

***2 Loadings  
supported***

*The loadings available are as follows:*

· **SOURCE**

*Allows to apply voluminal sources.*

· **FLUX\_REP**

*Allows to apply normal flows to faces of elements.*

· **EXCHANGE**

*Allows to apply conditions of exchange with an outside temperature with faces elements.*

**3 Possibilities**

*non-linear*

*Nothing.*

**4**

*Examples of implementation: case-tests*

· **Stationary linear Thermique**

*TPLV305A [V4.04.305]: Analyze thermal linear of a cylinder subjected to a temperature imposed on external surface, according to a harmonic function (mode 1).*

*Instruction manual*

*U3.23 booklet: Thermal finite elements 2D*

*HT-66/05/004/A*

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**Code\_Aster** ®

**Version**

**7.4**

**Titrate:**

**Modelings thermal 3D and 3D\_DIAG**

**Date:**

**01/06/05**

**Author (S):**

**C. DURAND. F. LEBOUVIER Key**

**:**

**U3.24.01-E Page**

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***Organization (S): EDF-R & D /AMA, DeltaCAD***

***Instruction manual***

***U3.24 booklet: Thermal finite elements 3D***

***Document: U3.24.01***

***Modelings thermal 3D and 3D\_DIAG***

***Summary:***

***This document describes for modelings thermal 3D and 3D\_DIAG:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported materials and loadings,***
- nonlinear possibilities,***
- case-tests implementing modelings***

***Modeling 3D (Phenomenon: THERMICS) corresponds to finite elements whose meshes supports are voluminal.***

***Modeling 3D\_DIAG covers the same possibilities that 3D and differs from it only for one calculation from thermics where the thermal matrix of mass is then diagonalisée before resolution.***

***Instruction manual***

*U3.24 booklet: Thermal finite elements 3D*  
*HT-66/05/004/A*

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**Code\_Aster** ®

*Version*

7.4

*Titrate:*

*Modelings thermal 3D and 3D\_DIAG*

*Date:*

01/06/05

*Author (S):*

**C. DURAND. F. LEBOUVIER** *Key*

:

*U3.24.01-E Page*

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## ***1 Discretization***

### ***1.1***

#### ***Degrees of freedom***

##### ***Modeling***

##### ***Degrees of freedom***

***(with each node top)***

***3D and 3D\_DIAG TEMP: corresponds to the temperature***

***HYDR: corresponds to the hydration***

### ***1.2***

#### ***Net support of the matrices of rigidity***

***The meshes support of the finite elements can be tetrahedrons, pyramids, prisms or hexaèdres. The elements are isoparametric.***

#### ***Modeling Nets Interpolation***

##### ***Remarks***

##### ***3D and 3D\_DIAG***

##### ***TETRA4***

##### ***Linear***

### ***3D TETRA10***

***Quadratic***

***3D and 3D\_DIAG***

***PYRAM5***

***Linear***

***3D PYRAM13***

***Quadratic***

***3D and 3D\_DIAG***

***PENTA6***

***Bilinear***

***3D PENTA15***

***Serendip***

***3D and 3D\_DIAG***

***HEXA8***

***Trilinear***

***3D HEXA20***

***Serendip***

***3D HEXA27***

***Tri-quadratic***

## ***1.3***

***Net support of the surface loadings***

***Modeling Nets Interpolation***

***Remarks***

***3D and 3D\_DIAG***

***TRIA3***

***Linear or***

***Bilinear***

***3D and 3D\_DIAG***

***TRIA6***

***Quadratic or***

***Serendip***

***3D and 3D\_DIAG***

***QUAD4***

***Bilinear***

***3D and 3D\_DIAG***

**QUAD8**  
**Serendip**  
**QUAD9**  
**Quadratic**

**Instruction manual**  
**U3.24 booklet: Thermal finite elements 3D**  
**HT-66/05/004/A**

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**Code\_Aster** ®  
**Version**  
**7.4**

**Titrate:**  
**Modelings thermal 3D and 3D\_DIAG**

**Date:**  
**01/06/05**  
**Author (S):**  
**C. DURAND. F. LEBOUVIER Key**  
**:**  
**U3.24.01-E Page**  
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**2 Loadings**  
**supported**

**The loadings available are as follows:**

- **SOURCE**  
**Allows to apply voluminal sources to a field 3D.**  
**Supported modelings: 3D, 3D\_DIAG**
- **FLUX\_REP**  
**Allows to apply normal flows to faces of voluminal elements.**  
**Supported modelings: 3D, 3D\_DIAG**
- **EXCHANGE**  
**Allows to apply conditions of exchange with an outside temperature with faces voluminal elements.**  
**Supported modelings: 3D, 3D\_DIAG**
- **ECHANGE\_PAROI**



*Allows to apply conditions of exchange between two walls.*

*Supported modelings: 3D, 3D\_DIAG*

*· GRAD\_TEMP\_INIT*

*Allows to impose a presumed uniform variation in temperature in an element*

*Supported modelings: 3D, 3D\_DIAG*

*· CONVECTION*

*Allows to take into account the terms of transport of heat by convection, for THER\_NON\_LINE\_MO only.*

*Supported modeling: 3D*

*· RADIATION*

*Allows to take into account the flow radiated ad infinitum with faces of voluminal elements*

*Supported modelings: 3D, 3D\_DIAG*

### *3 Possibilities*

*non-linear*

*Two operators are available for the study of non-linear behaviors:*

*· THER\_NON\_LINE [U4.54.02]: this operator allows, in hover or in transient, of to solve the problems of:*

*Standard non-linear thermics: material depend on the temperature, conditions with limits (radiation and nonlinear imposed flow),*

*Nonlinear thermics with calculation of the hydration of the concrete,*

*Drying of the concrete.*

*· THER\_NON\_LINE\_MO [U4.54.03]: this operator allows to solve the equation of heat stationary in a mobile reference frame related to a loading and moving in a direction and at a given speed.*

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*Modelings thermal 3D and 3D\_DIAG*

*Date:*

*01/06/05*

**Author (S):**

**C. DURAND. F. LEBOUVIER Key**

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**4**

**Examples of implementation: case-tests**

**4.1 Thermics**

**standard**

**· 3D**

**Stationary linear thermics**

**TPLL100A [V4.02.100]: Analyze thermal of an anisotropic plane wall subjected to one temperature imposed and on a flow.**

**Transitory linear thermics**

**TTLL01C [V4.21.001]: Analyze thermal linear transient of an infinite wall subjected to a shock thermics.**

**Stationary non-linear thermics**

**TPNA01A [V4.41.001]: Analyze thermal of a hollow roll whose internal wall is subjected to a radiation and the external wall with an exchange by convection.**

**Transitory non-linear thermics**

**TTNL03A [V4.22.003]: simulation of an adiabatic test: analyze behavior thermo-hydrating of freshly-mixed a concrete sample plunged in a calorimeter, the catch being carried out with release of heat.**

**Stationary non-linear thermics with mobile loading**

**TPLV105A [V4.04.105]: This test presents thermal simulation by finite elements of the test Vastrestraint. This test of weldability is employed to characterize resistance to hot cracking of materials.**

**· 3D\_DIAG**

**Transitory linear thermics**

**TTLL01J [V4.21.001]: Analyze thermal linear transient of an infinite wall subjected to a shock thermics.**

**4.2 Hydration**

**· 3D**

**TTNL03A [V4.22.003]: simulation of an adiabatic test: analyze behavior thermo-hydrating of freshly-mixed a concrete sample plunged in a calorimeter, the catch being carried out with release of heat.**

## **4.3 Drying**

### **· 3D**

**HSNA100B [V7.20.100]: Calculation of the drying of a concrete enclosing wall: drying is carried out by exchange with outside, on the walls internal and external of the wall.**

### **· 3D\_DIAG**

**HSNA100D [V7.20.100]: Calculation of the drying of a concrete enclosing wall: drying is carried out by exchange with outside, on the walls internal and external of the wall.**

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**Organization (S): EDF-R & D /AMA**

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***U3.3- booklet: Finite elements acoustic***  
***Document: U3.33.01***

***Modelings 3D and PLAN of the phenomenon***  
***ACCOUSTICS***

***Summary:***

***This document describes for modelings 3D and PLAN:***

- degrees of freedom carried by the finite elements which support modeling,***
- the related meshes supports,***
- supported materials and loadings,***
- options of calculations for the elementary matrices and the post treatments,***
- nonlinear possibilities as well as the options of the breaking process if they exist.***

***Modelings 3D and PLAN (Phenomenon: ACCOUSTICS) correspond to finite elements acoustic in formulation pressure (cf [R4.02.01]). Modeling 3D has voluminal meshes supports, modeling PLAN has plane meshes supports.***

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## ***1 Discretization***

### ***1.1***

#### ***Degrees of freedom***

##### ***Finished Elément***

##### ***Degrees of freedom (with each node top)***

***ACOU\_... (3D)***

***NEAR: pressure***

***ACOU\_FACE... (3D)***

***NEAR: pressure***

***ACPL... (PLANE)***

***NEAR: pressure***

### ***1.2***

#### ***Net support of the matrices of rigidity***

##### ***Modeling Nets Element***

***finished***

***Remarks***

***3D TETRA4***

***ACOU\_TETRA4***

***TETRA10***

***ACOU\_TETRA10***

***PENTA6***

***ACOU\_PENTA6***

***PENTA15 ACOU\_PENTA15***

***HEXA8 ACOU\_HEXA8***

***HEXA20 ACOU\_HEXA20***

***HEXA27 ACOU\_HEXA27***

**PLAN TRIA3  
ACPLTR3**

**TRIA6 ACPLTR6**

**QUAD4 ACPLQU4**

**QUAD8 ACPLQU8**

**QUAD9 ACPLQU9**

**1.3  
Net support of the loadings**

**Modeling Nets Element  
finished  
Remarks**

**3D TRIA3  
ACOU\_FACE3**

**TRIA6  
ACOU\_FACE6**

**QUAD4  
ACOU\_FACE4**

**QUAD8  
ACOU\_FACE8**

**QUAD9  
ACOU\_FACE9**

**PLAN SEG2  
ACPLSE2**

**SEG3  
ACPLSE3**

***Significance of the symbols***

***.  
corresponds to a functionality available***

***corresponds to a functionality which could exist but not  
currently available***

***Name of  
corresponds to test implementing the functionality.  
case-test***

***////  
corresponds to a functionality without significance for the element or  
asking a major questioning of the code***

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***3 Materials  
supported***

***DEFI\_MATERIAU  
3D PLAN  
Remarks***

***ELAS  
////  
////***

***ELAS\_FO***

*////*

*////*

***ELAS\_ORTHO***

*////*

*////*

***TRACTION***

*////*

*////*

***ECRO\_LINE***

*////*

*////*

***ECRO\_LINE\_FO***

*////*

*////*

***CHABOCHE***

*////*

*////*

***FLUID***

***AHLV100A AHLV100F***

***speed of sound***

***complex***

***THER***

*////*

*////*

***THER\_FO***

*////*

*////*

***THER\_ORTHO***

*////*

*////*

***META\_REFR***

*////*

*////*



**4 Loadings  
supported**

**AFFE\_CHAR\_ACOU  
3D PLAN  
Remarks**

**PRES\_IMPO**

..

**VITE\_FACE  
AHLV100A AHLV100F**

**IMPE\_FACE  
AHLV100A AHLV100F**

**LIAISON\_UNIF**

..

**5 Possibilities  
non-linear**

**None.**

**6  
Elementary calculations of matrices**

**OPTIONS  
3D PLAN  
Remarks**

**“RIGI\_MECA” ////  
////**

**“RIGI\_GEOM” ////  
////**

**“RIGI\_ROTA” ////  
////**

**“RIGI\_MECA\_HYST” ////  
////**

**“MASS\_MECA” ////  
////**

**“MASS\_MECA\_DIAG” ////  
////**

**“AMOR\_MECA” //**

**////**

**“IMPE\_MECA” //**

**////**

**“RIGI\_THER” //**

**////**

**“MASS\_THER” //**

**////**

**“RIGI\_ACOU”**

**AHLV100A AHLV100F**

**“MASS\_ACOU”**

**AHLV100A AHLV100F**

**“AMOR\_ACOU”**

**AHLV100A AHLV100F**

**MODE\_FOURIER // //**

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***7***

***Postprocessing of calculation***

***7.1 Option***

***CALC\_ELEM***

**3D PLAN**

**Remarks**

**“PRES\_ELNO\_DBEL”**

**AHLV100A ·**

**“PRES\_ELNO\_REEL”**

**AHLV100A ·**

**“PRES\_ELNO\_IMAG”**

**AHLV100A ·**

**“INTE\_ELNO\_ACTI”**

**AHLV100A ·**

**“INTE\_ELNO\_REAC”**

**AHLV100A ·**

**7.2 Option**

**CALC\_CHAM\_ELEM**

**3D PLAN**

**Remarks**

**“PRES\_ELNO\_DBEL”**

**AHLV100A ·**

**“PRES\_ELNO\_REEL”**

**AHLV100A ·**

**“PRES\_ELNO\_IMAG”**

**AHLV100A ·**

**7.3 Option**

**CALC\_NO**

**3D PLAN**

**Remarks**

**“PRES\_NOEU\_DBEL”**

..

**“PRES\_NOEU\_REEL”**

..

**“PRES\_NOEU\_IMAG”**

..

**“INTE\_NOEU\_ACTI”**

..

**“INTE\_NOEU\_REAC”**

..

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*Organization (S): EDF-R & D /AMA*

***Instruction manual***

***U4.0- booklet: Use of the orders***

***Document: U4.01.00***

***How to read the documentation of the orders***

***Summary:***

*This note is a guide of reading of the U4 booklets and U7 of the Instruction manual.*

*It explains in particular the significance of the méta-characters and the typographical conventions used for the description of the syntax of the orders.*

*All the examples given here are given as illustration and do not replace complete description orders appearing in the booklets U4 and U7.*

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matters*

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**1**

**Recalls on the syntax of the orders Aster**

**The process control language and its supervisor are completely described in the document [U1.03.01]. One recalls here some notions on syntax of the Aster orders.**

**In Aster, one understands by the generic term of orders at the same time the operators, them procedures and macro-orders of the process control language. An operator provides a concept product typified (by the operator) and named by the user. A procedure does not generate a concept product, it achieves actions such as impressions or resource allocations.**

*In the example below, one recalls the vocabulary which is used in the description of orders.*

*Operand (S) or body of the order*  
*Character of end of assignment*

*obligatory*

*Name chosen by the user*

*Operand*  
*Operand*

*Operand*

*bet0 = DEFI\_MATERIAU (ELAS = \_F (E = 3.4E10, NAKED = 0.25, RHO = 2500.) );*

*Produced concept*  
*Name of Word-key-factor*  
*Key word*  
*Argument*  
*End of order*

*the operator*  
*(optional)*

*Terminology Aster*

*An operand is thus the unit consisted a key word and its argument. However, in documentation of the orders, one often indicates the operands of an operator or one procedure by the name of their key word. For example: RHO, single-ended spanner word, or ELAS, key word factor.*

*The term of produced concept is generic for all the operators, it is the result of the work of*



*the operator.*

*Here in example `DEFI_MATERIAU`, there was creation of the structure of data of the `MATER` type (material), named `concrete` by the user. It gathers the denominations (key word `E`, `NAKED`, `RHO`) and the values (arguments `3.4E10`, `0.25`, `2500.`) mechanical elastic characteristics (key word factor `ELAS`) of material.*

*The term of concept-product of the result type is reserved to the operators of end of calculation of one modeling Aster. In general, these operators provide the result of calculation, i.e. physical fields of sizes (displacements, temperatures, constraints, efforts, etc...) on nodes or on the meshes at various moments or for various frequencies.*

*The concept result comprises in general under types.*

**2**

*Standard plan of the documents of use of the orders*

*Each document of presentation of an order comprises the following chapters:*

- .  
*Drank,*
- .  
*Syntax,*
- .  
*Operands,*
- .  
*Phase of checking/Production run (possibly),*
- .  
*Examples.*

*This presentation makes it possible the user to find in only one document all knowledge necessary to the implementation of an order.*

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### **3 Paragraph**

**Drank**

*One states the functionality filled by the order (actions carried out). They are also specified types of the concepts awaited in entry and the produced concept, as well as characteristics of order. The first sentence of this paragraph is also posted automatically in so much what bars information by Efficas.*

*This paragraph is also posted by the search engines; it thus contains only text without equations or formula.*

*Example: Operator STAT\_NON\_LINE [U4.51.03]*

**Drank:**

*To calculate the quasi-static mechanical evolution of a structure into nonlinear.*

*Nonthe linearity is related either to the behavior of material (for example plastic), or with geometry (for example in great displacements). To have details on the method of resolution employed, one will refer to the reference material [R5.03.01].*

*The evolution can be studied in several successive work (réentrant concept), that is to say in continuation (the last calculated moment is the initial moment of following calculation), is in recovery in on the basis of one former moment.*

*If time necessary to carry out calculation is not sufficient, the program stops, but the already calculated results are safeguarded if a data base were defined in profile of study of the user. Product a structure of data of the evol\_noli type.*

### **4 Paragraph**

**Syntax**

*One gives, in this paragraph, the whole of the operands of the order. One specifies, for each operand, using méta-characters and of indentations suitable for the typographical presentation of orders (cf example of operator AFFE\_MATERIAU):*

- 
- the name of the operator,*
- 
- the name of the key words,*
- 
- the reference symbols user of the produced concept and the arguments of the key words,*
- 
- obligatory or optional character of the operands (statute),*
- 
- alternatives in the choices of the operands,*
- 
- types of the arguments awaited by the key words,*
- 
- default values taken by the arguments in the case of optional operands,*
- 
- the type of the produced concept, when it is about an operator.*

*Reference symbol of*  
*Type of*

*Name of the operator*  
*Produced concept*  
*Produced concept*  
*Name*

*symbolic system of*

*chm [*  
*cham\_mater] = AFFE\_MATERIAU*  
*the argument*

*(*  
*GRID = my,*

*[grid]*  
*Argument*

*imposed of type*  
*AFFE = \_F (*

*/TOUT= "YES",*  
*text*  
*Méta-character*

**“obligatory”**

**/MAILLE= lma, [l\_maille]**

**/GROUP\_MA= lgma, [l\_gr\_maille]**

**M**

**ATER = chechmate, [to subdue]**

**Type of Concept**

**Méta-character**

**TEMP\_REF =/0. , [DEFECT]**

**awaited user**

**“optional”**

**/tref, [R]**

**)**

**Argument**

**Type of argument**

**Méta-character**

**);**

**by defect**

**waited**

**“alternate”**

**Presentation of the syntax (partial) of operator AFFE\_MATERIAU**

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### **4.1**

#### ***Méta-characters of statute of operands (/)***

***Four méta-characters are used to indicate the statute of the operands. It is necessary to understand here by statute of the operands their obligatory or optional declaration and the nature of the alternatives in choice of the operands.***

***These méta-characters do not form part of the process control language. They have only one function of documentary presentation and should not thus be used for the drafting of the file of orders.***

#### **4.1.1 Obligatory or optional operands**

***They are located by the presence at the head black or white rhombus.***

***black rhombus: it is obligatory to declare in the order the operands which follow it sign.***

***white rhombus: the declaration of the operands which follow this sign is optional. In case of absence of the operand, the order will affect possibly one or of the default values.***

***Example: operator `DEFI_LIST_ENTI`  
(definition of a list of strictly increasing entirities  
whose values are regularly spaced)***

***Li  
= `DEFI_LIST_ENTI`  
(***

***BEGINNING***

***=***

***deb.***

***,***

***INTERVAL = \_F (JUSQU\_A = yew,***

***NOT***

***=***

***ipas,***

***)***

***);***

***.***

***It is obligatory to declare the operand identified by the key word BEGINNING and to provide deb. which is the first entirety of the list to be built.***

***.***

***It is not obligatory to declare the operand identified by the key word factor INTERVAL. In this case the list of entireties will be summarized with only one entirety of value deb. (this is specified in the description of the operands).***

.  
*If the operand INTERVAL is declared, then it is obligatory to declare the operand JUSQU\_A which specifies the whole end yew of the interval to be cut out with a constant step and the operand NOT which indicates the step ipas interval division.*

#### *4.1.2 Alternatives in the choice of the operands*

*They are located by the presence at the head each choice of the alternative:*

.  
*of one/(slash): exclusive alternative, only one choice among those proposed,*

.  
*of one | (pipe, semi colonist): nonexclusive alternative, one or more choice among those proposed.*

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*Example of exclusive alternative: operator AFFE\_MODELE*

*(assignment of the type of finite elements on whole or part of a grid).*

*Mo = AFFE\_MODELE (*

*GRID = my*

***AFFE = \_F (***  
*/*  
***ALL = “YES”,***

*/*  
***NET***  
*=*  
***email***  
*,*  
***[l\_maille]***

*/*  
***NODE***  
*=*  
***noeu***  
*,*  
***[l\_noeud]***

*/*  
***GROUP\_MA = g\_mail***  
*, [l\_gr\_maille]*



/  
**GROUP\_NO = g\_noeu**  
**, [l\_gr\_noeud]**

.....

)

);

*In operand AFFE (obligatory) it should be indicated where will be affected, on the grid, the type of finite element specified in the operands PHENOMENON and MODELING of the same order:*

- *maybe on all the grid (ALL),*
- *maybe on certain meshes (MESH),*
- *maybe on certain nodes (NODE),*
- *maybe on certain groups of meshes (GROUP\_MA),*
- *maybe on certain groups of nodes (GROUP\_NO).*

*Example of nonexclusive alternative:*

*operator AFFE\_CHAR\_MECA operand DDL\_IMPO (assignment of displacements imposed on degrees of freedom).*

**DDL\_IMPO**

=

**\_F**

**(/ALL =**

**“YES”,**

**/**

**NODE**

=

**lno**

**, [l\_noeud]**

**/**

**GROUP\_NO=**

**lgno,**

**[l\_gr\_noeud]**

**/**

**NET**

=

**lma**

**, [l\_maille]**

**/**

**GROUP\_MA=**

**lgma,**

**[l\_gr\_maille]**

**/DX**

=

**ux**

**,**

**[R]**

***/DY***

=  
***uy***,  
***[R]***

***/DZ***

=  
***uz***,  
***[R]***

***/DRX***

=  
***X***,  
***[R]***

***/DRY***

=

*y,*  
*[R]*

*/DRZ*  
*=*  
*Z,*  
*[R]*

*/GRX*  
*=*  
*G*  
*,*  
*[R]*

*/PRES=*  
*p*  
*,*  
*[R]*

**/ PHI**  
**=**  
**, [R]**

**/ TEMP=**  
**T**  
**,**  
**[R]**

**/ PRE1=**  
**pr1**  
**, [R]**

**/ PRE2=**  
**pr2**  
**, [R]**

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**How to read the documentation of the orders**

**Date:**

**31/01/05**

**Author (S):**

**COURTEOUS Mr., F. WAECKEL, Key Mr. BOIN**

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**In this operator, it is necessary to specify obligatorily:**

**.**  
**the applicability on the grid: everywhere (ALL), on certain nodes (NODE) or on certain groups of nodes (GROUP\_NO),**

**.**  
**on which degrees of freedom with which specified values by the user.**

**The méta-character | indicates that the user can impose a value of displacement on one (it symbol indicates that one needs at least one of them) or several of the degrees of freedom (DX, DY, DZ, DRX, DRY, DRZ, GRX, NEAR, PHI, TEMP, PRE1, PRE2) of the beforehand indicated nodes.**

#### **4.1.3 Combinations of the méta-characters of choice of the operands**

**These méta-characters can be combined to illustrate the multiplicity of the choices in some orders.**

**Example: order DEFI\_MATERIAU (definition of a material by its properties of behavior)**

**For a study of thermomechanics, one needs to define a material at the same time having mechanical characteristics (ELAS) and thermics (THER) from where use of the pipe: |**

*But in each choice, one is obliged to choose if the properties of material are dependent ( $\_FO$ ) or not of the temperature from where use of the slash: /; cf below:*

*my = DEFINI\_MATERIAU*

*(  
//ELAS =  $\_F$  (  
E =*

*yg,*

*NAKED  
= naked,*

*RHO  
=  
rho,*

***ALPHA***  
***= dil,***

)  
.....

***/ELAS\_FO = \_F***

(  
***E =***

***f1,***



***NAKED***  
***= f2,***

***RHO***  
***=***  
***f3,***

***ALPHA***  
***= f4,***

)

**//THER = \_F (**  
**RHO\_CP =**  
**CP,**

**LAMBDA =,**

)  
.....

***/THER\_FO =\_F***  
(  
***RHO\_CP = g1,***

***LAMBDA***  
***= g2,***

)

.....

);  
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**4.2**  
**Méta-characters of the type of concept or argument**

**Like the méta-characters of statutes of operands, the hooks [] and the star \* do not form part of process control language. They have only one function of documentary presentation.**

**4.2.1 Types of concepts or arguments []**

**They frame the type of the concepts produced as well as the type of the arguments.**

**Example: order AFFE\_MODELE (Assignment of the finite elements on the meshes of a grid)**

**Mo [model] = AFFE\_MODELE**  
**(**  
**GRID =**  
**my,**

**[grid]**

***AF FE = \_F (/ALL =  
“YES”,***

***/  
NET = email,  
[l\_maille]  
.....***

***);***

***In the example above, one thus specifies that the concept produced by AF FE \_MODELE is of type model and that the awaited concept as argument of the key word MESH must be of l\_maille type (i.e list of mesh).***

#### ***4.2.2 Type of the produced concept [\*]***

***This mé ta-character indicates that the type of the produced concept, or under type of the produced concept of type result, depends on the types of the arguments of certain operands. In this case the various ones possibilities are registered after the syntax of the order.***

***Example: order COMB \_CHAM \_NO***

***In this example, if CH is a cham \_no \_DEPL \_R given in argument of key word CHAM \_NO under key word factor COMB \_C then cchno will be a cham \_no \_DEPL \_C. If, on the other hand, CH is given under key word factor COMB \_R then cchno will be a cham \_no \_DEPL \_R.***

*cchno [cham\_no\_\*] = COMB\_CHAM\_NO*

*(/COMB\_R = \_F (  
CHAM\_NO = CH,  
[cham\_no\_DEPL\_R]  
[cham\_no\_TEMP\_R]  
[cham\_no\_PRES\_R]*

*COEF\_R  
=  
R,  
[R]*

*)  
/  
COMB\_C  
=  
\_F  
(CHAM\_NO = CH,  
[cham\_no\_DEPL\_R]  
[cham\_no\_DEPL\_C]  
[cham\_no\_TEMP\_R]  
[cham\_no\_TEMP\_C]  
[cham\_no\_PRES\_R]  
[cham\_no\_PRES\_C]*

/  
**COEF\_R**  
=  
**R,**  
**[R]**  
/  
**COEF\_C**  
=  
**C,**  
**[C]**

)  
  
);  
**if COMB\_R and CHAM\_NO:**  
**[cham\_no\_DEPL\_R] then [\*]**  
**- > DEPL\_R**  
**[cham\_no\_TEMP\_R]**  
**[\*]**  
**- > TEMP\_R**  
**[cham\_no\_PRES\_R]**  
**[\*]**  
**- > PRES\_R**

**if COMB\_C and CHAM\_NO:**  
**[cham\_no\_DEPL\_R] then [\*]**  
**- > DEPL\_C**  
**[cham\_no\_DEPL\_C]**  
**[\*]**  
**- > DEPL\_C**  
**[cham\_no\_TEMP\_R]**  
**[\*]**  
**- > TEMP\_R**  
**[cham\_no\_TEMP\_R]**  
**[\*]**

- > **TEMP\_C**  
**[cham\_no\_PRES\_R]**  
**[\*]**  
- > **PRES\_C**  
**[cham\_no\_PRES\_C]**  
**[\*]**  
- > **PRES\_C**

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### **4.3 Comments**

**For certain complex orders such as AFFE\_CARA\_ELEM or DEFI\_MATERIAU for example, the character of comment is employed to comment on the alternatives of the operands. It has it even smell that in the process control language and is interpreted like such by the supervisor.**

**Example for AFFE\_CARA\_ELEM:**

**POUTRE=\_F (**  
**/**  
**NET**  
**= lma,**  
**[l\_maille]**  
**/**  
**GROUP\_MA**  
**=**



*lgma,*  
*[l\_gr\_maille]*

*/SECTION = "GENERAL",*

*/*  
*# constant section*

*CARA= / "A"*

*/ "IY" /*  
*"IZ"*

*list*

*choice*  
*/ "AY" /*  
*"AZ"*

*possible for one*

*/ "EY" /*  
*"EZ"*

*section*  
*constant* / “*JX*”

/ “*RY*” / “*RZ*” / “*RT*”,

/  
# *section variable*

*CARA*= / “*A1*” / “*A2*”

/ “*IY1*” / “*IY2*” / “*IZ1*” / “*IZ2*”  
*list*

*choice*  
/ “*AY1*” / “*AY2*” / “*AZ1*” / “*AZ2*”  
*possible for one*

/ “*EY1*” / “*EY2*” / “*EZ1*” / “*EZ2*”  
*variable section*

/“JX1” / “JX2”

/ “RY1” / “RY2” / “RZ1” / “RZ2” / “RT1” / “RT2”,

.....

)

#### 4.4 *Types of the arguments awaited by the key words*

*The key words of the operands await arguments which correspond, in general, to four classes:*

- .  
*values, one then specifies by a reference symbol the accepted data-processing type (real, entirety, character string, etc...),*
- .  
*imposed texts, then the texts (“YES”, “HY1”) are indicated between quotes,*
- .  
*names of topological entities simple (name of node, meshes, or lists of names), declared in the file of grid, or the names of groups of nodes or meshes, or lists of names of groups of nodes or meshes,*
- .  
*names and lists of names of concepts produced by the operators.*

*The table below gathers all the principal types of the arguments awaited by the key words:*

[R] real  
3.  
[l\_R]  
list realities  
(1., 3., 7.)  
[I]  
entirety  
7

**[l\_I]**

**list entirities**

**(9, 6, 1, 9)**

**[C]**

**complex**

**IH 1.1, 7.8 or MP 10. , 1.57**

**[l\_C]**

**list complexes**

**(IH 1.1, 7.), (IH 4.7, 9.)**

**[L]**

**logic**

**TRUTH or FORGERY**

**[TXM]**

**unconstrained text (name of TITLE...)**

**“my title”**

**[KN]**

**text lower or equal to N characters**

**“INST”**

**[l\_Kn]**

**list texts lower or equal to N**

**(“SIXX”, “SIYY”, “SIXY”)**

**characters**

**[node]**

**name of node**

**N23**

**[l\_noeud]**

**list names of nodes**

**(N23, N24, N25)**

**[gr\_noeud]**

**name of group of nodes**

**NBORD6**

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**[l\_gr\_noeud]**

**list names of groups of nodes**

**(NBORD, NBASE, NBORD)**

**[mesh]**

**name of mesh**

**M34**

**[l\_maille]**

**list name of mesh**

**(M34, M35)**

**[gr\_maille]**

**name of group of meshes**

**MPIQUAGE**

**[l\_gr\_maille]**

**list names of groups of meshes**

**(MSOM, MDROI, MGA)**

**[type\_concept]**

**type of concept (or field) produced**

**monresu**

**beforehand with generally**

**automatic checking of the type**

**[l\_type\_concept] list of the type of concept user**

**(resu1, resu2)**

**4.5**

**Types of the concepts produced in Aster**

**One uses the méta-character of choice of exclusive alternative/to mean the plurality of concept waited behind a key word.**

**Example: operator ASSE\_MATRICE**

**(assembly of the elementary matrices contained**

**in a list of concepts of the matr\_elem\_\* type.)**

**my [matr\_asse\_\*] = ASSE\_MATRICE**

```
(  
MATR_ELEM  
=  
lme1,  
/  
[l_matr_elem_DEPL_R]  
  
/  
[l_matr_elem_DEPL_C]  
  
/  
[l_matr_elem_TEMP_R]  
  
/  
[l_matr_elem_TEMP_C]  
/  
[l_matr_elem_PRES_R]  
/  
[l_matr_elem_PRES_C]  
...  
  
);
```

```
if MATR_ELEM  
[matr_elem_DEPL_R]  
then [*]
```

```
DEPL_R  
[matr_elem_DEPL_C]
```

```
DEPL_C  
[matr_elem_TEMP_R]
```

**TEMP\_R**  
**[matr\_elem\_TEMP\_C]**

**TEMP\_C**  
**[matr\_elem\_PRES\_R]**

**PRES\_R**  
**[matr\_elem\_PRES\_C]**

**PRES\_C**

***In the example above the concept awaited in argument of MATR\_ELEM can be various types and on the type of the last concept in argument by the user will depend (according to stated rules' above) the typing of the concept produced by operator ASSE\_MATRICE.***

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## **5 Paragraph**

### **Operands**

*One describes, for each operand the direction of the operand for this order, the nature and the type of arguments awaited by the key words, and the restrictions and difficulties of employment.*

*For example, in the documentation of operator AFFE\_MATERIAU, for operand AFFE, operand intended to specify on which (S) entity (S) topological (S) of the grid of name my will be affected the material of name chechmate produced by operator DEFI\_MATERIAU, one will read:*

**AFFE**

*Key word factor which makes it possible to affect various materials on “pieces” of the grid.*

**/ALL: “YES”,**

*This key word makes it possible to affect on all the meshes of the grid.*

**/GROUP\_MA: l<sub>g</sub>ma,**

*This key word makes it possible to affect on a list of groups of meshes of the grid.*

**/**

**NET**

:

**l<sub>ma</sub>,**



*This key word makes it possible to affect on a list of meshes of the grid.*

*With each group of meshes, (key word `GROUP_MA`) or each list of meshes (key word `NETS`), or still with all the grid (key word `ALL`) is affected a material chechmate, which is a produced concept by one of operators `DEFI_MATERIAU [U4.43.01]` or `DEFI_COQU_MULT [U4.42.03]`.*

*If a mesh appears explicitly (or implicitly) in several occurrences of the key word factor `AFFE`, the rule of overload is applied: it is the last assignment which precedes [U2.01.08].*

## **6** **Phases of checking/execution**

*The Syntaxe paragraph of the documentation of use is the exact reflection of the catalogue of order. This catalogue is a file which includes/understands, written in the language of the supervisor, all rules on the key words: presence, exclusion, implication, contained...*

*Editor `EFICAS` exploits this catalogue of order and allows the user, if with final the file composed is valid, to obtain a correct command set.*

*With the execution of the study, the supervisor of `Code_Aster` reproduces the same task of checking syntactic: either overall for all the file, or while alternating with the execution, orders by order.*

*Moreover, during the execution itself of the orders (entered part `FORTTRAN` of source code), of the additional checks can be made. They are impossible constraints to manage on the level of the process control language (equality of cardinals of different lists...).*

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## **7** ***Print and indentations***

*For the legibility of the documents relating to the orders, all that refers to syntax is printed in police force Courier 10 points. One differentiates the various types of functional elements (produced concept, key word, key word factor, argument) by the use of capital letters and tiny.*

*In capital letters:*

- .  
*names of the operators, the procedures*
- .  
*names of the key words and the key words factors,*
- .  
*imposed arguments of type text (those are between “quotes” as in the syntax of orders).*

*In small letters:*

- .  
*names of the produced concepts,*
- .  
*reference symbols of the arguments,*
- .  
*types of the produced concepts and the arguments.*

*Into mixed tiny - capital letter when the produced concept admits under type. This one appears in capital letters as well as type FORTRAN of the size of under type.*

*One reinforces the legibility of syntax by the use of indentations. They are used for the location of the blocks*

*operands and with the release of a group of operands under a key word factor. They too are used to lay out the brackets of the same block under the same balance.*

*Example:*

*my [matr\_asse\_\*] = ASSE\_MATRICE*

*(  
MATR\_ELEM  
=*

*lme1,*

/

*[l\_matr\_elem\_DEPL\_R]*

/

*[l\_matr\_elem\_DEPL\_C]*

/

*[l\_matr\_elem\_TEMP\_R]*

/

*[l\_matr\_elem\_PRES\_C]*

*NUME\_DDL =*

*naked,*

*[nume\_ddl]*

*CHAR\_CINE*

=

*lcha,*

/

*[l\_char\_cine\_meca]*

/

*[l\_char\_cine\_ther]*

/

*[l\_char\_cine\_acou]*

*INFORMATION*

=

/

*1,*

*[DEFECT]*

/ 2,

);

*if*  
*MATR\_ELEM*  
*[matr\_elem\_DEPL\_R]*  
*then*  
*[\*]*

*DEPL\_R*  
*[matr\_elem\_DEPL\_C]*  
*DEPL\_C*  
*[matr\_elem\_TEMP\_R]*  
*TEMP\_R*  
*[matr\_elem\_PRES\_C]*  
*PRES\_C*

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***Organization (S): EDF-R & D /AMA***

***Instruction manual***

***U4.0- booklet: Use of the orders***

***Document: U4.01.03***

***Innovations and modifications of version 7***

***Summary:***

***The object of this document is to offer a global vision of the modifications of syntax and new possibilities***

***orders of Code\_Aster occurred between each version since version 7.0.***

***Index A of this document thus gives a report on the changes introduced since version 7.3 of April 2004 and***

***valid for version 7.4 of December 2004.***

***For more precise details, one will consult the documentation of the orders and the file histor of corresponding under-version (e.g.: [7.3.12], section Development of the [www.code-aster.org](http://www.code-aster.org) site).***

***The impacted orders are listed alphabetically.***

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## **1**

***Innovations between 7.3 and 7.4***

### **1.1**

***Modifications of the environment***

#### **1.1.1 Med**

***Code\_Aster is pressed now on library MED 2.2. For reading files with the format med 2.1.5, they should be converted with the tool med\_import (there are not tools in the opposite direction).***

#### **1.1.2 Lobster**

***Following the change of version of med, lobster also evolved/moved to support the same level of library. lobster 7.1 also brings other innovations (cf [U7.03.xx]).***

### **1.2 News**

***orders***

#### **1.2.1 CREA\_TABLE**

***This order makes it possible to create a table starting from a function or several lists of entirities, of realities or of character strings. One can create a full table or with holes by indicating the lines that one wishes to inform.***

#### **1.2.2 DEFI\_COMPOR**

***This order makes it possible to define a single-crystal or polycrystalline behavior.***

#### **1.2.3 DEFI\_PART\_FETI**

*This order makes it possible to create a partitioning in under-fields for a resolution by Feti method.*

#### **1.2.4 IMPR\_FONCTION**

*This new order replaces IMPR\_COURBE, and it treats only the functions (from where it renaming), tables being treated by IMPR\_TABLE (cf [7.3.13]).*

#### **1.2.5 MACR\_ECLA\_PG**

*This macro-order replace options ECLA\_PG of two orders CREA\_MAILLAGE and CREA\_RESU. Coherence between the two orders is thus ensured.*

#### **1.2.6 MODI\_MODELE\_XFEM**

*This order makes it possible to create finite elements with ddl nouveau riches necessary to the method XFEM.*

### **1.3 Orders reabsorbed**

#### **1.3.1 DEFI\_VALEUR**

*Contents of the Python objects being safeguarded (in the file pick.1) “at side” of the base Aster (file glob.1), it is not necessary any more to have a specific order to define a parameter.*

*For example (see also [U3.01.0x]):*

*deuxpi = 2.\*pi*

#### **1.3.2 IMPR\_COURBE**

*Replaced by IMPR\_FONCTION (cf [7.3.13]).*

#### **1.3.3 POST\_GOUJ2E**

*This order had not been reabsorbed at the same time as the associated macros MACR\_GOUJ2E\_MAIL/CALC. The method for calculation is preserved in the case-tests zzzz120a and zzzz120b (cf [7.2.14]).*

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***1.4***

***Modifications common to several orders***

***1.4.1 Key words***

***FILE and UNIT***

***According to the type of order, one was to use is UNIT (reading commands) where one was awaited logical number of unit, is FILE (orders of postprocessing) behind which one waited not not a file name but a “label” (ddname) which was associated a logical unit by defect or affected via order DEFI\_FICHER (ex-DEFUFI).***

***The concept of label disappears; the orders function all with UNIT and, those which know to use a true file name also the key word FILE accepts.***

***The risk of confusion is reduced: one provides to UNIT the logical unit well informed in astk and to FILE a file name complete Unix (see also the use of REPE\_IN/REPE\_OUT in documentation of astk [U1.04.00]).***

***1.4.2 Orders of postprocessing CALC\_ELEM, CALC\_NO, CALC\_G\_LOCAL\_T, CALC\_G\_THETA\_T, POST\_ELEM***

***MODEL, CHAM\_MATER, CARA\_ELEM, EXCIT become optional:***

***· The structure of data result (exit of STAT\_NON\_LINE, THER\_LINEAIRE...) keep in memory these 4 parameters, it thus becomes optional to provide them to these operators post-treatments. One can however inform these key words in certain particular cases; one check whereas they are the same ones which was used for calculation, if it is not the case, one emits an alarm or one stops in error (case of the MODEL) (cf [7.3.7], [7.3.24]).***

***1.5 Orders***

***modified***

***1.5.1 AFFE\_CARA\_ELEM***



**ANGL\_L, POUR\_CENT\_L, POUR\_CENT\_T removed, famous SECTION\_L in SECTION:**  
· *These key words do not have any more interest since the introduction of new elements of grid membrane which makes it possible to model the grids of reinforcement in a given direction, and who are usable jointly with a modeling 3D of the concrete. In the same way elements roast (usable with “hull” work from now on in only one direction. Orientation reinforcements is defined under ANGL\_REP (cf [7.3.10]).*

**Modified POUTRE/VARI\_SECT:**

· *To guide the user among the possible choices, one chooses a value now for SECTION, then for VARI\_SECT (new choice: CONSTANT by defect) what allows to limit the list of possible for CARA (cf [7.3.23]).*

**PREC\_AIRE, PREC\_INERTIE new:**

· *One checks the coherence of the information (surface and inertia of the multifibre beams) provided under key words BEAM and AFFE\_SECT with the precision indicated by these key words (cf [7.3.28]).*

**1.5.2 AFFE\_CHAR\_MECA/AFFE\_CHAR\_MECA\_F**

**FORMULATION new:**

· *At the time of the resolution of a problem of contact with the method continues, one has the choice enters a formulation in displacement (value DEPL) or of speed (value QUICKLY, well adapted numerically with the treatment of the shocks) (cf [7.3.18]).*

**TOLE\_PROJ replaced by TOLE\_PROJ\_EXT, new TOLE\_PROJ\_INT:**

· *In the case of symmetrical pairing MAIT\_ESCL\_SYME, it is necessary to lay out of a tolerance of projection for the detection of the null pivots (cf [7.3.23]).*

**New ITER\_MULT\_MAXI:**

· *ITER\_MULT\_MAXI multiplied by the number of nodes slaves gives the maximum number iterations of contact (cf [7.3.23]).*

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**COEF\_MULT\_2,**

**VECT\_NORM\_2,**

**DIST\_1,**

**DIST\_2 replaced by COEF\_MULT\_ESCL,**

**VECT\_NORM\_ESCL, DIST\_MAIT and DIST\_ESCL:**

· Homogénéisation of the vocabulary following the renaming of GROUP\_MA\_1/2 in GROUP\_MA\_MAIT/ESCL (cf [7.3.24]).

**GRAPPE\_FLUIDE new key words:**

· Several key words allowing to locate the forces according to their type and their zone application were added (APPL\_FORC\_xxxx, DIRE\_FORC\_FPLAQ, UNITE\_IMPR\_xxxx) (cf [7.3.23]).

**HARLEQUIN modifications:**

· Amélioration of the method Harlequin (cf reference document) and addition of the key words COND\_LIM, JOINING, POIDS\_GROSSIER, POIDS\_FIN (cf [7.3.28]).

### **1.5.3 AFFE\_MATERIAU**

**New SECH\_REF:**

· Permet to inform the value of the drying of reference; with this concentration, withdrawal of desiccation is null. The user must think of informing K\_DESSIC if his field of drying is variable (cf [7.3.2]).

### **1.5.4 CALC\_FATIGUE**

**Removed MODEL:**

· The key word was not useful (cf [7.3.2]).

### **1.5.5 CALC\_FONCTION**

**METHOD new:**

· Amélioration of the calculation of the FFT by adding the method PROL\_ZERO in which one the signal with zeros supplements (cf [7.3.14]).

### **1.5.6 CALC\_G\_LOCAL\_T and CALC\_G\_THETA\_T**

### ***EXCIT replaces LOAD:***

· *The multiplicative coefficient of the loads was not taken into account. It is now the case, CHARGE, FONC\_MULT and TYPE\_CHARGE are added under EXCIT. Even modification in CALC\_G\_THETA\_T (cf [7.3.6]). By defect, it is not necessary besides to provide EXCIT, who is stored in the SD result (cf [§1.4.2]).*

### ***QUICKLY, new ACCE:***

· *Permettent to take into account the terms of inertia in the calculation of G (cf [7.3.4]).*

### ***1.5.7 CREA\_MAILLAGE***

#### ***New NOM\_CHAM:***

· *To burst elements (ECLA\_PG), it is necessary to know the family of points of Gauss used. For that, one must provide the name of the field (cf [7.3.19]).*

### ***1.5.8 CREA\_RESU***

#### ***MODEL, CHAM\_MATER, CARA\_ELEM new:***

· *Permettent to create a result of the elas\_mult type (MACRO\_ELAS\_MULT) (cf [7.3.7]).*

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### ***1.5.9 BEGINNING***

#### ***FORMAT\_HDF=' OUI'/'NOT" replaces the key word factor HDF:***

· *The bases with format HDF (binary format portable enters of the machines of architectures*

*different) are now supported by askt, it is thus enough to specify if one wants to read one base with this format or not (cf [7.3.8]).*

**New VISU\_EFICAS:**

*· Permet to indicate (in the case-tests) if a command file is readable in Eficas or not (cf [7.3.5]).*

### **1.5.10 DEFI\_FICHER**

**FILE replaces NOM\_SYSTEME:**

*· In the idea of the simplification of the key words UNIT and FILE (cf [7.3.14]).*

**Turn over a free logical unit (primarily for the macros):**

*· In order not to cause conflict by choosing a logical unit already used, DEFI\_FICHER returns a free number of unit (cf [7.3.23]).*

### **1.5.11 DEFI\_MATERIAU**

**New LEMA\_SEUIL/\_FO:**

*· Introduction of a law of behavior derived from the law of Lemaître: in lower part of the threshold law is elastic, starting from the threshold, it behaves like a particular case of the law of Lemaître (cf [7.3.27]).*

**New GRANGER\_FP\_INDT:**

*· It acts of a law of Granger at a constant temperature (cf [7.3.24]).*

**New ENDO\_ORTH\_BETON:**

*· Orthotropic Loi of behavior of the concrete with taking into account of the damage (cf [7.3.23]).*

**New DRUCK\_PRAGER/\_FO (old DRUCKER\_PRAGER):**

*· Ajout of the possibility of calculating the sensitivity in 2D and 3D of the model of Drucker-Prager, the addition of the \_FO obliged has famous the model to avoid the conflicts of name (cf [7.3.21]).*

**VISC\_SINH replaces ROUSS\_VISC:**

*· With the addition of the laws of viscoplastic behavior VISC\_ISOT\_TRAC and VISC\_ISOT\_LINE, the viscous model being that already used by ROUSS\_VISC, the key word have famous summer to be more general (cf [7.3.19]).*

**New JOINT\_BA:**

*· Nouvelle law of behavior of steel-concrete connection in 2D (cf [7.3.8]).*

**BARCELONA - new ALPHAB:**

*· If it is not provided, the parameter is calculated by the code (cf [7.3.6]).*

**ECOU\_VISCi, ECOU\_ISOTi, ECOU\_PLASi, ECOU\_CINEi new:**

· Permettent to define the parameters of the single-crystal behaviors (cf [7.3.1]).

### **1.5.12 DEFI\_MODELE\_GENE**

**New OPTION=' REDUIT':**

· This option makes it possible to use the dynamic under-structuring by a method of modes of interface in order to reduce the size of the generalized modes, key words associated

:

**GROUP\_MA\_MAIT\_1/2, MAILLE\_MAIT\_1/2 (cf [7.3.18]).**

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### **1.5.13 TO DESTROY**

**ALARM new:**

· To be used only in the macros-orders, this key word makes it possible not to emit of alarm when one tries to remove a concept which does not exist (cf [7.3.27]).

**CLASS new:**

· Permet to remove an Aster object on the volatile basis (cf [7.3.8]).

### **1.5.14 DYNA\_NON\_LINE**

**New TETA\_METHODE:**

· Introduction of a formulation of speed for integration of the contact in dynamics. value of (parameter of the diagram of integration in time) can be selected between 0.5 and 1. ,

*this allows at the time of the resolution of a problem of contact with the method continues to make to vary dissipation during the phase of separation (cf [7.3.18], [7.3.22]).*

**New REAC\_ITER\_ELAS:**

· *Paramètre to control the frequency of reactualization of the secant matrix (cf [7.3.21]).*

### **1.5.15 DYNA\_TRAN\_EXPLI**

*It should be noted that this order will amalgamate with DYNA\_NON\_LINE in version 8.1.*

**New REAC\_ITER\_ELAS:**

· *Paramètre to control the frequency of reactualization of the secant matrix (cf [7.3.21]).*

### **1.5.16 END/CONTINUATION**

**FORMAT\_HDF=' OUI'/'NOT'** replaces the key word factor HDF:

· *The bases with format HDF (binary format portable enters of the machines of architectures different) are now supported by ask, it is thus enough to specify if one wants to or not see/write a base with this format (cf [7.3.8]).*

### **1.5.17 FORMULATE**

**NOM\_PARA, VALE new:**

· *The formulas are now unspecified Python expressions (it is enough that one can to evaluate all the same!). The names of parameters and the expression are defined under these two distinct key words (cf [7.3.21] and [U4.31.05]).*

### **1.5.18 IMPR\_FICO\_HOMA**

**UNITE\_CONF, UNITE\_DONN** replace **FICHER\_CONF, FICHER\_DONN:**

· *In the same spirit as in the paragraph [[§ 1.4.1](#)] (cf [7.3.23]).*

**MAJ\_CHAM** becomes a key word factor...

· *... to offer more flexibility in the choice of the fields to be updated at the time of one adaptation of grid (cf [7.3.20]).*

### **1.5.19 IMPR\_FONCTION**

*The order was completely rewritten (cf [7.3.13]).*

**Modified FORMAT:**

· *In a preoccupation with a homogenisation with the other orders, the format EXCEL becomes TABLE.*

· *Formats XMGRACE and AGRAF are dedicated to the tracers of the same name.*

· *The formats RESULT, ORDER and SEISM are removed.*

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***New PILOT (if FORMAT=' XMGRACE'):***

· *By defect, one produces a file ready to be to visualize in xmgrace. One also can to invite the various pilots available for xmgrace in order to produce a file ready to be introduced into a note of calculation like a file POSTSCRIPT, png or JPEG.*

***STYLE, COLOR, MARKER modified:***

· *These key words make it possible to define the style of each curve, they are now entirities that it is necessary to provide.*

***FREQ\_GRILLE\_X/Y replace GRILLE\_X/Y:***

· *Car agraf awaits a frequency of squaring and xmgrace a step of grid.*

***FREQ\_MARQUEUR is moved under the CURVED key word factor.***

***UNIT, UNITE\_DIGR modified:***

· *UNIT contains the logical number of unit of the file in which one produces the curve (file .dogr with format AGRAF). UNITE\_DIGR makes it possible to choose the logical unit associated with the file*

*.digr with format AGRAF.*

***TITLE replaces TITRE\_GRAPHIQUE, SOUS\_TITRE replaces COMMENT.***

***COUNT removed:***

· *It is the role of order IMPR\_TABLE.*

### **Removed RECU\_GENE:**

· *The order treats only the functions (or tablecloths). It is necessary to proceed in two times: to recover the values with RECU\_FONCTION, then impression itself with IMPR\_FONCTION.*

### **1.5.20 IMPR\_RESU**

#### **FILE, FORMAT moved:**

· *These key words are moved out of the key word factor RESU so that one cannot any more to use only one IMPR\_RESU to write in two different files (because the files were often incomplete) (cf [7.3.14]).*

### **1.5.21 IMPR\_TABLE**

*The order was completely rewritten (cf [7.3.27], [7.3.29]).*

#### **Modified FORMAT:**

- *In a preoccupation with a homogenisation with the other orders, the format EXCEL becomes TABLE, TABLE becomes TABLEAU\_CROISE (a parameter function of 2 others).*
- *One adds the format XMGRACE which produces a directly displayable file in xmgrace.*
- *Formats ASTER and AGRAF are unchanged (note: with format AGRAF, the file .digr is not created).*
- *Format MOT\_CLE is removed.*

#### **Removed TOUT\_PARA:**

· *It is enough to omit key word NOM\_PARA to select all the parameters of the table.*

#### **Modified SORTING:**

- *One can sort according to NR parameters, in the event of equality on a parameter, one passes to the following;  
ORDER is worth GROWING or DECREASING.*
- *CRITERION and PRECISION are removed.*

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**PAGINATION modified:**

· *The number of parameter is unlimited.*

**TITLE replaces TITRE\_TABLE.**

**1.5.22 INFO\_EXEC\_ASTER**

**LISTE\_INFO new possibility: ETAT\_UNITE**

· *One can know if a file attached to a logical unit currently is opened or closed (cf [7.3.20]).*

**1.5.23 LIRE\_FONCTION**

*The order was completely rewritten (cf [7.3.10], [7.3.21], [U4.32.02]).*

**New INDIC\_xxxx, FORMAT, TYPE, SEPAR:**

· *Permettent to build a real, complex function or a tablecloth starting from files of which the format can slightly vary.*

**1.5.24 LIRE\_RESU**

**Removed NOM\_CHAM:**

· *This key word is useless out of the specific blocks to each format (cf [7.3.28]).*

**1.5.25 MACR\_ADAP\_MAIL/MACR\_INFO\_MAIL**

**Modified NON\_SIMPLEXE:**

· *Traitement of the quadrangular elements (cf [7.3.20]).*

**1.5.26 MACR\_FIAB\_IMPR**

**New PARA\_SENSI:**

· *Nécessaire to treat the case of the sensitivity (cf [7.3.24]).*

**1.5.27 MACRO\_MISS\_3D**

**VERSION new:**

· *Permet to specify the version of the Miss3D software used (cf [7.3.27]).*

**1.5.28 MECA\_STATIQUE**

***New METHODE=' FETI':***

***· Introduction of a method of resolution by decomposition of fields of the Feti type.  
New key words simple associates: PARTITION, RENUM, RESI\_RELA, NMAX\_ITER,  
TYPE\_REORTHO\_DD, NB\_REORTHO\_DD, PRE\_COND, SCALING, VERIF\_SDFETI,  
TEST\_CONTINU (cf [7.3.3]).***

***New INFO\_FETI:***

***· To modulate the quantity information to print at the time of a resolution by the Feti method  
(cf [7.3.27]).***

***1.5.29 MODE\_ITER\_INV/MODE\_ITER\_SIMULT/NORM\_MODE***

***SENSITIVITY new:***

***· Possibilité of making calculations of sensitivities for the generalized and quadratic problems  
(cf [7.3.15]).***

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### **1.5.30 MODI\_MAILLAGE**

**ORIE\_FISSURE** replaces **ORIE\_CONTACT**:

· *This functionality is used for the joined elements (cf [7.3.20]).*

### **1.5.31 POST\_RCCM**

New **TABL\_SIGM\_THER**:

· *Permet to calculate \**

*S starting from the statement of the constraints under thermal loading only*

*N*

*(cf [7.3.6]).*

### **1.5.32 STAT\_NON\_LINE**

New **REAC\_ITER\_ELAS**:

· *Paramètre to control the frequency of reactualization of the secant matrix (cf [7.3.21]).*

### **1.5.33 TEST\_FICHER**

New **EXPR\_IGNORE**:

· *Permet not to preserve certain lines of the file tested by using expressions regular (cf [7.3.22]).*

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**2**

***Innovations between 7.2 and 7.3***

**2.1 News**

**orders**

**2.1.1 MACR\_FIABILITE**

***This macro-order calculates the probability that a physical variable (displacement, forced,...) exceed a threshold defined by the user according to a certain number of parameters which will have been***

***defined as sensitive by the user. These significant parameters can be the Young modulus, Poisson's ratio, a pressure, etc***

***The macro-order calls upon the software MEFISTO which is external in Code\_Aster, and which puts in***

***work method FORM. (cf [7.2.11]).***

**2.1.2 STANLEY**

***Stanley, tool for interactive postprocessing, was already present in version 7; this macro-order simplify its call since one now launches it like an ordinary order. (cf [7.2.25]).***

**2.1.3 TEST\_FICHER**

***This macro-order makes it possible to test nonthe regression of the orders which produce files, to the attention of the developers (cf [7.2.25]).***

## **2.2 Orders reabsorbed**

### **2.2.1 FACT\_INTE\_SPEC**

*This order was amalgamated with GENE\_FONC\_ALEA (cf [7.2.3]).*

### **2.2.2 MACR\_GOUJ2E\_MAIL and MACR\_GOUJ2E\_CALC**

*These two macro-orders are reabsorbed. The method for calculation is preserved in command files zzzz120a and zzzz120b which validated these functionalities. (cf [7.2.14]).*

## **2.3 Orders modified**

### **2.3.1 AFFE\_CARA\_ELEM**

*New RIGI\_MISS\_3D:*

*· Permet to affect the terms of a matrix of impedance of ground calculated by MISS3D for one frequency of extraction given (cf [7.2.2]).*

### **2.3.2 AFFE\_MODELE**

*\*\_HH2D new modelings:*

*· These modelings make it possible to take into account two phases in both components; the pressure of dissolved air is connected to the pressure of dry air by the law of Henry (cf [7.2.7]).*

*GRILLE\_MEMBRANE new modeling:*

*· It acts of a new element of tablecloths of reinforcement which works only out of membrane, not of ddl of rotation (cf [7.2.21]).*

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### **2.3.3 AFFE\_CHAR\_MECA/AFFE\_CHAR\_MECA\_F**

**New GRAPPE\_FLUIDE:**

*· Permet to take into account the fluid forces due to the displacement of the bunch in fluid which bathes the internal elements of the heart. (cf [7.2.2]).*

**New TOLE\_PROJ:**

*· Permet to adjust the projection of the nodes slaves towards the meshes Masters (cf [7.2.1]).*

**CONTACT famous key words:**

*· GROUP\_MA\_MAIT,*

*MAILLE\_MAIT,*

*GROUP\_MA\_ESCL,*

*MAILLE\_ESCL replace*

*respectively GROUP\_MA\_1, MAILLE\_1, GROUP\_MA\_2, MAILLE\_2 (cf [7.2.4]).*

### **2.3.4 ASSE\_MAILLAGE**

**OPERATION, MAILLAGE\_1, GRID new:**

*· Three types of operation are now available SOUS\_STR, SUPERIMPOSES, JOINING (cf [7.2.4]).*

### **2.3.5 CALC\_CHAM\_ELEM/CALC\_ELEM**

**Doubled bloom:**

*· These two orders made doubled bloom on the majority of the calculated options, only some options persist in CALC\_CHAM\_ELEM (cf [7.2.17]).*

### **2.3.6 CALC\_FATIGUE**

**New TYPE\_CHARGE:**

*· Définit the type of loading (periodic or not), under the key word CRITERION, the choice is thus restricted according to the type of loading (cf [7.2.5]).*

**CRITERE=' DOMM\_MAXI', PROJECTION, DELTA\_OSCI new:**

*· These key words are associated the new criterion adapted to the nonperiodic loadings; it acts of a criterion with variable amplitude based on a critical level selected according to*

*induced maximum damage (cf [7.2.5]).*

**CRITERE=' DANG\_VAN\_\_MODI\_AC'/new "DANG\_VAN\_MODI\_AV":**

*· It acts of a criterion with variable amplitude based on a critical level selected from maximum damage. This criterion which is adapted if the loading is not periodical is an evolution of the criterion of original DANG VAN. "AC" for constant amplitude, "AV" for variable amplitude (cf [7.2.11]).*

### **2.3.7 CALC\_G\_THETA\_T**

*New type for the field:*

*· One can now provide a field of the cham\_no\_depl\_r type (and to build it made-to-order!) in the place of that provided by CALC\_THETA (cf [7.2.8]).*

### **2.3.8 CALC\_NO**

**GROUP\_MA\_RESU, GROUP\_NO\_RESU, MAILLE\_RESU, NOEU\_RESU new:**

*· Permettent to specify the zone on which the field by element will be tiny room before calculating the values with the nodes because one could obtain incorrect results when a node is with border of two modelings (cf [7.2.7]).*

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### **2.3.9 CREA\_MAILLAGE /CREA\_RESU**

**ECLA\_PG new possibilities:**

*· One can now burst a grid (by creating an element by point of Gauss) on one*

*part only of one grid; and in 2D, to give a fictitious thickness to flattened elements.*

**Caution:**

*The parameters provided to CREA\_MAILLAGE and CREA\_RESU must be coherent: same groups of meshes given in the same order (cf [7.2.25]).*

**2.3.10 DEFI\_FONCTION**

**NOM\_PARA new values:**

- *Added Noms of parameter: NORM and DSP (cf [7.2.4]).*

**2.3.11 DEFI\_GROUP**

**CREA\_GROUP\_NO/TOUT=' OUI' limited to the option TUNNEL:**

- *The use of TOUT=' OUI' is not available for all the options, only for the option TUNNEL (cf [7.2.8]).*

**2.3.12 DEFI\_MATERIAU**

**BARCELONA new behavior for KIT\_HHM and KIT\_THHM:**

- *Loi of mechanical and hydrous behavior of the unsaturated grounds. This model utilizes two criteria, a mechanical criterion of plasticity which is that of CAM\_CLAY and another criterion hydrous controlled by suction (cf [7.2.21]).*

**GLRC/GLRC\_FO new behavior:**

- *Loi of behavior of the concrete plates arms written in generalized efforts; finite element associated DKTG (on meshes TRIA3 and QUAD4) (cf [7.2.4]).*

**New CORR\_ACIER:**

- *Elastoplastic Modèle endommageable of a steel in which plastic deformation with rupture depends on the rate of corrosion (cf [7.2.23]).*

**VISC\_IRRA\_LOG new behavior:**

- *Viscoelastic Loi of behaviour for the axial creep of the tubes guides under irradiation (cf [7.2.1]).*

**DRUCKER\_PRAGER new behavior:**

- *Loi of behavior for the soil mechanics (cf [7.2.7]).*

**New LIQU\_AD\_GAZ\_VAPE:**

- *Rate mixing of the air dissolved for the THM (law of Henry) which connects the pressure of air dissolved to pressure of dry air (cf [7.2.7]).*



### **DOMM\_A, DOMM\_B, COEF\_CISA\_TRAC new:**

· *Associés the criterion of tiredness DOMM\_MAXI of CALC\_FATIGUE (cf [7.2.5]).*

### **EPSP\_SEUIL, EXP\_S new:**

· *Associés the criterion of tiredness DOMMA\_LEMAITRE of CALC\_FATIGUE (cf [7.2.19]).*

### **LAMBDA and D\_LAMBDA\_TEMP removed under THM\_\*:**

· *Thermal conductivity is now defined like the product of three functions of temperature (LAMB\_T), of saturation (LAMB\_S) and porosity (LAMB\_PHI) more one constant (LAMB\_CT), as well as the three derived from functions (D\_LB\_T, D\_LB\_S, D\_LB\_PHI) (cf [7.2.10]).*

*In the thermal case, only LAMB\_T is obligatory, the other functions being then taken equal to one and their derivative null.*

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### **2.3.13 GENE\_FONC\_ALEA/GENE\_MATR\_ALEA/GENE\_VARI\_ALEA**

· *These orders were completely altered; FACT\_GENE\_ALEA was reabsorbed with profit of GENE\_FONC\_ALEA. One will refer to documentations of the orders for new syntax of use (cf [7.2.3]).*

### **2.3.14 IMPR\_RESU**

**FORMAT=' GMSH'/VERSION new defect:**

· *The version of file GMSH by defect is now 1.2 (in which GMSH knows post-to treat the quadrangles): the quadrangles are not cut out in triangles (cf [7.2.9]).*

### ***2.3.15 INCLUDE\_MATERIAU***

***New materials available in the catalogue material:***

- ***Z3CN20-09M, Z6NCTDV25-15 (cf [7.2.10], to see on the Intranet Code\_Aster under Use/Materials).***

### ***2.3.16 MACR\_RECAL***

***New WEIGHT:***

- ***One can balance the various curves on which retiming (cf [7.2.4] is made).***

### ***2.3.17 MODI\_MAILLAGE***

***SYMMETRY new:***

- ***Permet to take the symmetrical one of a grid compared to a line or a plan according to dimension (cf [7.2.16]).***

### ***2.3.18 POST\_ELEM***

***New:***

- ***One can now use POST\_ELEM after a multiple resolution with MACRO\_ELAS\_MULT (cf [7.2.22]).***

### ***2.3.19 POST\_K1\_K2\_K3***

***VERY new:***

- ***Permet to calculate the stress intensity factors on all the nodes of the meshes composing the bottom of crack (cf [7.2.4]).***

### ***2.3.20 PROJ\_CHAMP***

***New DISTANCE\_MAX:***

- ***Permet to astutely project fields of a model A towards a model B. When nodes of the grid B are not in an element of the grid A and which they are beyond one certain distance, the field is not projected (cf [7.2.16]).***

***NUAG\_DEG\_\* removed methods:***

- ***These methods of projection of fields were removed, results vague (cf [7.2.22]).***

### ***2.3.21 POST\_RCCM***

***New TYPE\_RESU\_MECA, modification of the options:***

- ***This key word can take the values "UNIT" or "PIPING", OPTION=' FATIGUE' replace B3200 and B3600... (cf [7.2.17]).***

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### **2.3.22 MACRO\_CARA\_POUTRE**

**RT new result:**

· *One can obtain under this key word of ray of torsion of the section of a beam (cf [7.2.2]).*

### **2.3.23 STAT\_NON\_LINE/DYNA\_NON\_LINE**

**New ALGO\_ID:**

· *One can thus use all the behaviors (small deformations) 3D in the elements of bar, grids, multifibre beams, one extended the method suggested by R. De Borst for plane constraints with the behaviors 1D. That is translated, as for the constraints plane, by 4 internal variables (cf [7.2.18]).*

**Obligatory ETAT\_INIT in mode réentrant (when the result is enriched) (cf [7.2.1]).**

**BARCELONA new:**

· *Comportement of the grounds in medium unsaturated (cf [7.2.21]).*

**New GLRC:**

· *Comportement of the concrete plates arms written in generalized efforts (cf [7.2.4]).*

**CORR\_ACIER, CORROSION new:**

· *Permettent to provide the parameters necessary to the elastoplastic model endommageable of a steel in which the plastic deformation with rupture depends on the rate of corrosion (cf [7.2.23]).*

### ***New SOUS\_STRUC:***

· *Intégration of the static macronutrients. The application concerned is to optimize the resolution of problems of important size in which only a restricted part with a behavior nonlinear (cf [7.2.23]).*

### ***THER\_HOMO, THER\_POLY removed:***

· *Suppression of the thermal law of behavior under RELATION\_KIT in THM (cf [7.2.16]).*

### ***2.3.24 THER\_NON\_LINE\_MO***

*The order is not any more réentrante because only one moment is calculated (stationary calculation in reference mark mobile).*

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***Innovations between 7.0 and 7.2***

***One finds here the consecutive modifications of syntax to the evolutions introduced into the versions 7.1 and 7.2 (version 7.0 being similar to the 6.4).***

***3.1 News***

## **orders**

### **3.1.1 CALC\_PRECONT**

*This order makes it possible to define and apply the prestressing of the cables of a concrete structure armed by taking into account various types of anchoring, and while allowing to tend individually each cable while respecting the standards of the BPEL (cf [7.0.14]).*

### **3.1.2 CREA\_TABLE**

*This order makes it possible to create a table starting from a function or of two lists (cf [7.1.17]).*

### **3.1.3 DYNA\_TRAN\_EXPLI**

*It is about the first grinding of the operator of dynamics clarifies in which all them possibilities were not introduced yet (master-slave contact for example) (cf [7.1.16]).*

### **3.1.4 EXTR\_TABLE**

*This order makes it possible to recover the contents of a cell of a table; only the type MATR\_ASSE\_GENE\_R is treated for the moment (cf [7.1.17]).*

### **3.1.5 MACR\_CABRI\_MAIL MACR\_CABRI\_CALC**

*These orders make it possible to net supports automatically, and of launching calculations on these grids (cf [7.1.5]).*

## **3.2 Orders reabsorbed**

*Orders MACRO\_CHAR\_F\_U and MACRO\_MADMACS were removed in version 7.1.*

## **3.3 Orders re-elected**

- *MACR\_CARA\_POUTRE replaces MACRO\_CARA\_POUTRE.*
- *DEFI\_FICHER replaces DEFUFI and TO CLOSE (these last will be reabsorbed in version 7.3). Moreover, DEFI\_FICHER gives access a file by indicating its name system (and not only with its number of logical unit FORTRAN) (cf [7.1.16]).*

## **3.4 Modifications common to several orders**

### **3.4.1 FOND\_FISS replaces FUND, FOND\_3D**

*In orders CALC\_G\_LOCAL\_T, CALC\_G\_THETA\_T, CALC\_THETA, POST\_K1\_K2\_K3  
· Homogénéisation of the vocabulary in breaking process (cf [7.0.9]).*

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### **3.4.2 Options of prepacking of the solver key word PRE\_COND**

*In orders CALC\_FORC\_AJOU,*

*CALC\_MATR\_AJOU,*

*DYNA\_NON\_LINE,*

*MACR\_ASCOUF\_CALC, MACR\_ASPIC\_CALC, MACRO\_MATR\_AJOU, MECA\_STATIQUE,*

*STAT\_NON\_LINE, THER\_LINEAIRE, THER\_NON\_LINE, THER\_NON\_LINE\_MO*

*· Option PRE\_COND='DIAG' is removed, only remains option LDLT\_INC (incomplete)  
(cf [7.0.14]).*

## **3.5 Orders**

*modified*

### **3.5.1 AFFE\_CARA\_ELEM**

**New GROUP\_MA\_POII:**

*· Mot-clé introduced to affect characteristics of RIGI\_PARASOL on elements of  
type POII (cf [7.0.14]).*

### 3.5.2 AFFE\_CHAR\_MECA

#### *New DDL\_POUTRE:*

- *Permet to impose boundary conditions in the local reference mark of a beam (cf [7.0.10]).*

#### *CONNECTION new:*

- *Under DDL\_IMPO, to block all displacements of a blow (cf [7.1.5]).*

#### *SIGM\_BPEL default value:*

- *The default value is now “NOT”, the value “YES” is usually used only for the setting in prestressed cables (cf [7.0.13]).*

### 3.5.3 AFFE\_CHAR\_MECA\_C

#### *CONNECTION new:*

- *Under DDL\_IMPO, to block all displacements of a blow (cf [7.1.5]).*

### 3.5.4 AFFE\_CHAR\_MECA\_F

#### *CONNECTION new:*

- *Under DDL\_IMPO, to block all displacements of a blow (cf [7.1.5]).*

#### *New EFFET\_FOND:*

- *Permet the taking into account of the basic effect according to time (cf [7.0.1]).*

### 3.5.5 AFFE\_MATERIAU

#### *GROUP\_NO, NODE removed:*

- *The assignment is not possible that on meshes (cf [7.1.8]).*

### 3.5.6 AFFE\_MODELE

#### *SHB8 new modeling:*

- *Nouvel element of hull under-integrated without mode of blocking (cf [7.1.18]).*

#### *AFFE modification:*

- *possibility of providing a list under AFFE, with rule of overload (cf [7.1.18]).*

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### ***3.5.7 CALC\_ELEM***

***EQUI\_ELNO\_SIGM different method of calculation:***

***Equivalent constraints (Von Mises, Tresca,...) were calculated starting from the constraints extrapolated with the nodes. One calculates from now on the equivalent constraints by extrapolation of***

***constraints equivalent calculated to the points of Gauss (as for the internal variables). only stress fields provided are thus SIEF\_ELGA\_DEPL into linear and SIEF\_ELGA in nonlinear.***

***On the other hand for the elements of hulls, the mode of calculation of the equivalent constraints does not have***

***changed: the user must calculate the stress field in a point thickness***

***(SIGM\_ELNO\_DEPL into linear and SIGM\_ELNO\_COQU into nonlinear), and the option EQUI\_ELNO\_SIGM calculate the invariant of this field to the nodes.***

### ***3.5.8 CALC\_FATIGUE***

***CRITERION news possibility:***

***· Ajout of the criterion of DANG\_VAN (cf [7.0.7]).***

***MODEL, GRID, GROUP\_MA, MESH, GROUP\_NO, NODE new:***

***· Permettent post-to treat with the nodes on part of the grid by using the method of critical plan (cf [7.1.7]).***

### ***3.5.9 CALC\_FONC\_INTERP***

***VALE\_PARA replaces VALE\_R;***

***NOM\_PARA,***

***NOM\_PARA\_FONC,***

***VALE\_PARA\_FONC,***



**LIST\_PARA\_FONC,**  
**INTERPOL\_FONC,**  
**PROL\_GAUCHE\_FONC, PROL\_DROITE\_FONC new:**

- *Possibilité of creating a tablecloth starting from a formula with two parameters (cf [7.0.14]).*
- *The order is not any more réentrante: it treats a function and produces a function or one tablecloth.*

### **3.5.10 CALC\_FONCTION**

**New ABS:**

- *Calcul the absolute value of a function (cf [7.0.14]).*

**OPPOSITE new:**

- *Calcul the reverse of a function (cf [7.0.14]).*

**New ECART\_TYPE:**

- *Calcul of the standard deviation of a function (cf [7.0.15]).*

### **3.5.11 CALC\_G\_THETA\_T**

**CALC\_DG removed option:**

- *The calculation of derived from G follows the standard formalism now (key word SENSITIVITY) (cf [7.1.12]).*

### **3.5.12 COMB\_SISM\_MODAL**

**TYPE\_COMBI replaces STANDARD:**

- *Under the key words factors COMB\_MULT\_APPUI and COMB\_DEPL\_APPUI. Possible choices are “QUAD” and “LINE”, “ABS” was removed (cf [7.0.14]).*

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### **3.5.13 CREA\_CHAMP**

**OPTION new:**

- *Permet to initialize a field as if it had been created by such option (cf [7.0.15]).*

### **3.5.14 CREA\_MAILLAGE**

**New COQU\_VOLU:**

- *Crée a voluminal grid starting from a surface grid and a thickness (cf [7.1.11]).*

**New LINE\_QUAD:**

- *Crée a quadratic grid starting from a grid made up of linear elements (cf [7.0.5]).*

**New QUAD\_TRIA3:**

- *Crée triangular meshes with three nodes starting from quadrangles (cf [7.1.9]).*

### **3.5.15 BEGINNING/CONTINUATION**

**New HDF:**

- *Définir parameters for the reading of a base in format HDF (portable between machines) (cf [7.1.16]).*

### **3.5.16 DEFI\_CABL\_BP**

**New CONE:**

- *Permet to define a cone which will support the tension loads of the cable (cf [7.0.16]).*

**Note:**

*It is now about an macro-order.*

### **3.5.17 DEFI\_GROUP**

**New APPUI\_LACHE:**

- *Définit the group of the meshes being based on a node or a group of nodes (releases: “containing at least a node of the group”) (cf [7.1.10]).*

**New TUNNEL:**

- *Définit the group of the nodes contained in a tunnel describes by its axis and its ray (cf [7.0.16]).*

**ALARM new:**

- *Permet to decontaminate the release of the alarms emitted normally by the order.*

**Caution:**

*Must be used only by macro-orders which are ensured in addition of the validity groups obtained.*

**3.5.18 DEFI\_MATERIAU**

**New BETON\_ECRO\_LINE:**

- *Prise in account of containment for model ENDO\_ISOT\_BETON, one adds like parameter maximum material SYC forced in simple compression (cf [7.0.17]).*

**New BETON\_UMLV\_FP:**

- *Ajout of a relation of behavior for the taking into account of the clean creep of the concrete (cf [7.0.4]).*

**BPEL\_ACIER/SY becomes F\_PRG:**

- *F\_PRG is the guaranteed constraint of the maximum loading with rupture (cf [7.1.17]).*

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**New COMP\_THM:**

· Regroupement of the parameters required for a calculation THM according to the mixing rate used (cf [7.1.18]).

**DIS\_CONTACT/ANGLE\_i and MOMENT\_i:**

· For the connection grid-pencil, one introduces the angles and moments function of the temperature and fluence (cf [7.1.7]).

**In fatigue:**

· Ajout of the CRITERION of DANG\_VAN (cf [7.0.7]).  
· For criterion MATAKE, ENDU\_FT is replaced by COEF\_FLEX\_TORS.

### **3.5.19 TO DESTROY**

**New OBJECT:**

· Possibilité of destroying objects associated with concepts inaccessible to the user (cf [7.1.9]).

### **3.5.20 DYNA\_LINE\_TRAN and DYNA\_NON\_LINE**

**SENSITIVITY new:**

· Ajout of the calculation of derived from the fields results compared to the data material or boundary conditions (cf [7.1.5] for DYNA\_LINE\_TRAN, [7.1.3] DYNA\_NON\_LINE).

### **3.5.21 END**

**New HDF:**

· Définir parameters for the writing of a base in format HDF (portable between machines)

(cf [7.1.16]).

### **3.5.22 FORMULATE**

**Removed ENTIRETY:**

· *The whole formulas are henceforth prohibited (cf [7.0.17]).*

### **3.5.23 IMPR\_FICO\_HOMA**

*There are changes of syntax in this procedure, called by MACR\_ADAP\_MAIL, which are not thus not described here.*

### **3.5.24 IMPR\_RESU**

**VERSION new:**

· *Permet to specify the level of version of the files to format GMSH. With version 1.2 (available in the recent versions of GMSH), the quadrangles are not cut out any more in triangle, GMSH knowing to treat all the linear elements (cf [7.0.3]).*

### **3.5.25 IMPR\_TABLE**

**New TITRE\_TABLE:**

· *Possibilité of defining a title during the impression of a table (cf [7.0.16]).*

### **3.5.26 INCLUDE\_MATERIAU**

**New UNITE\_LONGUEUR:**

· *Permet to use the data of the catalogue material with the millimetre like unit of length (cf [7.0.14]).*

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### **3.5.27 LIRE\_CHAMP**

**New INST:**

· **One can now locate it (S) field (S) with reading with the moment in a file with format MED (cf [7.1.10]).**

### **3.5.28 LIRE\_RESU**

**FORMAT replaces FORMAT\_IDEAS:**

· **One specifies behind this key word the format of reading: IDEAS or IDEAS\_DS58 (cf [7.0.13]).**

### **3.5.29 MACR\_ADAP\_MAIL**

**New NON\_SIMPLEXE:**

· **Permet acceptance of the quadrangular, hexahedral, pentaedric elements (which are not refined) in a grid subjected to Homard (cf [7.1.10]).**

**New MAILLAGE\_FRONTIERE:**

· **Possibilité of providing a grid for the follow-up of border (cf [7.1.10]).**

**TYPE\_CHAM modification:**

· **One now awaits the same thing as in order CREA\_CHAMP (cf [7.0.12]).**

### **3.5.30 MACR\_INFO\_MAIL**

**New NON\_SIMPLEXE and MAILLAGE\_FRONTIERE:**

· **Voir MACR\_ADAP\_MAIL.**

### **3.5.31 MECA\_STATIQUE**

**New INST\_FIN:**

· **The operator is now réentrant to be able to treat long transients (cf [7.1.8]).**

### **3.5.32 MODE\_ITER\_SIMULT**

**APPROACH new possibility:**

· **Ajout of the approach "COMPLEXES" to deal with the quadratic problem with the eigenvalues, for the strongly deadened cases for example (cf [7.0.12]).**

### **3.5.33 MODI\_MAILLAGE**

### ***New ORIE\_SHB8:***

- *Permet to direct the elements of hull SHB8 (cf [7.1.18]).*

### ***3.5.34 MODI\_OBSTACLE***

#### ***Removed TUBE\_NEUF:***

- *The key word was moved in order POST\_USURE (cf [7.0.2]).*

### ***3.5.35 MODI\_REPERE***

#### ***GROUP\_MA, MESH, GROUP\_NO, NODE new:***

- *Permet to restrict the change of reference mark to part of the grid (cf [7.0.9]).*

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### ***3.5.36 PROJ\_CHAMP***

#### ***SENSITIVITY new:***

- *Permet to project fields derived from a grid on another (cf [7.1.10]).*

### ***3.5.37 POST\_USURE***

#### ***New TUBE\_NEUF:***

- *Permet to provide new values of wear (cf [7.0.2]).*

### ***3.5.38 POST\_RCCM***

### ***New TYPE\_KE***

- *Offre two methods of calculation of Ke.*

### ***3.5.39 PRE\_GMSH***

#### ***Removed MODI\_QUAD:***

- *This functionality is included in CREA\_MAILLAGE and applies to an Aster grid some is its origin (cf [7.0.6]).*

#### ***Note:***

*PRE\_GMSH is again a procedure.*

### ***3.5.40 PRE\_IDEAS***

#### ***New CREA\_GROUP\_COUL:***

- *Permet to create or not the groups associated with the colors with IDEAS (cf [7.0.2]).*

### ***3.5.41 STAT\_NON\_LINE***

***RESI\_REFE\_RELA, SIGM\_REFE, EPSI\_REFE, FLUX\_THER\_REFE, FLUX\_HYD1\_REFE,  
New FLUX\_HYD2\_REFE:***

- *Nouvelle method for the test of convergence compared to a definite value of reference for each size (cf [7.0.16]).*

#### ***SELECTION new:***

- *Choix of parameter of piloting: NORM\_INCR\_DEPL, ANGL\_INCR\_DEPL, RESIDUE: one respectively minimize the increment of displacement (defect), the angle between  $u_+$  and  $U$ , the residue (cf [7.0.9]).*

#### ***ETA\_PILO\_R\_MAX, ETA\_PILO\_R\_MIN, PROJ\_BORNES new:***

- *Permettent to define the terminals of the interval of research (cf [7.0.9]).*

#### ***PAS\_MIN\_CRIT, ITER\_LINE\_CRIT, RHO\_MAX, RHO\_MIN, RHO\_EXCL new:***

- *Bornes of linear research in the event of piloting (cf [7.0.9]).*

#### ***New CRIT\_FLAMB:***

- *Recherche of the modes of buckling of a structure (cf [7.1.17]).*

#### ***SENSITIVITY new:***

- *Introduction of calculations of sensitivity into nonlinear (cf [7.1.3]).*

### ***3.5.42 TEST\_TABLE***

#### ***SENSITIVITY new:***

- *Permet the test of the derived tables (cf [7.1.12]).*



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## **Summary:**

*The object of this document is to offer a global vision of the modifications of syntax and new possibilities*

*orders of Code\_Aster occurred between each version since version 8.0.*

*Index A of this document thus gives a report on the changes introduced since version 8.0 of December 2004*

*(identical to version 7.4) and valid for version 8.2 of December 2005.*

*For more precise details, one will consult the documentation of the orders and the file histor of corresponding under-version (e.g.: [8.0.7], section Development of the [www.code-aster.org](http://www.code-aster.org) site). The impacted orders are listed alphabetically.*

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**1**

**Innovations between 7.4/8.0 and 8.2**

**1.1 Modifications**

**general**

**1.1.1 Local criteria of convergence**

*The local criteria of convergence are by nature relevant only for a given behavior; the accepted residue, the diagram of integration or the iteration count can now be defined of manner different for each behavior from the model.*

*In the field of syntax, key words RESI\_INTE\_RELA, INTER\_INTE\_REAL, INTER\_INTE\_MAXI, RESO\_INTE are moved of CONVERGENCE towards COMP\_INCR/COMP\_ELAS (of which an occurrence each behavior defines).*

*The orders concerned are DYNA\_NON\_LINE, DYNA\_TRAN\_EXPLI, STAT\_NON\_LINE and in cascade macro-orders CALC\_PRECONT, MACR\_ASCOUF\_CALC, MACR\_ASPIC\_CALC, MACR\_CABRI\_CALC.*

### **1.1.2 Solvor MUMPS**

*A new direct solvor is available in Code\_Aster: MUMPS.*

*It makes it possible to solve problems known with the traditional solveurs when the matrix is not positive (case XFEM, incompressible elements,...).*

*It is usable by orders DYNA\_NON\_LINE, MECA\_STATIQUE, RESO\_LDLT, STAT\_NON\_LINE, THER\_LINEAIRE and THER\_NON\_LINE (cf [8.0.14]).*

*Notice for the version local*

*This solvor does not form part of the sources of Code\_Aster, it acts of an external package.*

### **1.1.3 Solvor FETI**

*Solvor FETI is a parallel solvor by decomposition of fields.*

*He is under development; its field of application is thus limited in version 8.2.*

## **1.2 News orders**

### **1.2.1 CALC\_TABLE**

*This order makes it possible to handle the data of the tables to the manner of a spreadsheet. The order makes it possible to carry out operations on the data of the tables. Operations currently available are:*

*.  
concaténer/to combine two tables having common parameters,  
.  
to apply a formula,  
.*

*to re-elect parameters,*

.

*to filter the lines according to certain criteria,*

.

*to extract from the columns of a table,*

.

*to order the lines.*

### **1.2.2 INFO\_FONCTION/CALC\_FONCTION**

*Order CALC\_FONCTION was deeply rewritten so that it is simple and fast of y  
to introduce new generic treatments at the request of the users.*

*Thus, only the operations which calculate a function (or a tablecloth) starting from other functions  
were*

*preserved in CALC\_FONCTION.*

*It should be noted that the operation of smoothing wraps spectra of floor (SRO), LISS\_ENVELOP,  
was*

*review according to regulations' of EDF Septen.*

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*All the operations on the functions which produce another thing today (it acts only of  
count) are now available in order INFO\_FONCTION:*

*· MAX, RMS, NOCI\_SEISME, STANDARD and ECART\_TYPE.*

### **1.2.3 LIRE\_FORC\_MISS/LIRE\_IMPE\_MISS**

***LIRE\_IMPE\_MISS and LIRE\_FORC\_MISS make it possible respectively to create a generalized matrix and a generalized vector of seismic force starting from the matrix of impedance of ground or the forces seismic of ground created by MISS3D for a frequency of extraction given.***

#### ***1.2.4 POST\_MAIL\_XFEM/POST\_CHAM\_XFEM***

#### ***1.2.5 MAC\_MODES***

*This order makes it possible to calculate a criterion of orthogonality, the Modal Criterion Insurance, enters two modal bases (in general, experimental and a one calculated) (cf [8.1.14]).*

### ***1.3 Orders modified***

#### ***1.3.1 AFFE\_CARA\_ELEM***

***Removed CARA\_SECT:***

*· Mot-clé not used (cf [8.0.6]).*

***New RIGI\_PARASOL/GROUP\_MA\_POI1 and GROUP\_MA\_SEG2:***

*· Permettent to define a carpet of springs to model a displacement of foundation, one landslide and to apply boundary conditions in efforts (cf [8.0.17]).*

#### ***1.3.2 AFFE\_CHAR\_CINE and AFFE\_CHAR\_CINE\_F***

***AFFE\_CHAR\_CINE and AFFE\_CHAR\_CINE\_F are usable with STAT\_NON\_LINE and DYNA\_NON\_LINE.***

***GROUP\_MA, MESH new:***

*· Définition of the zones to be forced (cf [8.0.6]).*

#### ***1.3.3 AFFE\_CHAR\_MECA***

***CONTACT/new METHODE=' VERIF':***

*· Permet to check if there is or not matter interpenetration a posteriori without paying the overcost resolution with contact (cf [8.0.7]).*

***New CONTACT/SLIDE, ALARME\_JEU:***

*· Permet to carry out with the method of the active constraints the “sticking” contact, surfaces in opposite cannot fall apart, by emitting an alarm if the play becomes excessive (value defined by the user) (cf [8.0.7], [8.1.11]).*

**New CONTACT\_INIT:**

· *This key word makes it possible to do without artificial stiffnesses blocking the movements of body rigid (cf [8.0.8], [8.0.11]).*

**New CONTACT/COMPLIANCE:**

· *Introduction of a microphone-macro model for the interface of contact (effect of roughness to the microscopic scale) (cf [8.1.13]).*

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**New CHAMNO\_IMPO:**

· *Permet to take the contents of a CHAM\_NO like second member of the linear relation (cf [8.0.8]).*

**New ELIM\_MULT:**

· *If one wishes to bind several grids between them (key word LIAISON\_MAIL), one eliminate the redundant conditions now in order to avoid obtaining null pivots with moment of resolution (ELIM\_MULT='NON'). If in certain particular cases, one does not want not to eliminate these conditions, one can modify the default value (cf [8.0.3]).*

**New LIAISON\_CYCL:**

· *Application of cyclic condition of symmetry with dephasing (cf [8.0.8]).*

**Removed PRESSION\_CALCULE:**

· *EVOL\_CHAR makes the same thing and accepts other types of fields (cf [8.1.19]).*

### **Removed VERI\_DDL:**

- *The inexpensive checking is henceforth systematic (cf [8.1.19]).*

### **1.3.4 AFFE\_MATERIAU**

#### **New AFFE\_VARC:**

- *The variables of orders are now provided in AFFE\_MATERIAU and either in the operators of resolution DYNA\_NON\_LINE/STAT\_NON\_LINE (cf [8.1.4]).*

### **1.3.5 AFFE\_MODELE**

#### **New modelings PLAN\_ELDI, PLAN\_JOINT, AXIS\_ELDI, AXIS\_JOINT:**

- *XXX\_JOINT replaces to distinguish the elements JOINT from the elements with internal discontinuity ELDI (cf [8.0.18]).*

#### **New modelings:**

- *These modelings known as “selective” rest on a diagram of integration at the tops for the terms of the capacitive type, and at the points of Gauss for the terms of the diffusive type (cf [8.1.10]).*

### **1.3.6 CALC\_ELEM**

#### **Removed DURT\_ELGA\_TEMP:**

- *Calculations are now carried out with nodes (DURT\_ELNO\_TEMP) (cf [8.0.14]).*

### **1.3.7 CALC\_FATIGUE**

#### **New COEFF\_PREECROU:**

- *This parameter makes it possible to take into account a préécrouissage in the criteria of MATAKE, DANG\_VAN\_MODI\_AC/AV and DOMM\_MAXI (cf [8.0.3]).*

### **1.3.8 CREA\_MAILLAGE**

#### **New CREA\_FISS:**

- *Permet to generate meshes QUAD4 (to associate it finite elements discontinuity) with to start from groups of nodes (cf [8.0.13], [8.0.18]).*

#### **New QUAD\_LINE:**

- *Transformation of quadratic meshes into linear meshes (cf [8.0.13]).*

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### ***1.3.9 CALC\_FATIGUE***

***CRITERION = new "FATEMI\_SOCIE":***

***· Ajout of the criterion of Fatemi and Socie in elasticity and plasticity (cf [8.1.5]).***

### ***1.3.10 CALC\_FLUI\_STRU***

***New AMOR\_REDUIT\_CONN:***

***· Méthode of Connors for the analysis of the vibratory behavior of the tubes of Steam Generator (cf [8.1.1]).***

### ***1.3.11 CALC\_G\_LOCAL\_T/CALC\_G\_THETA\_T***

***OPTION = new "K\_G\_MODA":***

***· Calcul of the modal stress intensity factors (cf [8.1.17]).***

### ***1.3.12 CALC\_META***

***META\_INIT, META\_ELGA\_TEMP removed:***

***· Supposer that the families of points of integration are the same ones for metallurgical calculation and mechanical calculation was not very healthy. Calculations are now made with the nodes.***

***META\_INIT is thus replaced by META\_INIT\_ELNO and META\_ELGA\_TEMP is removed, META\_ELNO\_TEMP is calculated by defect (cf [8.0.14]).***

### ***1.3.13 CREA\_CHAMP***

***New EXTR/TABLE:***

***· Permet to create a field starting from data contained in a table (cf [8.1.17]).***

### ***1.3.14 BEGINNING/CONTINUATION***

**ERROR new:**

· Permet to raise a Python exception instead of stopping on the level of FORTRAN (useful only for particular macro-orders) (cf [8.1.20]).

**New IMPR\_MACRO:**

· Permet to choose the view of the orders launched by an macro-order which is now decontaminated by defect (cf [8.1.13]).

**New RESERVE\_CPU:**

· Permet to ensure itself to have a minimum of time for the last stages of calculation (closing of the base, transfer of the results) (cf [8.0.13]).

**1.3.15 DEFI\_BASE\_MODAL**

**New ORTHO\_BASE:**

· Permet réorthogonaliser a modal base obtained by concatenation of several bases, the colinéaires modes can be eliminated by EXTR\_MODES (cf [8.1.7]).

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**1.3.16 DEFI\_FISS\_XFEM**

**CONTACT, INTEGRATION new:**

· Modélisation of the contact on the lips of the crack with the method continues (cf [8.0.6]) and choice of the method of integration to the nodes on the facets of contact (cf [8.1.7]).

### ***New RAYON\_ENRI:***

- *Permet to define a ray delimiting the zone of enrichment of the nodes in bottom of crack (cf [8.1.19]).*

### ***New ALGO\_LAGR:***

- *Sélection of the algorithm of choice of the space of Lagranges for the contact with X-FEM (cf [8.1.19]).*

### ***1.3.17 DEFI\_FLUI\_STRU***

#### ***CSTE\_CONNORS, RHO\_TUBE, NB\_CONNORS new:***

- *Méthode of Connors for the analysis of the vibratory behavior of the tubes of Steam Generator (cf [8.1.1]).*

### ***1.3.18 DEFI\_GROUP***

#### ***New DETR\_GROUP\_MA/DETR\_GROUP\_NO:***

- *Permettent to destroy existing groups, one can if need be create groups of same names (cf [8.1.6]).*

### ***1.3.19 DEFI\_MATERIAU***

#### ***RUPT\_FRAG, RUPT\_FRAG\_FO new:***

- *Définition of the parameters of the law of Barenblatt (tenacity, critical stress and jump of displacement) function of the temperature (cf [8.0.1]).*

#### ***LEMAITE\_IRRA, LMARC\_IRRA, GRAN\_IRRA\_LOG replace GRAN\_IRRA, FLU\_IRRA:***

- *Définition of the parameters of the various laws which one found before under the name ASSE\_COMBU (cf [8.0.8]).*

#### ***New GATT\_MONERIE:***

- *Nouvelle law of élasto-viscoplastic thermomechanics of the fuel (cf [8.0.16]).*

#### ***New BETON\_REGLE\_PR:***

- *Lawful Loi of concrete known as “right-angled parabola” (cf [8.0.17]).*

#### ***New HOEK\_BROWN:***

- *Loi of behavior of Hoek-Brown modified for the rock mechanics analysis (cf [8.1.1]).*

#### ***CABLE modification:***

- *The elastic parameters must be provided under key word ELAS (cf [8.1.17]).*

### ***1.3.20 DYNA\_NON\_LINE***

*See STAT\_NON\_LINE.*

### ***1.3.21 EXTR\_MODES***

***New SEUIL\_X/\_Y/\_Z:***

***· Permet to select the modes on a directional criterion (cf [8.1.17]).***

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### **1.3.22 GENE\_MATR\_ALEA**

**New MATR\_MOYEN:**

- Permet to generate a random *macr\_elem\_dyna* starting from an average value (cf [8.1.8]).

### **1.3.23 IMPR\_GENE**

**FORMAT, UNIT moved:**

- Was before under the key word factor *GENE* (cf [8.0.21]).

### **1.3.24 IMPR\_RESU**

**PART new:**

- Permet selection the real or imaginary part during the impression of complex fields (cf [8.1.1]).

**GROUP\_MA, MESH, GROUP\_NO, NODE new:**

- Sélection of topological entities added for format *MED* (cf [8.1.13]).

### **1.3.25 LIRE\_RESU**

**New POSI\_AMOR:**

- With format *IDEAS (unv)*, makes it possible to recover reduced damping (cf [8.1.17]).

### **1.3.26 MACR\_CABRI\_MAIL**

**Removed FILE:**

- Was not used any more (cf [8.0.6]).

### **1.3.27 MACR\_LIGN\_COUPE**

**LIGNE\_COUPE/new VECT\_Y:**

- Permet to define a local reference mark for postprocessing (cf [8.1.6]).

### **1.3.28 MACR\_RECAL**

**GRAPH/new FORMAT:**

- Permet to produce the curves with the format Xmgrace or Gnuplot (cf [8.1.22]).

### **1.3.29 MECA\_STATIQUE**

**NUME\_COUCHE, NIVE\_COUCHE, ANGLE and PLAN removed:**

- These key words were used for the calculation of certain options which are not calculated any more by

**MECA\_STATIQUE but CALC\_ELEM/CALC\_NO (cf [8.0.5]).**

### **1.3.30 MODI\_MODELE\_XFEM**

**New CRITERION:**

- Permet to remove the ddl jump to avoid a bad conditioning of the matrix (cf [8.1.7]).

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### **1.3.31 POST\_K1\_K2\_K3**

### ***New SYME\_CHAR:***

- *Permet to take into account the symmetry of modeling in the calculation of the factors of intensity of constraint (cf [8.0.6]).*

### ***1.3.32 PROJ\_CHAMP***

#### ***New PROL\_ZERO:***

- *Permet to prolong the fields projected by zero where the initial field is not defined (cf [8.1.4]).*

### ***1.3.33 STAT\_NON\_LINE***

#### ***Removed VARI\_COMM:***

- *The variables of orders are provided in AFFE\_MATERIAU (cf [8.1.4]).*

#### ***New POSTING:***

- *Personnalisation of the posting of the table of convergence (cf [8.1.11]).*

### ***1.3.34 TEST\_FONCTION***

#### ***New VALE\_ABS:***

- *To test the absolute value of a result (cf [8.1.1]).*

### ***1.3.35 TEST\_RESU***

#### ***New RESU\_GENE:***

- *To test the concepts resu\_gene (cf [8.0.19]).*

#### ***New VALE\_ABS:***

- *To test the absolute value of a result (cf [8.1.1]).*

### ***1.3.36 TEST\_TABLE***

#### ***New VALE\_ABS:***

- *To test the absolute value of a result (cf [8.1.1]).*

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***Procedure HELPS***

***1 Goal***



*To print a documentation partial of Code\_Aster starting from its programming.*

*Currently, are available:*

.  
*the interrogation on the names of already defined concepts,*

.  
*the interrogation on the couples (type of elements, option) really available in the version used.*

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**2 Syntax**

**HELP**

**(**

**UNIT**

**= num,**

**[I]**

**I CONCEPT**

**=**

**\_F**  
(  
**NAME**  
=  
/  
'\*'  
,  
**[DEFECT]**  
/  
**lnom**  
,  
**[I\_K]**

**OPTION**  
=/"TO CREATE",  
/  
"A\_CREER",  
/  
"TOUT\_TYPE",  
**[DEFECT]**

),

**I TYPE\_ELEM = \_F (INITEL**  
=  
/

**“NOT”,  
[DEFECT]**

/

**“YES”,**

),

)

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***3 Operands***

***3.1 Word***

***key***

***UNIT***

***UNIT = num***

*Logical number of unit associated a file on which the impressions will be directed. One will defer to order **DEFI\_FICHER** [U4.12.03].*

### **3.2 Word**

*key*

**CONCEPT**

**I**

**CONCEPT =**

*Interrogation on the names of concepts and their type already created and present in the base of data “TOTAL” at a given moment of an execution or concepts which remain to be created or the unit.*

#### **3.2.1 Operand**

**NAME**

*NAME = list of the names of concepts requested*

.

*lnom list of names of concepts, whose one wishes information,*

.

*star “\*” to ask for the list of all the concepts (“\*” cannot be used in one list lnom).*

#### **3.2.2 Operand**

**OPTION**

*OPTION = option of edition of concept.*

**“TO CREATE”**

:

*one obtains the list of the concepts already created,*

**“A\_CREER”**

:

*one obtains the list of the concepts to be created,*

**“TOUT\_TYPE”**

*: to obtain the two preceding options simultaneously.*

### **3.3 Word**

*key*  
*TYPE\_ELEM*

*I TYPE\_ELEM*

=

*Impression of the whole of the couples (type\_element, option) available in the version used.*

### *3.3.1 Operand*

*INTEL*

*INTEL =*

*“YES”*

*: impression of the names of the objects created at the time of the initialization of all type\_element,*

*“NOT”*

*: nothing for this impression.*

*In both cases “YES”, “NOT”, one prints:*

.

*the number of options,*

.

*the number of type\_element,*

*a list of the form: phenomenon, modeling, type\_element, option, number of routine YOU (numero\_te), it gives all possible elementary calculations. If numéro\_te is worth -1, calculation is theoretically possible, but is not established.*

.

*a summary of type\_element: for each type\_element, one prints the number calculated options,*

.

*a summary of the options: for each option, one prints the number of type\_element who calculates it.*

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***4***  
***Phase of checking/execution***

***Phase of checking:***

***It is checked that the character “\*” does not appear in a list of names of orders.***

***Production run:***

***If the name of an order does not exist in the catalogues charged in the data bases, one message is produced.***

***5 Examples***

***5.1***  
***Use of the key word CONCEPT***

***Example 1***

***Command file***

***%***  
***-----***  
***BEGINNING (***  
***.....***  
***)***  
***%***  
***-----***

***MA***

=  
*LIRE\_MAILLAGE*  
(  
)  
*MO*  
=  
*AFFE\_MODELE*  
(  
.....  
)  
*CARELEM =*  
*AFFE\_CARA\_ELEM*  
(  
.....  
)  
*CH*  
=  
*AFFE\_CHAR\_MECA*  
(  
.....  
)  
*MELR*  
=  
*CALC\_MATR\_ELEM*  
(  
.....  
)  
*MELM*  
=  
*CALC\_MATR\_ELEM*  
(  
.....  
)  
*VECT*  
=  
*CALC\_VECT\_ELEM*  
(  
.....  
)  
*NUM*  
=  
*NUME\_DDL*  
(

```
.....  
)  
MATASSR =  
ASSE_MATRICE  
(  
.....  
)  
MATASSM =  
ASSE_MATRICE  
(  
.....  
)  
VECTASS =  
ASSE_VECTEUR  
(  
.....  
)  
%
```

---

```
HELP (CONCEPT = _F (NAME = ' * '),)  
%
```

---

```
FOMULT  
=  
DEFI_FONCTION  
  
( ..... )  
LIFREQ  
=  
DEFI_LIST_REEL  
(  
.....  
)  
MATRIGC =  
COMB_MATR_ASSE  
(  
.....  
)  
DH001  
=  
DYNA_LINE_HARM  
(
```



```
.....  
)  
IMPR_RESU  
(  
.....  
)  
MATRIGC =  
COMB_MATR_ASSE  
(  
.....  
)  
DH01  
=  
DYNA_LINE_HARM  
(  
.....  
)  
IMPR_RESU  
(  
.....  
)  
%
```

-----  
*HELP (CONCEPT = \_F (NAME = “\*”,),)*  
%

-----  
*END (*  
*)*  
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The first procedure HELPS produces following information:

-----  
<AIDE> <INFORMATION ON CONCEPTS EXISTANTS.>

<NO

CMDE> <CONCEPT. > <TYPE OF THE CONCEPT. > < A BE CREATES BY >

< 2> <MA >

<MAILLAGE\_SDASTER

>

<LIRE\_MAILLAGE

>

< 3> <MO >

<MODELE\_SDASTER >

<AFFE\_MODELE

>

< 4> <CARELEM > <CARA\_ELEM

> <AFFE\_CARA\_ELEM

>

< 5> <CH >

<CHARGE\_MECA

>

<AFFE\_CHAR\_MECA >

< 6> <MELR

> <MATR\_ELEM\_DEPL\_R > <CALC\_MATR\_ELEM

>

< 7> <MELM

> <MATR\_ELEM\_DEPL\_R > <CALC\_MATR\_ELEM

>

< 8> <VECT

> <VECT\_ELEM\_DEPL\_R > <CALC\_VECT\_ELEM

>

< 9> <NUM

> <NUME\_DDL

> <NUME\_DDL

>

< 10> <MATASSR > <MATR\_ASSE\_DEPL\_R > <ASSE\_MATRICE

>

< 11> <MATASSM > <MATR\_ASSE\_DEPL\_R > <ASSE\_MATRICE

>

< 12> <VECTASS > <CHAM\_NO\_DEPL\_R

> <ASSE\_VECTEUR

>

<AIDE> INFORMATION ON THE CONCEPTS HAVING TO BE CREATE.

<NO

CMDE> <CONCEPT

> <TYPE OF THE CONCEPT. > <SERA CREATES BY >

< 14> <FOMULT

> <FONCTION\_SDASTER > <DEFI\_FONCTION

>

< 15> <LIFREQ

> <LISTR8\_SDASTER

> <DEFI\_LIST\_REEL

>

< 16> <MATRIGC > <MATR\_ASSE\_DEPL\_C > <COMB\_MATR\_ASSE

>

< 17> <DH001

> <DYNA\_HARMO

>

<DYNA\_LINE\_HARM >

< 19> <MATRIGC > <MATR\_ASSE\_DEPL\_C > <COMB\_MATR\_ASSE

>

< 20> <DH01

> <DYNA\_HARMO

>

<DYNA\_LINE\_HARM >

-----

*The second procedure HELPS produces following information:*

-----

<AIDE> <INFORMATION ON CONCEPTS EXISTANTS.>

<NO

CMDE> <CONCEPT. > <TYPE OF THE CONCEPT. > < A BE CREATES BY >

< 2> <MA >

<MAILLAGE\_SDASTER

>

<LIRE\_MAILLAGE

>

< 3> <MO >

<MODELE\_SDASTER >

<AFFE\_MODELE

>

< 4> <CARELEM > <CARA\_ELEM

> <AFFE\_CARA\_ELEM

>

< 5> <CH >

<CHARGE\_MECA

>

<AFFE\_CHAR\_MECA >

< 6> <MELR  
> <MATR\_ELEM\_DEPL\_R > <CALC\_MATR\_ELEM  
>

< 7> <MELM  
> <MATR\_ELEM\_DEPL\_R > <CALC\_MATR\_ELEM  
>

< 8> <VECT  
> <VECT\_ELEM\_DEPL\_R > <CALC\_VECT\_ELEM  
>

< 9> <NUM  
> <NUME\_DDL  
>

> <NUME\_DDL  
>

< 10> <MATASSR > <MATR\_ASSE\_DEPL\_R > <ASSE\_MATRICE  
>

< 11> <MATASSM > <MATR\_ASSE\_DEPL\_R > <ASSE\_MATRICE  
>

< 12> <VECTASS > <CHAM\_NO\_DEPL\_R  
> <ASSE\_VECTEUR  
>

< 14> <FOMULT  
> <FONCTION\_SDASTER > <DEFI\_FONCTION  
>

< 15> <LIFREQ  
> <LISTR8\_SDASTER  
> <DEFI\_LIST\_REEL  
>

< 16> <MATRIGC > <MATR\_ASSE\_DEPL\_C > <COMB\_MATR\_ASSE  
>

< 17> <DH001  
> <DYNA\_HARMO

>

<DYNA\_LINE\_HARM >

< 19> <MATRIGC > <MATR\_ASSE\_DEPL\_C > <COMB\_MATR\_ASSE

>

< 20> <DH01

> <DYNA\_HARMO

>

<DYNA\_LINE\_HARM >

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***Titrate and subtitles of a produced concept***

***1 Goal***

***To define a title or a subtitle during the execution of an order Aster.***

***The title and under title when they are envisaged by the order are:***

***.  
that is to say defined by defect,***

***.  
that is to say composed by the user.***

***In this last case the user has a certain number of tools allowing him to compose sound titrate or its subtitle.***

***The title is attached to the structure of data produced by an operator.***

***The titles of the modified concepts are piled up.***

***The composition of a title is possible since the operator has a single-ended spanner word TITRATES.***

***The awaited argument is a list of texts (l\_Kn).***

***The text provided by the user is used just as it is; in particular, there is no implicit conversion tiny/capital.***

***The subtitle makes it possible to add comments at the time of an impression by a procedure.***

***The subtitle exists only the time of the procedure and thus must be reconstituted with each call to procedure, in particular if that Ci is re-used in CONTINUATION. It is thus not attached to a concept.***

***The composition of a subtitle is possible since the procedure has the single-ended spanner word SOUS\_TITRE (possibly under a key word factor). It is thus not attached to a concept.***

***The awaited argument is a list of texts (l\_Kn).***

***The text provided by the user is used just as it is; in particular, there is no implicit conversion tiny/capital.***



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***Author (S):***

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***:***

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***2***

***Composition of a title or a subtitle***

***2.1***

***tools***

***As we said, the user lays out of named tools “demons” allowing to integrate certain information with the title; these “demons” will seek corresponding information dynamically.***

***Examples of “demons”:***

***&date***

***return the date of execution,***

***&heure***

***return the hour of execution,***

***&RL***

***return information according to which it is necessary to go to the line in the composition title.***

***The complete list of the “demons” and their effects is provided in appendix.***

***Syntactic remark:***

.  
*the “demons” are preceded by the special character “&”,  
it is thus not recommended to use this special character in a title.*

*Simple example of title:*

*TITRATE = “My passage was carried out the &date with &heure”*

## 2.2

*Parameterized “demons”*

*The preceding examples of “demons” are known as simple or independent of the context, but there exists  
demons which are parameterized. Example:*

***&TYPE***

*return the type of a concept.*

*It is seen well that it is necessary to specify the name of the concept whose one wants to write the type:*

***&TYPE (my)***

*my*

*indicate a concept.*

*Action by defect:*

*If no argument is specified, one takes the concept produced by the operator like argument.*

## 2.3

*Titrate by defect*

*For any operator for whom the key word TITLE is planned, the default value is:*

***TITRATE =***

***(“ASTER &VERSION CONCEPT &RESULTAT”,***

***“CALCULATES &DATE A &HEURE OF THE &TYPE TYPE”***

***)***

*What gives for an operator who produces a concept named RIGIDITY and of type*

***MATR\_ASSE\_DEPL\_R:***

***ASTER 1.02.12 CONCEPT RIGIDITY CALCULATES THE 24/10/90 A 13:24: 51 OF TYPE  
MATR\_ASSE\_DEPL\_R***

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**2.4**

***Under title by defect***

*For any procedure for which key word SOUS\_TITRE is planned, the default value is:*

.

*for a CHAM\_GD*

*- for a CHAM\_NO*

**SOUS\_TITRE**

=

(

**'FIELD**

**WITH**

**NOEUDS'**

)

*- for a CHAM\_ELEM*

**SOUS\_TITRE = ("FIELD BY ELEMENT &LOC (cham\_elem)")**

*what gives for a procedure which publishes a concept named CHAM of the type CHAM\_ELEM\_SIGM\_R with values at the points of Gauss.*

*FIELD BY ELEMENT AT THE POINTS OF GAUSS*

.

*for a result*

*- for a CHAM\_NO*

*SOUS\_TITRE*

*=*

*('FIELD  
WITH  
NOEUDS',*

*'OF  
NAME  
SYMBOLIC SYSTEM  
&NOM\_SYMB (result, cham\_no) &RL',*

*'NUMBER  
D " ORDER*

*:*

*&NUME\_ORDRE (result,  
cham\_no) ',*

*'&ACCES (result,  
cham\_no)  
'*

*what gives for a procedure which publishes a concept named LMBO of the mode\_meca type of name symbolic system DEPL, of sequence number 2.*

*FIELD WITH THE NODES OF REFERENCE SYMBOL DEPL*

*SEQUENCE NUMBER: 2 NUMERO\_MODE: 3*

*FREQ: 5.52739E+00*

*- for a CHAM\_ELEM*

*SOUS\_TITRE= ("FIELD BY ELEMENT &LOC (cham\_elem)"*

*“OF NAME SYMBOLIQUE&NOM\_SYMB (result, cham\_elem) &RL”,  
“NUMBER D " ORDER: &NUME\_ORDRE (result, cham\_elem)”,  
“&ACCES (result, cham\_elem)”*

*what gives for a procedure which publishes a concept named LMBO of the evol\_elas type of name symbolic system EPSI\_ELNO\_LINE, of sequence number 1.*

*FIELD BY ELEMENT WITH THE NODES OF NAME SYMLBOLIQUE EPSI\_ELNO\_LINE*

*SEQUENCE NUMBER: 1 INST: 0.00000E+00*

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***Appendix 1 Definition of the “demons” usable***

***Name of the “demon”***

*(1)*

*(2)*

***Definition of the “demon”***

***&VERSION 0***

***ST***

***Number of the version of Aster***

***&DATE 0***

***ST***

*Creation date of the title or under title*

**&HEURE 0**

**ST**

*Hour of creation of the title or under title*

**&DATE\_HEURE 0**

**ST**

*Go back and hour to creation of the title or under title*

**&CODE 0**

**ST**

*Name of "code" of the passage (cf procedure BEGINNING)*

**&RESULTAT 0**

**T**

*Name of the concept produced by the current operator*

**&TYPE 1**

**ST**

*Type of a concept*

**&COMMANDE 0**

**ST**

*Name of the current order*

**&TITRE\_MAILLAGE 0 ST**

*Titrate associated with the grid read by LIRE\_MAILLAGE*

**&DIM\_GEOM 1**

**ST**

*Dimension of the geometry*

**&NB\_ELEM 1**

**ST**

*A number of elements*

**&NB\_NOEUD 1**

**ST**

*A number of nodes*

**&PHENOMENE 1**

**ST**

***Phenomenon***

***&NB\_EQUA 1***

***ST***

***A number of equations***

***&NOM\_SYMB 2***

***S***

***Reference symbol of a field of a result***

***&NUME\_ORDRE 2***

***S***

***Sequence number of a field of a result***

***&LOC 1***

***S***

***Localization of a cham\_elem (node, not of Gauss)***

***&ACCES 2***

***S***

***Reference symbols and values of the parameters of access to one field of a result***

***&RL***

***Return to the line***

***&VALEUR 1***

***ST***

***Value of variable of an unspecified type (scalar, text,...)***

***(1)***



***A number of arguments.***

***(2)***

***T applies to the title,***

***S applies to the subtitle,***

***ST applies to the title and the subtitle.***

***Note:***

*For the demons with two parameters: the first is the name of the concept result and the second nature of the field (cham\_no or cham\_lem) to treat.*

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***Appendix 2 Effects of the “demons”***

***The request***

***The result***

***Name of the “demon”***

***Numbers***

***Text Numbers***

***of***

***arguments \*v***

***characters***

***&VERSION 0***

**“01.02.09”**

8

**&DATE 0**

**“24/10/90”**

8

**&HEURE 0**

**“13: 24: 51”**

8

**&DATE\_HEURE 0**

**“MA-24-OCTO-90**

**13:24: 51 ”**

24

**&CODE 0**

**“SDLL01A”**

8

**&RESULTAT 0**

**“GRID”**

*variable 8*

**&TYPE 1**

**“MATR\_ASSE\_DEPL\_R”**

*variable 16*

**&COMMANDE 0**

**“LIRE\_MAILLAGE”**

*variable 16*

**&TITRE\_MAILLAGE**

0

*the title of the grid*

*N lines of 80*

**&DIM\_GEOM**

1

**“1D” or “2D” or “3D”**

2

**&NB\_ELEM 1**

**“123”**

*variable*

**&NB\_NOEUD 1**

**“1400”**

*variable*

**&PHENOMENE 1**

**“MECHANICAL”**

**variable 16**  
**&NB\_EQUA 1**  
**“5213”**  
**variable**

**&NOM\_SYMB 2**  
**“DEPL”**  
**variable 16**  
**&NUME\_ORDRE 2**  
**“12”**

**variable 16**  
**&LOC 1**  
**“WITH**  
**NODES " variable**  
**“AT THE POINTS OF GAUSS”**

**&ACCES**  
**2**  
**“NUMERO\_MODE:. FREQUENCY: .” variable**

**&RL**  
**0**  
**return to the line**  
**0**

**&VALEUR 1**  
**"356."**  
**variable**

**Note:**

**The doubles quotes are there only to mark the length of the chain.**

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***Organization (S): EDF-R & D /AMA***

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***Procedure BEGINNING***

## ***1 Goal***

***To allocate the resources memory, disc and files.***

***The execution consists of a whole of orders starting with BEGINNING and ending in END [U4.11.02], (see also the procedure CONTINUATION [U4.11.03]).***

***The order BEGINNING which is carried out, as of its reading by the Supervisor, carries out the tasks following:***

- .  
definition of the logical units of the files used in impression,***
- .  
definition of the characteristics of the data bases (managed by JEVEUX) and allowance of associated files,***
- .  
reading of the catalogues of the elements and the orders.***

***The apparently complex syntax of this procedure should not worry the user; its call with the operands by defect, sufficient in the majority of the cases, is: BEGINNING ()***

***The operands are to be used studies in the case of requiring a size of the files "bases of data " more important or to divert the various files on numbers of logical unit different from the numbers affected by defect.***

***The orders placed before BEGINNING, if they are syntactically correct, are ignored.***

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## ***2 Syntax***

### ***BEGINNING***

```
(  
PAR_LOT  
=  
/  
“YES”,  
[DEFECT]  
/  
“NOT”,  
IMPR_MACRO  
=  
/  
“NOT”,  
[DEFECT]  
/  
“YES”,
```

```
BASE = _F (FILE  
=  
/“TOTAL”,  
/  
“VOLATILE”,
```

```
/ |  
LONG_ENRE = lenr, [I]
```

/  
***NMAX\_ENRE = nenr, [I]***

/  
***LONG\_REPE = lrep, [I]***

),

***CODE***

=

***\_F***

(

***NAME***

=

***name***

***code,***



**[K8]**

**UNIT**

= / 15

,  
**[DEFECT]**

/ **unitd,**

**[I]**

**NIV\_PUB\_WEB =/"INTERNET",**

/  
**"Intranet"**

,

**VISU\_EFICAS**

=

/  
“**YES**”,  
[**DEFECT**]  
/  
“**NOT**”,

),

**IMPRESSION**

=  
**F (FILE**  
=  
**nomlocal**  
[**l\_Kn**]

**UNIT**

=  
**uniti**  
,  
[**l\_I**]

),

**ERROR = \_F (ERREUR\_F=**

/

**“ABORT”,**

**[DEFECT]**

/

**“EXCEPTION”,**

**DEBUG = \_F**

(

**JXVERI**

**=/“YES”,**

/

**“NOT”,**

**ENVIMA**

=

**“TEST”, [l\_Kn]**

**JEVEUX**

**=/“YES”,**

/

**“NOT”,**

),

**MEMORY**

=

**\_F (**  
**MANAGEMENT**

=

/

**“FAST”,**  
**[DEFECT]**

**/“COMPACTS”,**

**TYPE\_ALLOCATION =/ty,**

**[I]**

/

1,

**[DEFECT]**

***CUT***

=

***your,***

***[I]***

***PARTITION***

=

***Pa,***

***[R]***

***TAILLE\_BLOC***

=

/

***800.,***

***[DEFECT]***

/

***tbloc,***

***[R]***

),

**RESERVE\_CPU**

=

**\_F (**  
**/VALE**

=

**vale**

**[R]**

**/POURCENTAGE = pcent**

**[R]**

**LIMIT =/bv,**

**[R]**

/

**180.**

**[DEFECT]**

)

)

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**3 Operands**

**3.1 Operand**

**PAR\_LOT**

**PAR\_LOT**

**=**

**Mode of treatment of the orders:**

**“YES”:**

**(default option); the supervisor analyzes all the orders before in to ask the execution.**

**“NOT”:**

**after having analyzed an order the supervisor asks for his execution then passes to the analysis (and the execution) of the following order (treatment order by order).**

**3.2 Word**

**key**

**IMPR\_MACRO**

**IMPR\_MACRO**

=

*Authorize or not the postings produced by the macros in the file of message. Reading files of message can be painful when it contains the totality of the echoes of under orders generated by macro itself. By defect, only the echo of the orders explicitly called by the user in his command set will appear.*

### **3.3 Word**

*key*

**BASE**

**BASE**

=

*The functionality of this key word is to redefine the values of the parameters of the files direct accesses associated the “data bases” if one does not wish to use those fixed by defect.*

*Default values of the parameters associated with the data bases.*

**TOTAL**

**NMAX\_ENRE**

15728

**LONG\_ENRE**

100 K words

**LONG\_REPE**

2000

**BIRD**

**NMAX\_ENRE**

15728

**LONG\_ENRE**

100 K words

**LONG\_REPE**

2000

**LOCAL**

**NMAX\_ENRE**

512

**LONG\_ENRE**

100 K words

**LONG\_REPE**



2000

*The word is worth 8 bytes out of platform 64 bits under TRU64 and IRIX 64, 4 bytes on platform 32 bits under SOLARIS, HP-UX and WINDOWS-NT, LINUX.*

*Under TRU64, with the default values, the procedure BEGINNING will allocate a file of access direct of with more the 15728 recordings of 100 Kmots (K is worth 1024) for the base "TOTAL".*

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**Note:**

*The real size of the file is dynamic; it depends on the volume of information to store indeed. But this size is limited by the conditions of operating and one parameter preset among the values characterizing the platform. On the platform of reference TRU64 the maximum size is fixed at 12 Go. This value can be modified in placing an argument on the line of order of achievable behind the key word max\_base size where size is an actual value measured out of Mo.*

*On the platforms 32 bits, the maximum size is fixed at 2.047 Go (2 147.483.647), but the code manages several files to go beyond this limit when the parameter max\_base passed in argument.*

### **3.3.1 Operand**

#### **FILE**

**FILE**

=

*Reference symbol of the base considered.***3.3.2 Operands*****LONG\_ENRE/NMAX\_ENRE/LONG\_REPE****Definition of the parameters of the data base (files of direct access).*

/

/

***LONG\_ENRE***

=

***lenr****lenr is the length of the recordings in Kmots of the files of direct accesses used.***Note:***The manager of memory JEVEUX uses this parameter to determine two types of objects: the large objects which will be cut out in as much recordings that necessary, and the small objects which will be accumulated in a plug of the size of a recording before being discharged.*

/

***NMAX\_ENRE***

=

***nenr****nenr is the number of recordings per defect, this value is given with to start from LONG\_ENRE and an operating parameter on the platform of reference TRU64 fixed at 12 Go (12 884.901.888 bytes) for the maximum size of the file associated a data base, if this value were not modified by the use key word max\_base on the line of ordering of the achievable one.***Note:***Two operands LONG\_ENRE and NMAX\_ENRE must be used with precaution, a bad use which can lead to the brutal stop of program by saturation of the files of direct access. Coherence enters maximum size of the file and the value resulting from the product of both parameters LONG\_ENRE and NMAX\_ENRE is checked at the beginning of execution.*

/  
**LONG\_REPE**  
=  
*lrep*

*lrep is the initial length of the repertory (a maximum number of addressable objects by JEVEUX), it is managed dynamically by the manager of memory which extends size of the repertory and all the system objects progressively associated with needs.*

**Note:**

*The choice by the user to modify these various parameters, or to indicate a value behind the parameter max\_base determines in a final way certain characteristics of the TOTAL base which cannot be any more modified in CONTINUATION.*

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**3.4 Word**

**key**

**CODE**

**CODE**

=

*Definition of a name for the whole of a study.*

### **3.4.1 Operand**

#### **NAME**

*NAME = name codes*

*Name of identification of the study, this name is with more than 8 characters.*

### **3.4.2 Operand**

#### **UNIT**

*UNIT = unitc*

*Number of the logical unit positive, associated the “condensed” writing of the orders.*

*Default value UNIT = 15.*

#### **Note:**

*This possibility is in particular used by all the tests of validation to preserve an image of the orders used by each one of them [VI.02.00].*

*It is possible to give a name to its study, without starting the impression of orders by indicating UNIT = 0.*

### **3.4.3 Operand**

#### **NIV\_PUB\_WEB**

*NIV\_PUB\_WEB = “INTRANET”*

*Level gauge of publication. Meaning that the test is only diffusable on internal network.*

*NIV\_PUB\_WEB = “INTERNET”*

*Indicate that the test is diffusable just as it is on the external network.*

*VISU\_EFICAS = "YES"*

*Indicate that the command file can be open without problem with tool EFICAS. It key word is primarily used for the tests and at ends of receipt of the news poured tool.*

*VISU\_EFICAS = "NOT"*

*Announce the presence of python source in the command file not allowing sound edition with tool EFICAS.*

### **3.5 Word**

*key*

**IMPRESSION**

*IMPRESSION*

=

*Definition of the logical units of the files used in impression.*

#### **3.5.1 Operand**

**FILE**

*FILE*

=

*List reference symbols of files.*

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### **3.5.2 Operand UNIT**

*UNIT = uniti*

*Number of the logical unit associated the files of the list.*

*If uniti is negative or null, there is no impression on this (S) file (S).*

*By defect:*

#### **FILE UNIT**

*“ERROR” 9*

*“MESSAGE” 6*

*“RESULT” 8*

*“MED” 80*

*The definition of association file name, logical number of unit feeds the structure of data internal with the code which is generated by order DEF1\_FICHER [U4.12.03].*

### **3.6 Word**

*key*

#### **ERROR**

*ERROR =*

*Allows to recover an error of the <F> type to carry out a particular treatment, it mechanism was installed to check the emission of error message in the tests of not-regression of the code. It is also interesting to be able to recover the hand properly in some macros (Stanley or tools trades) without stopping brutally in fatal error.*

#### **3.6.1 Operand ERREUR\_F**

*ERREUR\_F*

*=*

*“ABORT” the behavior of the code is unchanged and the code stops by printing one*

*increase of error.*

*“EXCEPTION” one raises the exception aster.FatalError (code 20) and one returns to standard behavior in the event of error (“ABORT”)*

### **3.7 Word**

**key**

**DEBUG**

*DEBUG*

=

*Option of débogage (reserved for the developers and the maintenance of the code).*

#### **3.7.1 Operand**

**JXVERI**

*JXVERI*

=

*Allows to control the integrity of the segments of the memory between two executions of consecutive orders.*

*By defect the execution is carried out without “DEBUG”.*

#### **3.7.2 Operand**

**ENVIMA**

*ENVIMA = “TEST”*

*Allows to print in the file RESULT the values of the parameters preset in software package ENVIMA characterizing the machine [D5.01].*

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### **3.7.3 Operand**

#### **JEVEUX**

**JEVEUX**

=

*Allows to activate the operating mode in debug of the manager of memory*

*JEVEUX: unloadings on disc not differed and assignment from the segments values with an indefinite value [D6.02.01].*

### **3.8 Key word**

#### **MEMORY**

*Allows to modify the mode of management of the memory. During the allowance in memory of a segment values, it is possible is to carry out a search for place by causing unloadings on disc (MANAGEMENT = "COMPACTS"), which makes it possible to use less memory capacity but with*

*price of many accesses disc, is to seek in a priority way the free zones or correspondent with accesses in reading alone (MANAGEMENT = "FAST").*

#### **3.8.1 Operand**

##### **MANAGEMENT**

**MANAGEMENT =**

*"COMPACT": allows to activate the mode of most sparing memory allocation in total place.*



*“FAST”*: allows to activate the mode of memory allocation privileging a fast access.

### **3.8.2 Operand**

#### **TYPE\_ALLOCATION**

*TYPE\_ALLOCATION* = *ty*

- 1: standard management of memory, one does not distinguish the objects to be allocated,*
- 2: the systems objects of collection are allocated at the end of the zone memory in order to avoid to scatter the latter and to too much split the zones likely to accomodate the large one objects,*
- 3: even standard of allowance that previously, but applying to a criterion of size of objects,*
- 4: the zone memory is partitionnée into two, a zone is reserved for the allowance of small objects.*

### **3.8.3 Operand**

#### **CUT**

*CUT* = size in words (unit of addressing in entirety) defining the small objects used for one type of allowance 3 or 4.

### **3.8.4 Operand**

#### **PARTITION**

*PARTITION* = relationship between the size of the zone memory used for the allowance of the “large” objects and total zone.

*This zone is located at the end of the segmentation, the systems objects specific to JEVEUX are allocated in the partition reserved for the “small” objects.*

#### **Note:**

*If one of the partitions is saturated, one returns to a mode of standard management of the memory (TYPE\_ALLOC = 1).*

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Version

8.2

*Titrate:*

## *Procedure BEGINNING*

*Date:*

*31/01/06*

*Author (S):*

*Key J.P. LEFEBVRE*

*:*

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### **3.8.5 Operand**

#### **TAILLE\_BLOC**

*This key word, formerly placed under SOLVEUR in the total orders, is used to define cut blocks of the matrix.*

*TAILLE\_BLOC =*

*One can choose the size of the blocks of the matrix of rigidity (tbloc). This size is given in kiloR8 (1 kiloR8 = 1024 realities). This parameter influences the number of operations of input/output and thus over the time of assembly and resolution. By defect this value is fixed at 800 kiloR8, that is to say 8 recordings per defect on the file of direct access associated base JEVEUX.*

### **3.9 Key word**

#### **RESERVE\_CPU**

*Allows to reserve a share of the time CPU allotted to the job to finish the execution properly in case of stop for lack of time CPU detected by an order Aster. This mechanism is not useful that in the case of an execution batch of Code\_Aster. The value of this reserve can be indicated in absolute value or in the form of a percentage of total time CPU. This value is limited by the value of the key word LIMITS.*

#### **3.9.1 Operand**

##### **VALE**

*Value expressed in seconds withdrawn from the total time CPU, over which certain orders total bases itself to stop the execution properly.*

#### **3.9.2 Operand**

##### **PERCENTAGE**

*Percentage withdrawn from the total time CPU, over which certain total orders is based for to stop the execution properly.*

### **3.9.3 Operand LIMIT**

*Maximum value of the reserve of time, being worth by defect 180 seconds.*

### **4 Example of use**

*The standard use of this procedure is:*

**BEGINNING**

(  
)

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*Date:*

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**Key J.P. LEFEBVRE**

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*Organization (S): EDF-R & D /AMA*

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***Procedure END***

***1 Goal***

***To finish the work started by one of the orders “BEGINNING” or “CONTINUATION”.***

***The orders placed after END are ignored.***

***The call to this procedure is obligatory, which requires to finish any command file by:***

***END ()  
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Procedure END***

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**Author (S):**  
**Key J.P. LEFEBVRE**  
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## **2 Syntax**

**END**

(  
**FORMAT\_HDF**  
=  
/  
**“NOT”**  
,  
**[DEFECT]**  
/  
**“YES”**  
,

**UNIT**  
=  
/  
6,  
**[DEFECT]**  
/  
**numfic**  
,  
**[I]**

**RETASSAGE**  
=/**“YES”**

,  
/  
**“NOT”**  
,  
**[DEFECT]**

**PERFORMANCE**

=  
/  
**“YES”**  
,  
**[DEFECT]**  
/  
**“NOT”**  
,

**INFO\_RESU**

=  
/  
**“YES”**  
,  
**[DEFECT]**  
/  
**“NOT”**  
,

)  
**Instruction manual**  
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***Procedure END***

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### ***3 Operands***

#### ***3.1 Operand***

##### ***RETASSAGE***

##### ***RETASSAGE***

***= “YES”,***

***“NOT”,***

***[DEFECT]***

***Cause the retassage “TOTAL” base before writing on the associated file. This allows to preserve smaller bases (débarassées of the objects associated with the concepts destroyed by the user).***

***This retassage is carried out as follows by the order:***

***.***

***closing of the bases,***

***.***

***opening of the “TOTAL” base,***

***.***

***opening of a “VOLATILE” base,***

***.***

***recopy, nonempty recording by nonempty recording of the “TOTAL” base on the “VOLATILE” base,***

***.***

***renaming by the code of this “VOLATILE” base for safeguard as if it were base “TOTAL” traditional.***

#### ***3.2 Operand***

##### ***PERFORMANCE***

## **PERFORMANCE**

=

“YES”,  
[DEFECT]  
“NOT”,

*Cause the impression in the file **RESULT** of the values of time spent in each order: it is a summary of the values printed during calculation.*

### **3.3 Operand INFO\_RESU**

**INFO\_RESU**  
= “YES”,  
[DEFECT]  
“NOT”,

*Cause the impression in the file defined under the key word **FILE** of information relative to contained of the whole of the structures of data result stored in the **TOTAL** base.*

**Note:**

*The use of this key word can increase in a consequent way the execution time of order **FINE**, it is thus advised to modify the default value when one carries out calculations generating of important quantities of data by their diversity.*

### **3.4 Operand UNIT**

**UNIT**  
= *numfic*

*Allows to redefine the logical unit of impression of the information produced by **INFO\_RESU**.*

### **3.5 Operand FICHER\_HDF**

**FORMAT\_HDF** = “YES”

*Allows to write the **TOTAL** base in a file with format **HDF**. The base could then be rebuilt starting from objects **JEVEUX** stored in the file, this file can be created on a different platform (operating system, platform 32 or 64 bits). Characteristics original base will be read again in the file and the base rebuilt with identical (one for example the length of the recordings will preserve).*



*The user will be able to then read again either file HDF, or base JEVEUX.*

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#### **4 Phase of execution**

*Cause the closing of the data bases and stops the execution of the program on clayastr. It is detection of the messages transmitted by the order END which will cause, if necessary, the recopy of and all file data bases of results by the interface of access to Code\_Aster astk, thus that the emission of a first diagnosis on the passage.*

#### **5**

#### **Example of impression resulting from the order END**

*The example below is extracted from the file MESSAGE associated with the case test TTNL02A.*

```
# -----  
# ORDERS NO: 0026 CONCEPT OF THE TYPE:  
# -----  
END (RETASSAGE=' NON',  
INFO_RESU=' OUI',  
FORMAT_HDF=' NON',  
UNITE=6,
```

PERFORMANCE=' OUI',  
)

=====>

*STRUCTURE OF the CONCEPT TEMPLE CALCULATES FOR 15 SEQUENCE NUMBERS*

*LIST REFERENCE SYMBOLS:*

! -----!-----!-----!  
! NUME\_ORDRE! TEMP! HYDR\_ELGA!  
! ----- !-----!-----!  
! 0! TEMP\_R! HYDR\_R!  
! 1! TEMP\_R! !  
! ... ! ... !!  
! 9! TEMP\_R! !  
! 10! TEMP\_R! HYDR\_R!  
! 28! TEMP\_R! !  
! ... ! ... !!  
! 118! TEMP\_R! !  
! ----- !-----!-----!

*LIST NAMES OF VARIABLES Of ACCESS:  
INST OF THE TYPE R*

*LIST NAMES OF PARAMETERS:*

! -----!-----!-----!-----!-----!  
! NUME\_ORDRE! MODEL! CHAMPMAT! CARAELEM! EXCIT!  
! ----- !-----!-----!-----!-----!  
! 0! K8! K8! K8! K24!  
! 1! K8! K8! K8! K24!  
! ... ! ... ! ... ! ... ! ... !  
! 118! K8! K8! K8! K24!  
! ----- !-----!-----!-----!-----!....

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*Organization (S): EDF-R & D /AMA*

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*Procedure CONTINUATION*

*1 Goal*

*To continue a study starting from the safeguard with format JEVEUX or format HDF of its base “TOTAL”.*

*The apparently complex syntax of this procedure should not worry the user, the call with the operands by defect, is sufficient in the majority of the cases: CONTINUATION ()*

*The use of this order is completely similar to that of BEGINNING.*

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*2 Syntax*

*CONTINUATION*

*(  
PAR\_LOT*

*=*

*/*

*“YES”*

*,*

*[DEFECT]*

*/*

*“NOT”*

*,*

*IMPR\_MACRO*

*=*

*/*

*“NOT”,*

*[DEFECT]*

/

“YES”,

*BASE*

=

*\_F*

*(FILE*

=

*/“VOLATILE”,*

*/| LONG\_ENRE=*

*lenr,*

*[I]*

*/ NMAX\_ENRE=*

*nenr,*

*[I]*

*/ LONG\_REPE=  
lrep,  
[I]*

*),*

*CODE  
=  
\_F  
(  
NAME  
=  
name  
code,  
[K8]*

*UNIT  
= / 15  
,  
[DEFECT]*

/ *unitd*,  
[1]

*NIV\_PUB\_WEB* =/"INTERNET",  
/  
"Intranet"  
,

*VISU\_EFICAS*  
=  
/  
"YES",  
[DEFECT]  
/  
"NOT",

),

*IMPRESSION*

=

*F (FILE*

=

*nomlocal*

*[l\_Kn]*

*UNIT*

=

*uniti*

,

*[l\_I]*

),

*ERROR = \_F (ERREUR\_F =/"ABORT",*

*[DEFECT]*

/

*"EXCEPTION",*



*DEBUG = \_F (JXVERI*  
*=/"YES",*  
*/*  
*"NOT",*

*ENVIMA*  
*=*  
*"TEST", [l\_Kn]*

*JEVEUX*  
*=/"YES",*  
*/*  
*"NOT",*

*),*  
*MEMORY = \_F (MANAGEMENT*  
*=*  
*/*  
*"FAST",*  
*[DEFECT]*  
*/*  
*"COMPACTS",*

*TYPE\_ALLOCATION* =/ty,

[I]

/

1,

[DEFECT]

*CUT*

=

*your,*

[I]

*PARTITION*

=

*Pa,*

[R]

*TAILLE\_BLOC*

=

/

400.,

[DEFECT]

/

*tbloc,*

[R]

),

*RESERVE\_CPU*

=

*\_F (*

*/VALE = vale [R]*

*/PERCENTAGE = pcent*

[R]

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*LIMIT =/bv,*

*[R]*

*/*

*180.*

*[DEFECT]*

*)*

*FORMAT\_HDF*

*=*

*/*

*“NOT”,*

*[DEFECT]*

*/*

*“YES”,*

*)*

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**3**

### ***Principle of operation***

*This procedure affects, moreover, the resources memory necessary to the continuation of calculation.*

*The operands of the order are homologous with those of the procedure BEGINNING [U4.11.01]. They allow to specify certain resources assigned to the new execution.*

*The study carried out previously continues with a whole of orders starting with CONTINUATION and ending in END [U4.11.02].*

*Orders placed before CONTINUATION (except obviously BEGINNING) or after END, if they are syntactically correct, are ignored.*

*The procedure CONTINUATION which is carried out, as of its reading by the supervisor, carries out the tasks following:*

- *definition of the logical units of the files used in impression,*
- *allowance of the files associated with the data bases managed by JEVEUX,*
- *reading of the catalogues of orders but not of the catalogues of the elements which were*

*recopied on the basis of data during the first execution.*

*The operands are to be used to divert the various files on numbers of logical unit different from the numbers affected by defect or to adjust certain parameters of files.*

*The simple concepts of python (of variable type) created during a preceding execution are preserved in a file associated with base JEVEUX (pickle.1). during the execution of the procedure CONTINUATION these concepts are regenerated and can thus be used under the name under which they have summer created.*

## **4 Operands**

*The operand PAR\_LOT and words key IMPRESSION and DEBUG are identical to those of the procedure BEGINNING [U4.11.01].*

*The key word BASE is different for the procedure CONTINUATION.*

### **4.1 Operand PAR\_LOT**

*PAR\_LOT*

=

*Mode of treatment of the orders:*

*“YES”:*

*(default option); the supervisor analyzes **all the** orders before in to ask the execution.*

*“NOT”:*

*after having analyzed an order the supervisor asks for his execution then pass to the analysis (and the execution) of the following order (treatment order by order).*

### **4.2 Word**

*key*

*IMPR\_MACRO*

*IMPR\_MACRO*

=

*Authorize or not the postings produced by the macros in the file of message. Reading*

*files of message can be painful when it contains the totality of the echoes of under orders generated by macro itself. By defect, only the echo of the orders explicitly called by the user in his command set will appear.*

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### **4.3 Word**

**key**

**BASE**

BASE

=

*The functionality of this key word is to redefine the values of the parameters of the files of access direct associated the "data base" if one does not wish to use those fixed by defect.*

*In CONTINUATION mode, the various characteristics of the TOTAL base cannot be any more modified.*

*Default values of the parameters associated with the data bases*

**BIRD**

**NMAX\_ENRE 15728**

**LONG\_ENRE**

*100 K words*

**LONG\_REPE 2000**

**LOCAL**

**NMAX\_ENRE**

**512**

**LONG\_ENRE**

*100 K words*

**LONG\_REPE 2000**

*The word is worth 8 bytes out of platform 64 bits under TRU64 and IRIX 64, 4 bytes on platform*



*32 bits under SOLARIS, HP-UX and WINDOWS-NT, LINUX.*

*Under TRU64, the procedure CONTINUATION, with the default values, will allocate a file of access direct of with more the 15728 recordings of 100 Kmot (K is worth 1024) for the “VOLATILE” base.*

**Note:**

*The real size of the file is dynamic; it depends on the volume of information to store indeed. But this size is limited by the conditions of operating and one parameter preset among the values characterizing the platform. On the platform of reference TRU64 the maximum size is fixed at 12 Go. This value perhaps modified in placing an argument on the line of order of achievable behind the key word max\_base size where size is an actual value measured out of Mo.*

**4.3.1 Operand  
FILE**

*FILE*

=

*Only the parameters of the data bases “LOCAL” and “VOLATILE” can be redefined.*

**4.3.2 Operands**

***LONG\_ENRE/NMAX\_ENRE/LONG\_REPE***

*Definition of the parameters of the data base (files of direct access).*

/

|

*LONG\_ENRE*

=

*lenr*

*lenr is the length of the recordings in Kmots of the files of direct accesses used.*

**Note:**

*The manager of memory JEVEUX uses this parameter to determine two types of objects: the large objects which will be cut out in as much recordings that necessary, and the small objects which will be accumulated in a plug of the size of a recording before being discharged.*

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*NMAX\_ENRE*

=

*nenr*

*nenr is the number of recordings per defect, this value is given with to start from LONG\_ENRE and an operating parameter under IRIX 64 fixed at 12 Go (12 884.901.888 bytes) for the maximum size of the file associated with a base with data.*

**Note:**

*Two operands LONG\_ENRE and NMAX\_ENRE must be used with precaution, a bad use which can lead to the brutal stop of program by saturation of the files of direct access. Coherence enters maximum size of the file and the value resulting from the product of both parameters LONG\_ENRE and NMAX\_ENRE is checked at the beginning of execution.*

/

*LONG\_REPE*

=

*lrep*

*lrep is the initial length of the repertory (a maximum number of addressable objects by*

*JEVEUX*), it is managed dynamically by the manager of memory which extends size of the repertory and all the system objects progressively associated with needs.

#### **4.4 Word**

**key**

#### **IMPRESSION**

*IMPRESSION*

=

*Definition of the logical units of the files used in impression.*

#### **4.4.1 Operand**

#### **FILE**

*FILE*

=

*List reference symbols of files.*

#### **4.4.2 Operand**

#### **UNIT**

*UNIT = uniti*

*Number of the logical unit associated the files of the list.*

*If uniti is negative or null, there is no impression on this (S) file (S).*

*By defect:*

**FILE**

**UNIT**

“ERROR” 9

“MESSAGE” 6

“RESULT” 8

“MED” 80

*The definition of association file name, logical number of unit feeds the structure of data internal with the code which is generated by order `DEFI_FICHER` [U4.12.03].*

#### **4.5 Word**

**key**

#### **ERROR**

**ERROR =**

*Allows to recover an error of the <F> type to carry out a particular treatment, it mechanism was installed to check the emission of error message in the tests of not-regression of the code. It is also interesting to be able to recover properly hand in some macros (Stanley or tools trades) without stopping brutally in fatal error.*

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#### **4.5.1 Operand**

**ERREUR\_F**

**ERREUR\_F =**

*“ABORT” the behavior of the code is unchanged and the code stops by printing one increase of error.*

*“EXCEPTION” one raises the exception aster.FatalError (code 20) and one returns to standard behavior in the event of error (“ABORT”)*

#### **4.6 Word**

**key**

**DEBUG**

**DEBUG =**

*Option of débogage (reserved for the developers and the maintenance of the code).*

#### **4.6.1 Operand**

##### **JXVERI**

*JXVERI*

= “YES”

“NOT”

*Allows to control the integrity of the memory between two executions of orders consecutive. By defect the execution is carried out without “DEBUG”.*

#### **4.6.2 Operand**

##### **ENVIMA**

*ENVIMA = “TEST”*

*Allows to print in the file “RESULT” the values of the parameters preset in software package ENVIMA characterizing the machine [D5.01].*

#### **4.6.3 Operand**

##### **JEVEUX**

*JEVEUX = “YES”*

“NOT”

*Allows to activate the operating mode in debug of the manager of memory JEVEUX: unloadings on disc not differed and assignment from the segments of values to a value indefinite [D6.02.01].*

#### **4.7 Word**

*key*

##### **MEMORY**

*Allows to modify the mode of management of the memory. During the allowance in memory of a segment values, it is possible is to carry out a search for place by causing unloadings on disc (MANAGEMENT = "COMPACTS"), which makes it possible to use less memory capacity but with price of many accesses disc, is to seek in a priority way the free zones or correspondent with accesses in reading alone (MANAGEMENT = "FAST").*

#### **4.7.1 Operand MANAGEMENT**

*MANAGEMENT =*

*"COMPACTS"*

*:*

*allows to activate the mode of most sparing memory allocation in total place*

*"FAST": allows to activate the mode of memory allocation privileging a fast access*

#### **4.7.2 Operand TYPE\_ALLOCATION**

*TYPE\_ALLOCATION = ty*

- 1: standard management of memory, one does not distinguish the objects to be allocated,*
- 2: the systems objects of collection are allocated at the end of the zone memory in order to avoid to scatter the latter and to too much split the zones likely to accomodate the large one objects,*
- 3: even standard of allowance that previously, but applying to a criterion of size of objects,*
- 4: the zone memory is partitionnée into two, a zone is reserved for the allowance of small objects.*

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### **4.7.3 Operand CUT**

*CUT = size in words (unit of addressing in entirety) defining the small objects used for a type of allowance 3 or 4.*

### **4.7.4 Operand PARTITION**

*PARTITION = relationship between the size of the zone memory used for the allowance of the large objects and total zone.*

*This zone is located at the end of the segmentation, the systems objects specific to JEVEUX are allocated in the partition reserved for the “small” objects.*

#### **Note:**

*If one of the partitions is saturated, one returns to a mode of standard management of the memory (TYPE\_ALLOC = 1).*

### **4.7.5 Operand TAILLE\_BLOC**

*This key word, formerly placed under SOLVEUR in the total orders, is used to define cut blocks of the matrix.*

*TAILLE\_BLOC =*

*One can choose the size of the blocks of the matrix of rigidity (tbloc). This size is given in kiloR8 (1 kiloR8 = 1024 realities). This parameter influences the number of operations of input/output and thus over the time of assembly and resolution. By defect this value is fixed at 800 kiloR8, that is to say 8 recordings per defect on the file of direct access associated base JEVEUX.*

## **4.8 Key word**

### **RESERVE\_CPU**

*Allows to reserve a share of the time CPU allotted to the job to finish the execution properly in case of stop for lack of time CPU detected by an order Aster. This mechanism is not useful that in the case of an execution batch of Code\_Aster. The value of this reserve can be indicated in absolute value or in the form of a percentage of total time CPU. This value is limited by the value of the key word LIMITS.*

### **4.8.1 Operand**

#### **VALE**

*Value expressed in seconds withdrawn from the total time CPU, over which certain orders total bases itself to stop the execution properly.*

### **4.8.2 Operand**

#### **PERCENTAGE**

*Percentage withdrawn from the total time CPU, over which certain total orders is based for to stop the execution properly.*

### **4.8.3 Operand**

#### **LIMIT**

*Maximum value of the reserve of time, being worth by defect 180 seconds.*

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## **4.9 Word**

**key**

**FORMAT\_HDF**

*FORMAT\_HDF = "YES"*

*Allows to read again a TOTAL base safeguarded in a file with format HDF (cf orders END [U4.11.02]). The base is then rebuilt starting from objects JEVEUX stored in the file, this file can be built on a different platform (operating system, punt form 32 or 64 bits). The characteristics of the original base are read again in the file and the base is rebuilt with identical (one preserves for example the length of the recordings).*

*The file associated with the TOTAL base with format HDF is named bhdf.1 in the repertory of execution of the code.*

## **5 Example of use**

*The standard use of this procedure is:*

*CONTINUATION ()*

*To make an execution with a "VOLATILE" base with a record length of 400 Kmots:*

*CONTINUATION  
(BASE = \_F (FILE = "VOLATILE", LONG\_ENRE = 400),)*

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**Code\_Aster** ®

*Version*

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*Titrate:*

*Procedure CONTINUATION*

*Date:*

31/01/06

Author (S):

Key **J.P. LEFEBVRE**

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**Code\_Aster** ®

Version

8.2

Titrate:

Procedure *DEFI\_FICHER*

Date:

31/01/06

Author (S):

**J-P. Key LEFEBVRE**

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*Organization (S): EDF-R & D /AMA*

*Instruction manual*  
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*Document: U4.12.03*

*Procedure DEFI\_FICHER*

*1 Goal*

*To open or close a file associated with a number with logical unit. This number can be indicated in procedure or obtained in return of the latter. This action can be carried out constantly during work.*

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*Code\_Aster* ®

**Version**

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**Titrant:**

**Procedure *DEFI\_FICHER***

**Date:**

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**Author (S):**

**J-P. Key *LEFEBVRE***

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**2 Syntax**

***[nfic [whole] =] DEFI\_FICHER***

**(  
ACTION  
=  
/  
“TO ASSOCIATE”  
,  
[DEFECT]**

**/“TO RELEASE”,**

**/“TO RESERVE”,**

**FILE = nomfic,**  
**[K255]**

**UNIT = numul,**  
**[I]**

**TYPE =**  
**/**  
**“ASCII”,**  
**[DEFECT]**  
**/**  
**“BINARY”**

**,**  
**/**  
**“FREE”,**

**ACCESS**  
**=**  
**/**  
**“NEW”**  
**,**  
**[DEFECT]**  
**/**  
**“OLD”**

**,**  
**/**  
**“SUSPENDS”**  
**,**

**INFORMATION =/I,**

/ 2

,

)

*The obligatory or optional character of certain operands depends on the presence or the value associated previously well informed key words.*

*This operator has the characteristic to function at the same time like an order while providing a result of the whole type reusable behind a key word of a further order, is like one procedure.*

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*3 Operation*  
*of*  
*DEFI\_FICHER*

*The inputs/outputs on the ASCII files since Code\_Aster are carried out for the majority, with the assistance instructions FORTRAN using the concept of unit logical, it is a variable entirety from 1 to 99*

*associated*

*assistance of an instruction of the “open” type to a file. By defect this number xx is associated the name*

*fort.xx, but it is possible to associate it an unspecified file name. The logical number of unit is used in the interface of access to the code astk to recopy the exit and input files.*

*In the command file Aster various operators carrying out of the readings or the writings admit the key word UNIT like argument.*

*Several logical units are reserved by the code at the time of the phase of initialization, they are associated the following files, it is in general not allowed to modify them.*

*· 6 :*

*MESSAGE*

*· 8 :*

*RESULT*

*· 9 :*

*ERROR*

*· 80: MED*

*The key word IMPRESSION of the procedure BEGINNING [U4.11.01] or the procedure CONTINUATION [U4.11.03]*

*at the head command file can define associations between imposed names of files and their logical units FORTRAN.*

*The user can wish to add or modify associations using the procedure*

*DEFI\_FICHER to use for example new file names, to print some*

*results or to differently gather them in files. Procedure DEFI\_FICHER allows in*

*in addition to directly indicating the file of the ASCII type which will be associated the specified logical unit. It*

*can be specified either by a name in absolute (limited to 255 characters) if the file is localised on machine, is by a relative name in an agreed repertory (. /REPE\_IN or ./REPE\_OUT) when the interface takes care of the distant and total transfer of the whole of the files located under the repertory*

*(repe type in astk). OPEN named FORTRAN is then carried out on the files of the ASCII type. order makes it possible of more than position either file at the head, or at the end of the file.*

*The code manages in-house a structure of data gathering the unit of associations unit logic standard file name of file - type of access.*

## *4 Operands*

*The modifications of association unit logic-name of file relates to the output files and of entry.*

### *4.1 Operand*

## **ACTION**

### **ACTION = “TO ASSOCIATE”**

*The logical number of unit is associated, when that is allowed, the name defined behind the key word FILE if it is indicated, with the name fort.xx if not.*

*It is not possible to redefine associations of the logical numbers 6 and 9.*

### **ACTION = “TO RELEASE”**

*The logical number of unit is released, it is not more possible to use this number of unit, the file associated, when it is of ASCII type, is the subject of an order of closing using the instruction FORTRAN CLOSED. It then becomes possible to re-use the logical number of unit. This mechanism is*

*essential if one wants to be able D-to immediately exploit the contents of the associated file in command file in progress, indeed the buffers must be completely emptied and it file must be able to be accessible, possibly at the time of a call to a software since one order python of the os.system type.*

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### **ACTION = “TO RESERVE”**

*This type of action is used in the macros orders and makes it possible to avoid the conflicts of number of logical unit between FORTRAN and python.*

*The logical number of unit is associated, when that is allowed, the name defined behind the key word FILE if it is indicated, with the name fort.xx if not. There is no instruction of the OPEN type*



*carried out, with load for the macro order to carry out the various actions necessary.*

## **4.2 Operand FILE**

**FILE = nomfic**

*Physical name of the file (255 characters) which one wishes to associate a logical unit. This file will be created under the repertory of execution of the code, but one can indicate a name directly of file (respecting conventions UNIX) in the repertory of the user. Under the repertory of execution, it is possible to use an additional level of tree structure of name conventional REPE\_IN (data files) or REPE\_OUT (files of results) recognized by the interface of access to the code ask. This name must be placed between quotes. Although they are not associated a logical unit by an OPEN order FORTRAN, binary files (for example MED) can be treated with this mechanism, it is necessary nevertheless to specify the type of access NEW or OLD to activate the recopy (by a call system since the code) since the data directory or towards the repertory in result.*

*When the operand misses, it is by defect the file name fort.ul where ul is the number of unit which is associated the logical unit definite behind UNIT.*

*For the file of the ASCII type, an OPEN instruction FORTRAN is carried out on the name associated with the logical unit.*

## **4.3 Operand UNIT**

**UNIT = numul**

*Number of logical unit associated, its value for the ASCII file opened by instructions is ranging between 1 and 99 included.*

*It is possible to re-use an already affected number but in this case it is necessary to take the precaution*

*to release this last before. Certain numbers D `units logical cannot be redefined since the orders Aster, they are the numbers 6 and 9 which are respectively allocated with files MESSAGE, and ERROR.*

*This number can be used then in all the Aster orders which have the operand UNIT (IMPR\_RESU, IMPR\_TABLE, IMPR\_COURBE, etc).*

*The operand UNIT can sometimes be omitted, it is then the code which will choose to affect a number, according to the availabilities, it is then necessary imperatively to specify the operand FILE, the code*

*then in-house load to associate the logical number of unit and the associated file. It is then possible to recover a whole value at exit of the operator.*

#### **4.4 Operand TYPE**

**TYPE = "ASCII"**

*The file associated with the logical unit is of ASCII type.*

**TYPE = "BINARY"**

*The file associated with the logical unit is of binary type (not still used in the code).*

**TYPE = "FREE"**

*The file associated with the logical unit is of unspecified type within the meaning of FORTRAN, that allows*

*to manage in a more flexible way the access to the file, this type is primarily used for the access to files MED. The logical unit is not really used in this case, but that makes it possible to have convention of name fort.ul on the file and being able to easily transmit it through the interface access to the code.*

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#### **4.5 Operand ACCESS**

*Is used only in the case of the files of the ASCII type.*

*ACCESS = "NEW"*

*The file is opened and one positions at the head, a Fortan instruction of the type REWIND is carried out.*

*ACCESS = "OLD"*

*The file is opened and one positions just as it is.*

*ACCESS = "SUSPENDS"*

*The file is opened and one positions at the end of the file.*

#### **4.6 Operand INFORMATION**

*INFORMATION = inf*

*Allows to print in the file MESSAGE the list of the open logical units with order DEFI\_FICHER as well as the associated parameters. If INFORMATION = 1, it does not have there of impression.*

## 5

### ***Declaration in the interface of access to the code of the unit logic implemented in DEFI\_FICHIER***

*Generally the user will invite DEFI\_FICHIER in order to carry out postprocessings when it test the need to physically create several files of results according to the cases of loads, of the sizes, the steps or moments of evolution of calculation.*

*The user must declare the names physical of the files and the associated logical units. This declaration is carried out, in the interface ask before the launching of the completion of the work. It is necessary to add the files in the profile of study by selecting the **libr** type and to associate the number to them of logical unit selected.*

*The repe type is used in the interface ask to transmit or receive all the contents of one file directory, with load for the user to make call in the command file with DEFI\_FICHIER to carry out association with the logical number of unit. For convention the data files are transmitted in the repertory of nonroom REPE\_IN, them files in result are transmitted in the repertory of local name REPE\_OUT. In order DEFI\_FICHIER, the name placed behind FILE is form:  
./REPE\_IN/mon\_fichier.*

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*Titrate:*

*Procedure INCLUDE*

*Date:*

10/01/05

*Author (S):*

***C. Key DURAND***

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*Organization (S): EDF-R & D /AMA*

***Instruction manual  
U4.1- booklet: Management  
Document: U4.13.01***

***Procedure INCLUDE***

***1 Goal***

***Disconnection towards another file containing of the orders Aster. The return to the appealing file be carried out when the end of the file is met. The continuation of orders also can to disconnect itself towards another file.***

***It is a question of inserting a succession of orders, which will be read such as they are written. There is not***

***possibility of passing from the arguments, and thus any possibility of instantiation of variables.***

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***Code\_Aster ®***

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***Procedure INCLUDE***

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***C. Key DURAND***  
***:***  
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***2 Syntax***

***INCLUDE (***  
***UNIT***  
***=/U, [I]***

***INFORMATION =***  
***/***  
***1***  
***,***  
***[DEFECT]***

***/***  
***2,***

***)***  
***Instruction manual***

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Titrate:

Procedure **INCLUDE**

Date:

10/01/05

Author (S):

**C. Key DURAND**

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### **3 Operands**

#### **3.1 Operand**

**UNIT**

**UNIT = U**

**Logical unit towards which one wants to be disconnected. It is essential to affect it explicitly number with a file within the interface of access to Code\_Aster astk.**

#### **3.2 Operand**

**INFORMATION**

**INFORMATION**

=

/

1,

**[DEFECT]**

/

2,

1

**no impression of the contents of the file included.**

2



*impression of the contents of the file included, in the file "MESSAGE"*

*Note:*

*It is possible that the file called also contains procedures INCLUDE.  
The number of disconnections is limited to 20.*

*4 Example  
of use*

*.  
Main file of orders:*

*BEGINNING ()*

*INCLUDE (UNITE=91, INFORMATION = 2)*

*Mo =  
AFFE\_MODELE (GRID = my,*

*AFFE  
=  
\_F (TOUT=' OUI', PHENOMENE=' MECANIQUE',  
MODELISATION=' 3D')*

*)*

*INCLUDE (UNITE=92, INFO= 1)  
END ()*

*.  
Command file attached to unit 91*

*my = LIRE\_MAILLAGE ()*

*.  
Command file attached to unit 92*

***lbew = DEFI\_FONCTION***

***(NOM\_PARA = "INST",***

***VALE***

***=***

***(***

***0.0***

***,  
-0.19949,***

***0.01000,***

***-0.25487,***

***0.02000,***

***-0.30562,***

***0.03000,***

***-0.23882,***

***0.04000,***

***-0.20780,***

***0.05000,***

***-0.13345,***

***0.06000,***

***-0.03455,***

***0.07000,***

***0.07837,***

***0.08000,***

***0.18178,***

***#***

***Etc***

***...***

***)***

)  
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**Titrate:**  
**Procedure INCLUDE**

**Date:**  
**10/01/05**  
**Author (S):**  
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**This sequence produced on the file "MESSAGE" the following sequence:**

**LECTURE-ANALYSE OF THE ORDERS USERS**

```
BEGINNING ()  
INCLUDE (UNITE=91, INFO=2)  
Mo = AFFE_MODELE (MAILLAGE=ma,  
AFFE= _F (TOUT=' OUI', PHENOMENE=' MECANIQUE', MODELISATION=' 3D')  
)  
INCLUDE (UNITE=92, INFO=1)  
END ()  
...  
# -----  
# ORDERS NO: 0001 CONCEPT OF THE TYPE:  
# -----  
BEGINNING (PAR_LOT=' OUI',  
);
```

```
# -----  
# ORDERS NO: None CONCEPT OF the TYPE:  
# -----  
INCLUDE (UNITE=91,  
INFO=2,  
);  
  
# -----  
# ORDERS NO: 0002 CONCEPT OF THE TYPE: grid  
# -----  
MA=LIRE_MAILLAGE (FORMAT=' ASTER',  
...  
  
% FINE ORDERS: LIRE_MAILLAGE TOTAL DURATION: 0.02 S (SYST: 0.00 S)  
  
# -----  
# ORDERS NO: 0003 CONCEPT OF THE TYPE: model  
# -----  
mo=AFFE_MODELE (MAILLAGE=ma,  
...  
# -----  
# ORDERS NO: None CONCEPT OF the TYPE:  
# -----  
INCLUDE (UNITE=92,  
INFO=1,  
);  
  
# -----  
# ORDERS NO: 0004 CONCEPT OF THE TYPE: function  
# -----  
lbew=DEFI_FONCTION (NOM_PARA=' INST',  
...  
% FINE ORDERS: DEFI_FONCTION TOTAL DURATION: 0.02 S (SYST: 0.00 S)  
  
# -----  
# ORDERS NO: 0005 CONCEPT OF THE TYPE:  
# -----  
END (FICHER=' MESSAGE',  
INFO_RESU=' OUI',  
PERFORMANCE=' OUI',  
RETASSAGE=' NON',  
);
```

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***Titrate:***

***Operator INFO\_EXEC\_ASTER***

***Date:***

***19/01/05***

***Author (S):***

***Key J.P. LEFEBVRE***

***:***

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***Organization (S): EDF-R & D /AMA***

***Instruction manual***

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***Document: U4.13.04***

***Operator INFO\_EXEC\_ASTER***

## ***1 Goal***

***To create a table containing of information suitable for the execution in progress, consultable since command file.***

***This order, intended to grow rich, allows for the moment to recover time CPU remaining, it first number of logical unit free, the state of a logical number of unit or a file. Recovery time thus makes it possible to stop or leave a structure of control python conditionally.***

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## ***2 Syntax***

***count = INFO\_EXEC\_ASTER***

***(***

***LISTE\_INFO =/"CPU\_RESTANT"***

/  
“*UNITE\_LIBRE*”

/  
“*ETAT\_UNITE*”

/  
*UNIT*

=  
*num*  
*[I]*

/  
*FILE =*  
*name*  
*[TXM]*  
*TITRATE*

=  
*titrate*

,  
*[l\_TXM]*

*INFORMATION = 1,*

)  
  
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**Operator INFO\_EXEC\_ASTER**

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## **3 Operands**

### **3.1 Operand**

**LISTE\_INFO**

**LISTE\_INFO = "CPU\_RESTANT"**

*Allows to recover time CPU remaining during the execution: it is the difference between affected time during the tender batch of the study, or the value of the time CPU spent on the line of order for an interactive execution and the value of spent time CPU.*

**LISTE\_INFO = "UNITE\_LIBRE"**

*Return the first number of logical unit available (by descending order from 99) to moment of L`call. This value, recovered in a variable python, can then have passed in argument of an order Aster. The numbers of logical unit are managed from order DEFI\_FICHER [U4.12.03] and are deposited within a structure of data intern with the code which establishes the link between the files and the numbers of units.*

**LISTE\_INFO = "ETAT\_UNITE"**

*Turn over a table containing information "OPEN" or "FIRM" indicating the state of the unit logic or of the associated file.*

### **3.2 Operand**

**UNIT**

**UNIT = num**



***Logical number of unit which one wants to know the state:***

***“OPEN”***: a file uses this number

***“FIRM”***: no file uses this number

### ***3.3 Operand***

#### ***FILE***

***FILE = name***

***File name, such as defined in the order DEFI\_FICHER [U4.12.03] which one wants to know the state:***

***“OPEN”***: this name is associated a logical unit and is used

***“FIRM”***: this name is associated no logical unit and the associated file is regarded as closed

### ***3.4 Operand***

#### ***TITRATE***

***TITRATE = title***

***Affected title with the structure of data counts associated. For more details to see [U4.03.01].***

### ***3.5 Operand***

#### ***INFORMATION***

***INFORMATION = 1***

***Operand unutilised for the moment.***

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***Date:***

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#### **4 Remark**

*The accessible table since the command file python makes it possible to recover the value of time CPU remaining, which is a function of the orders carried out previously, but does not take account of time CPU spent in the processes called by EXEC\_LOGICIEL and of the calls system since python.*

#### **5 Example**

*# One carries out a loop from 1 to 10*

*for K in arranges (1,10):*

*#*

*# one calls one or more orders (AFFE\_CHAR\_MECA, STAT\_NON\_LINE, etc)*

*...*

*# one recovers time remaining in table TCPU*

*TCPU=INFO\_EXEC\_ASTER (LISTE\_INFO=' CPU\_RESTANT')*

*# one recovers the value of time in a variable python*

*valcpu=TCPU ["CPU\_RESTANT", 1]*

*# one tests this variable python, if it remains less than 5 S, one leaves buckle*

*yew valcpu < 5.0:*

*station-wagon*

*# one destroys the concept of the type counts, to be able the récréer with the following iteration.*

*TO DESTROY (CONCEPT= (\_F (NOM=TCPU),))*

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*Date:*

19/01/05

*Author (S):*

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*Organization (S): EDF-R & D /AMA*

***Instruction manual***

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***Document: U4.14.01***

***Operator TO DESTROY***

## ***1 Goal***

***To destroy concepts users or directly objects JEVEUX.***

***After destruction, the concept cannot thus be called upon naturally more behind a single-ended spanner word following orders.***

***The use of this procedure allows a later re-use of the names of the destroyed concepts. destruction of concepts (which results in the destruction of objects JEVEUX constituting the structures data) makes it possible to prepare a reduction of the obstruction of the files associated with the base "TOTAL". The mechanism of retassage is dealt with by the manager of memory to the course work. However, another mechanism of retassage can be started by the user with the assistance key word RETASSAGE = "YES" within the procedure END [U4.11.02].***

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## ***2 Syntax***

***TO DESTROY***

***(***

***/***

***CONCEPT = \_F (***

**NAME**

=

**lco**

,

**[l\_co]**

),

/

**OBJECT =**

-

**F (CHAINS = lco,**

**[l\_TXM]**

**POSITION = ipos,**

**[I]**

**CLASSIFY =/"G"**

**[DEFECT]**

/

**"V"**

/

**"It**

),

***INFORMATION =***

***/ 1***

,

***/ 2***

,

***ALARM***

***= /***

***“YES” [DEFECT]***

***/“NOT”***

)

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***Key J.P. LEFEBVRE***  
***:***  
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***3 Operands***

***3.1 Word***  
***key***  
***CONCEPT***

***CONCEPT***  
***=***

***Mean that one destroys concepts users.***

***3.1.1 Operand***  
***NAME***

***NAME = lco***

***List names of concept to be destroyed.***

***3.2 Word***  
***key***  
***CLASSIFY***

***CLASSIFY =***

***Allows to select the base on which the objects will be destroyed. By defect the value is “G”, it corresponds to the TOTAL base, “V” corresponds to the VOLATILE base, “at the LOCAL base.***

***3.3 Word***  
***key***  
***OBJECT***



## **OBJECT**

=

*Mean that one destroys objects JEVEUX while reaching directly by a chain of characters located at the position ipos contained in the names of the objects. This makes it possible to destroy objects stored in base JEVEUX and associated inaccessible names of concept.*

### **3.3.1 Operand CHAINS**

**CHAINS = lco**

*Character string presents in the names of objects JEVEUX to destroy.*

### **3.3.2 Operand POSITION**

**POSITION = ipos**

*Position of the character string in the names of objects JEVEUX to be destroyed.*

### **3.4 Operand INFORMATION**

**INFORMATION = information**

*If INFO=2, the list of the destroyed objects are printed in the file MESSAGE.*

**Important remark:**

*It is not possible to simply destroy the concept associated with a formula, the operator stops in fatal error when one tries to destroy such a concept.*

### **3.5 Operand ALARM**

**ALARM = "NOT"**

*Allows to decontaminate the emission of the messages of alarm, this functionality can be activated at the time use of the macro-orders when temporary objects are removed.*

*Instruction manual*

*U4.1- booklet: Management*

HT-66/05/004/A

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**Code\_Aster** ®

Version

7.4

Titrate:

Operator *TO DESTROY*

Date:

19/01/05

Author (S):

Key **J.P. LEFEBVRE**

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#### **4 Example**

*% One creates a list of realities of name F*

*F = DEFI\_LIST\_REEL (...)*

*% One destroys the concept of name F*

*TO DESTROY (CONCEPT = \_F (NAME = F,))*

*% One can re-use the name F for another concept*

*F = DEFI\_FONCTION*

*( ... )*

#### **5 Remarks**

*This procedure must be used with prudence, indeed certain structures of data (field with node-classification, field by element-model, etc...) the ones are based on the others, it is thus dangerous to destroy the associated concept.*

*When a concept is removed, its name is destroyed space of names python and the jeveux objects related (prefixed by the name of the concept) are destroyed in the total base.*

*During calculations with the loops with great iteration count (parametric study...), it can be very advantageous to destroy the concepts not employed again from one iteration to another in order to preserve the size of the total base.*

*Instruction manual  
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*Code\_Aster ®*

*Version*

*7.4*

*Titrate:*

*Procedure MAJ\_CATA*

*Date:*

*04/01/05*

*Author (S):*

*Key J.P. LEFEBVRE*

*:*

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*Organization (S): EDF-R & D /AMA*

*Instruction manual  
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Document: U4.15.01*

## ***Procedure MAJ\_CATA***

### ***1 Goal***

***Compilation of the catalogues of orders and elements (scripts UNIX ccat92-py and ccat-ele.csh).***

***It does not have interest for the user.***

***If necessary, one will be able to refer to the Instruction manual of the AGLA [D1.02.01].***

***Instruction manual***

***U4.1- booklet: Management***

***HT-66/05/004/A***

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***Version***

***7.4***

***Titrate:***

***Procedure MAJ\_CATA***

***Date:***

***04/01/05***

***Author (S):***

***Key J.P. LEFEBVRE***

***:***

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### ***2 Syntax***

***MAJ\_CATA (***

*ELEMENT = \_F ()*,

)  
*Instruction manual*  
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*HT-66/05/004/A*

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*Code\_Aster* ®

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*Procedure MAJ\_CATA*

*Date:*

*04/01/05*

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*Key J.P. LEFEBVRE*

*:*

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*3 Operands*

*3.1 Word*

*key*

*ELEMENT*

*This operand induces the compilation of the catalogue of the elements.*

*Note:*

*The management of the logical units by names in JEVEUX entrainé the suppression of simple key words under this key word factor. The syntax of call is thus of the form:*

*MAJ\_CATA (ELEMENT = \_F*

*()), )*

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***Titrate:***

***Operator LIRE\_MAILLAGE***

***Date:***

***08/02/05***

***Author (S):***

***J. Key PELLET***

***:***

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***Organization (S): EDF-R & D /AMA***

***Instruction manual***

***U4.2- booklet: Grid***

***Document: U4.21.01***

***Operator LIRE\_MAILLAGE***

## ***1 Goal***

***To create a grid by reading on a file. The file with reading must be with the format “ASTER” or the format “MED”. For other formats (IDEAS and GIBI), it is necessary to use the orders as a preliminary PRE\_IDEAS or PRE\_GIBI.***

***Product a structure of data of the grid type.***

***Important remark:***

***One can check the quality of the grid read while using (following LIRE\_MAILLAGE), order MACR\_INFO\_MAIL [U7.03.02].***

***Instruction manual***

***U4.2- booklet: Grid***

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***Code\_Aster ®***

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***Titrate:***

***Operator LIRE\_MAILLAGE***

***Date:***

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***Author (S):***

***J. Key PELLETT***

***:***

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## ***2 Syntax***



***my [grid] = LIRE\_MAILLAGE***

(  
***FORMAT***  
=  
/  
***“ASTER”***  
,  
***[DEFECT]***  
/  
***“MED”***  
,

***UNIT***  
=  
/  
20  
,  
***[DEFECT]***

***/I,***

**[I]**

**NOM\_MED =  
nomed**

,  
**[KN]**

**VERI\_MAIL  
= \_F  
(**

**FLAT TINT  
=/1.D-3, [DEFECT]  
/  
ap  
,  
[R]**

***VERIF =  
/“YES”, [DEFECT]***

***/“NOT”,***

***),***

***ABSC\_CURV = \_F  
(ALL =/“NOT”, [DEFECT]***

/“YES”,

),

**INFORMATION**

=

/

1

,

**[DEFECT]**

/2 ,

)

***Instruction manual***  
***U4.2- booklet: Grid***  
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**Code\_Aster** ®

Version

7.4

Titrate:

Operator *LIRE\_MAILLAGE*

Date:

08/02/05

Author (S):

**J. Key PELLET**

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### **3 Operands**

#### **3.1 Operand**

##### **FORMAT**

*This key word is used to specify the format of the file to reading. Today 2 formats are available: "ASTER" and "MED".*

*The format "ASTER" is described in [U3.01.00]*

*Format "MED" is described in [U7.01.21.]*

#### **3.2 Operand**

##### **UNIT**

**UNIT =**

**I**

*Logical number of unit of the file grid. Unit 20 per defect.*

#### **3.3 Operand**

##### **NOM\_MED**

**NOM\_MED = *nomed***

*For a file with format "MED", one can give the name of the grid under which the grid has there recorded summer. By defect, one will seek it under the name of concept to create (my)*

### **3.4 Operand VERI\_MAIL**

**Key word VERI\_MAIL starts 3 checks on the grid:**

- .  
absence of orphan nodes,**
- .  
absence of meshes “in double”,**
- .  
absence of too flattened meshes.**

**If these checks are not satisfied, the code emits an alarm.**

**By defect (i.e. in the absence of key word VERI\_MAIL), the checks are made. If the user wants to avoid these checks, it will write:**

**VERI\_MAIL = \_F (VERIF = “NOT”),**

**A node is declared orphan if it does not belong to the connectivity of any mesh.**

**A mesh is declared “in double”, if 2 meshes (or more) have connectivities formed consequently list nodes.**

**The key word FLAT TINT = ap makes it possible to emit alarms when the grid contains meshes too much flattened.**

**The flatness of a mesh is defined like the Amin/Amax report/ratio where Amin and Amax are them lengths of stop shortest and longest of the mesh. The name of the meshes of which flatness is lower than ap will be printed on the file “MESSAGE”.**

**Other quality standards for the grid are available via order MACR\_INFO\_MAIL [U7.03.02].**

### **3.5 Operand ABS\_CURV**

**ABS\_CURV = \_F (ALL = “YES”),**

**Calculate a curvilinear X-coordinate for the whole of meshes SEG2 of the grid. One associates each mesh the curvilinear X-coordinate of the first and the second node in the direction of course.**

**This option is necessary, for example, to carry out a modal calculation for a tube with fluid external and intern, when the density of the external fluid is defined according to**

*the curvilinear X-coordinate.*

*Instruction manual*

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*y*

*N2*

*N4*

*N6*

*N8*

*N10*

*N11*

*X Total reference mark*

*R*

*N9*

*N1*

*N3*

*N5*

*N7*

*L*

*All the meshes of the grid must be of type “SEG2”.*

*The mesh origin is the first mesh met, during the reading of the file grid, not having that a consecutive mesh (mesh N1 N3).*

*The final mesh is the last mesh met in the direction of course having only one*



*consecutive mesh (mesh N4 N2).*

*If there is more than one way between the first and the last mesh, calculation is impossible.*

*The curvilinear X-coordinate is defined as the sum of the right-hand sides connecting the nodes:*

*K*

*for K meshes: S*

*K =*

*xi - xi-1*

*i=2*

### **3.6 Operand**

#### **INFORMATION**

#### **INFORMATION**

*=*

*/1, [DEFECT]*

*/*

*2*

*,*

*Level of impression.*

*If: INFORMATION = 1*

*.*

*titrate grid,*

*.*

*a number of nodes,*

*.*

*a number of meshes,*

*.*

*a number of groups of nodes and for each one of them its name and the number of nodes of group*

*.*

*a number of groups of meshes and for each one of them its name and the number of meshes of group.*

*If: INFORMATION = 2 one prints in addition to information of INFORMATION = 1:*

*list nodes*

*number, name, coordinated,  
list meshes  
number, name, type, name of the nodes,  
list groups of nodes  
number, name, a number of nodes, names of the nodes,  
list groups of meshes  
number, name, a number of meshes, names of the meshes.*

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*Operator DEFI\_GROUP*

*Date:*

*31/01/06*

*Author (S):*

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*:*

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*Organization (S): EDF-R & D /AMA*

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## ***Operator DEF1\_GROUP***

### ***1 Goal***

***To define in an existing grid, new groups of nodes or meshes. This can facilitate definition of new loci for inputs or postprocessings.***

***To create new groups, one uses topological, logical or geometrical criteria.***

***Modify a structure of data of the grid type or skeleton.***

***Instruction manual***

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***Titrate:***

***Operator DEF1\_GROUP***

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### ***2 Syntax***

***my (grid) =***

**DEFI\_GROUP**

(

*reuse = my,*

**GRID**

*= my*

,

/

*[grid]*

/

*[skeleton]*

**/DETR\_GROUP\_MA = \_F (**

**NAME**

=

*lgma*

),

*[l\_group\_ma]*

**/DETR\_GROUP\_NO = \_F (**

**NAME**

=

*lgno*

),  
[l\_group\_no]

/CREA\_GROUP\_MA = (\_F (

NAME  
=  
gma  
,  
[identifier]

/MESH  
=  
lmail  
,  
[l\_maille]

/ALL = "YES",

/  
INTERSEC  
=  
lgma  
,  
[l\_group\_ma]

/  
**UNION**  
=  
**lgma**  
,  
**[l\_group\_ma]**

/  
**DIFFE**  
=  
**lgma**  
,  
**[l\_group\_ma]**

**/GROUP\_MA = gma**  
,  
**[group\_ma]**

**/NUME\_INIT**  
**=/nuini**  
**, [I]**  
/  
**1**  
,  
**[DEFECT]**

***NUME\_FIN***

=

***nufin***

,

***[I]***

***/POSITION =/"INIT",***

***/***

***"FINE"***

,

***/***

***"MEDIUM"***

,

***/OPTION***

***= "FACE\_NORMALE",***

***/ANGL\_NAUT = (,), [l\_R]***

***/VECT\_NORMALE= (X, y, Z), [l\_R]***

*ANGL\_PREC =/, [R]*

/  
0.5,  
*[DEFECT]*

*VERI\_SIGNE*  
=  
/“NOT”,

/  
“YES”  
,  
*[DEFECT]*



***/OPTION***  
***= "SPHERE"***

,

***/NOT = (X, y, Z),***

***[l\_R]***

***/***  
***NOEUD\_CENTRE***  
***=***  
***No,***  
***[node]***

***/GROUP\_NO\_CENTRE = grno, [group\_no]***

***RAY***  
=  
***R, [R]***

***/OPTION***  
**= “CYLINDER”**  
,

***/NOT = (X, y, Z),***

***[l\_R]***

***/***  
***NOEUD\_CENTRE***  
=  
***No,***  
***[node]***

***/GROUP\_NO\_CENTRE = grno, [group\_no]***

**RAY**  
=  
**R, [R]**

**/ANGL\_NAUT = (,), [l\_R]**

**/**  
**VECT\_NORMALE=**  
**(X,**  
**y,**  
**Z),**  
**[l\_R]**

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**8.2**

**Titrate:**  
**Operator DEFI\_GROUP**

**Date:**  
**31/01/06**  
**Author (S):**  
**J. Key PELLET**  
**:**  
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***/OPTION***  
***= "BAND"***  
***,***

***/NOT = (X, y, Z),***

***[l\_R]***

***/***  
***NOEUD\_CENTRE***  
***=***  
***No,***  
***[node]***

***/GROUP\_NO\_CENTRE = grno, [group\_no]***

***/ANGL\_NAUT = (,), [l\_R]***

***/VECT\_NORMALE = (X, y, Z),  
[l\_R]***

***DIST  
=  
D,  
[R]***

***/OPTION  
= "APPUI\_LACHE"  
,***

***/GROUP\_NO  
=  
l\_gno  
,  
[l\_group\_no]***

/  
**NODE**  
=  
**lno,**  
**[l\_noeud]**

),),

/  
**CREA\_GROUP\_NO**  
=  
**(\_F (**

/  
**NAME**  
=  
**gno**  
,  
**[identfier]**

**/NODE**  
=  
**lnoeu**  
,  
**[l\_noeud]**

***/INTERSEC = lgn, [l\_group\_no]***

***/***  
***UNION***  
***=***  
***lgn***  
***,***  
***[l\_group\_no]***

***/***  
***DIFFE***  
***=***  
***lgn***  
***,***  
***[l\_group\_no]***

***/GROUP\_NO = gno***  
***,***  
***[group\_no]***

**/NUME\_INIT**

**=/nuini**

**, [I]**

**/**

**1**

**,**

**[DEFECT]**

**NUME\_FIN**

**=**

**nufin**

**,**

**[I]**

**/POSITION =/"INIT"**

**,**

**/**

**"FINE"**

**,**

**/**

**"MEDIUM"**

**,**

**/**

**OPTION**

**=**

**"ENV\_SPHERE"**

**,**

**/NOT = (X, y, Z),**



**[L\_R]**

**/NOEUD\_CENTRE = No,**

**[node]**

**/GROUP\_NO\_CENTRE = grno, [group\_no]**

**RAY**

**=**

**R, [R]**

**PRECISION**

**=**

**eps**

**,**

**[R]**

/  
**OPTION**  
=  
“**ENV\_CYLINDRE**”  
,

**/NOT = (X, y, Z),**

**[l\_R]**

**/NOEUD\_CENTRE = No,**

**[node]**

**/GROUP\_NO\_CENTRE = grno, [group\_no]**

**RAY**

=

***R, [R]***

***/ANGL\_NAUT = (,***

***[l\_R]***

***/***

***VECT\_NORMALE= (X,***

***y,***

***Z),***

***[l\_R]***

***PRECISION = eps, [R]***

***/***

***OPTION***

***=***

***“PLANE”***

***,***

***/NOT = (X, y, Z),***

***[l\_R]***

*/NOEUD\_CENTRE = No,*

*[node]*

*/GROUP\_NO\_CENTRE = grno, [group\_no]*

*/ANGL\_NAUT = (,),*

*[l\_R]*

*/*

*VECT\_NORMALE= (X,*

*y,*

*Z),*

*[l\_R]*

*PRECISION = eps, [R]*

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## 8.2

***Titrate:***

***Operator DEFI\_GROUP***

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***J. Key PELLETT***

***:***

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***/***

***OPTION***

***=***

***“SEGM\_DROI\_ORDO”***

***,***

***/NODE = lno,***

***[l\_noeud]***

***/***

***GROUP\_NO***

***=***

***gno2***

***,***

***[group\_no]***

***/NOEUD\_ORIG = noA,***  
***[node]***  
***/***  
***GROUP\_NO\_ORIG=***  
***gnoA***  
***,***  
***[group\_no]***

***/NOEUD\_EXTR = noB,***  
***[node]***  
***/***  
***GROUP\_NO\_EXTR=***  
***gnoB***  
***,***  
***[group\_no]***

***PRECISION***  
***=***  
***prec,***  
***[R]***

***CRITERION =/"RELATIVE",***

***/“ABSOLUTE”,***

***/***  
***OPTION***

***=***  
***“NOEUD\_ORDO”***

***,***

***GROUP\_MA***

***= gmaAB***

***,***

***[group\_ma]***

***/NOEUD\_ORIG = noA,***

***[node]***

***/***

***GROUP\_NO\_ORIG=***

***gnoA***

***,***

***[group\_no]***

```
/NOEUD_EXTR = noB,  
[node]  
/  
GROUP_NO_EXTR=  
gnoB  
,  
[group_no]  
/  
OPTION  
=  
“TUNNEL”  
,
```

```
/ALL = “YES”
```

```
//  
GROUP_MA = lgma,  
[l_group_ma]
```



/  
**NET = lmai,**  
**[l\_maille]**

**/MAILLE\_AXE = noA,**  
**[l\_maille]**

/  
**GROUP\_MA\_AXE**  
**=**  
**gnoA**  
**,**  
**[l\_group\_ma]**

**/NOEUD\_ORIG = noA,**  
**[node]**

/  
**GROUP\_NO\_ORIG=**  
**gnoA**  
**,**  
**[group\_no]**

**RAY = R, [R]**

***LENGTH = long,***  
***[R]***

***/***  
***GROUP\_MA***

***=***  
***lgma,***  
***[l\_identificator]***

***NAME = lgno,***

***[l\_group\_no]***

***CRIT\_NOEUD =/"ALL",***

***[DEFECT]***  
***/***  
***"SUMMIT"***

***,***  
***/***  
***"MEDIUM"***

***,***  
***/***

**“CENTER”**

,  
  
/  
**TOUT\_GROUP\_MA**  
:  
**“YES”**  
,  
),

**ALARM**  
=  
/  
**“YES”,**  
**[DEFECT]**  
/  
**“NOT”,**

**INFORMATION =/1,**

**/ 2,**

)

**Type of the result:**

**If GRID: grid**

**then:**

**grid**

**:**

**skeleton**

**skeleton**

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**Titrate:**

**Operator DEFI\_GROUP**

**Date:**

**31/01/06**

**Author (S):**

**J. Key PELLET**

**:**

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**3 Operands**

**3.1**

**General information on the operands**

**This order in the same way treats the concepts of the grid type or skeleton. In continuation one will use the vocabulary “grid”.**

**This order makes it possible to define new groups of meshes (or groups of nodes) in one existing grid: one enriches the grid my.**

**The definition of a new group can be done in several ways:**

•  
*in extension: key words NETS or NODE,*

•  
*by Boolean operation on existing groups: intersection (INTERSEC), meeting (UNION) or difference (DIFFE),*

•  
*according to a geometrical criterion: meshes whose node belongs to a given sphere,...*

•  
*for the groups of nodes, by referring to existing groups of meshes.*

*group nodes thus definite contains all the nodes of the meshes of the group of meshes origin (key words TOUT\_GROUP\_MA and GROUP\_MA).*

*The operator treats initially key word CREA\_GROUP\_MA so that one can make use of the groups of meshes thus defined in key word CREA\_GROUP\_NO.*

*With each occurrence of a key word CREA\_GROUP\_MA (\_NO) one defines a new group named (word key NAME). This new group can then be re-used in the following occurrences to define new groups by intersection, meeting,...*

*Key words DETR\_GROUP\_MA and DETR\_GROUP\_NO make it possible “to destroy” groups of meshes or of nodes. The meshes and the nodes of these groups are not removed, they are only them definitions of the groups which are unobtrusive. These key words are useful for example in the loops python when one wants to create a group with each iteration of the loop: one starts by destroying this group then one recreates it under the same name. That avoids changing name of group with each iteration.*

### **3.2 Operand GRID**

*GRID = my*

*my is the name of the grid which one wants “to enrich”.*

### **3.3 Words**

*keys*

*DETR\_GROUP\_MA and DETR\_GROUP\_NO*

*These two key words factor make it possible to remove the definition of groups of meshes or nodes. These key words are sometimes necessary because the code stops in fatal error if one tries to create one*

*group whose name is already used. It is necessary to destroy the group before being able to re-use its name.*

*behavior of the two key words is similar and we will speak here only about DETR\_GROUP\_MA.*

**Syntax:**

**DETR\_GROUP\_MA=\_F (NOM= (gm1, gm2,...)),**

*The key word factor DETR\_GROUP\_MA is a priori répétable but it is never necessary because the word*

*key NAME makes it possible to indicate a list of names of groups to be destroyed (gm1, gm2,...).*

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*It is important to know that all the occurrences of key word DETR\_GROUP\_MA are treated front those of key word CREA\_GROUP\_NO because the objective of this key word is to be able to re-use the destroyed name. It*

*is also necessary to know that the destruction of a non-existent group does not involve any message of alarm.*

*These choices make it possible for example to make in a loop python:*

*for I in arranges (N):*

*DEFI\_GROUPE (reuse=MA, MAILLAGE=MA,*

*DETR\_GROUP\_MA=\_F (NAME ("GMI"),*

*CREA\_GROUP\_MA=\_F (NOM=' GMI',...*

*At the time of the first iteration, group "GMI" does not exist, one requires his destruction but any message of alarm is not transmitted.*

**Note:**

*As the destruction takes place at the beginning of the order, it is impossible to modify one group by calling only one upon `DEFI_GROUP`. For example, one cannot make “grow bigger” (in a loop) a group by adding a small group (b1) to him:*

*for I in arranges (N):*

*b1=nouveau group...*

*DEFI\_GROUP (reuse=MA, MAILLAGE=MA,*

*CREA\_GROUP\_MA=\_F (NOM=' tout', UNION= (“all”, “b1”),),)*

*To do that, `DEFI_GROUP` should be invited twice:*

*for I in arranges (N):*

*b1=nouveau group...*

*DEFI\_GROUP (reuse=MA, MAILLAGE=MA,*

*DETR\_GROUP\_MA=\_F (NOM=' tout2'),*

*CREA\_GROUP\_MA=\_F (NOM=' tout2', UNION= (“all”, “b1”),),)*

*DEFI\_GROUP (reuse=MA, MAILLAGE=MA,*

*DETR\_GROUP\_MA=\_F (NOM=' tout'),*

*CREA\_GROUP\_MA=\_F (NOM=' tout', UNION= (“tout2”, “b1”),),)*

### *3.4 Word*

*key*

*CREA\_GROUP\_MA*

*/CREA\_GROUP\_MA*

*An occurrence of this key word factor makes it possible to define a new group of meshes.*

#### *3.4.1 Operand*

*NAME*

*NAME = gma*

*One gives here the name (with “quotes”) of the new group of meshes.*

#### *3.4.2 Operand*

*NET*

*/MESH = lmail*

*This key word makes it possible to define the group of meshes in extension: the list of the meshes is given*

*the component.*

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*3.4.3 Operand*

*ALL*

*/ALL = "YES"*

*This key word makes it possible to define a group containing all the meshes of the grid.*

*3.4.4 Operand*

*INTERSEC*

*/INTERSEC = (gma1, gma2, gma3,...),*

*The new group of meshes will be obtained by taking all the meshes of gma1 which also belong to gma2, gma3,.... The order of the meshes remains that of gma1.*

*3.4.5 Operand*

*UNION*

*/*  
*UNION*  
*= (gma1, gma2, gma3,...)*



*The new group of meshes will be obtained by taking all the meshes of gma1, then in adding the meshes of gma2 which do not belong to gma1, then those of gma3 which belong neither to gma1 nor with gma2, etc*

### **3.4.6 Operand DIFFE**

*/DIFFE = (gma1, gma2, gma3,...)*

*The new group of meshes will be obtained by taking all the meshes of gma1 which do not belong to the other groups of the list. The order of the meshes remains that of gma1.*

### **3.4.7 Sub-group of an existing group : key words GROUP\_MA/POSITION/ NUME\_INIT/NUME\_FIN**

*One can create a new group of mesh by selecting certain meshes of an existing group.*

*1st possibility:*

*One creates a group of only one mesh by specifying by the key word POSITION the required mesh.*

*Example:*

```
CREA_GROUP_MA = _F (  
GROUP_MA = G1  
, POSITION = "INIT", NAME = G11)
```

*Group G11 contains the 1st mesh of the G1 group.*

*2nd possibility:*

*One creates a group containing the meshes ranging between the rows nuini and nufin (included) in one existing group.*

*Example:*

```
CREA_GROUP_MA=_F (GROUP_MA = G1, NUME_INIT = 3  
, NUME_FIN = 7,  
NAME =  
GIP)
```

*Group GIP contains meshes 3, 4, 5,..., 7 of G1.*

**Caution:**

*These key words use the concept of order of the meshes in a group of meshes. This order is often unknown to the user. He can depend on the preprocessor. It is the order of the meshes at the time definition of the GROUP\_MA in the file of grid Aster.*

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### *3.4.8 Operand*

*OPTION = "FACE\_NORMALE"*

*/OPTION = "FACE\_NORMALE"*

*This option makes it possible to define a GROUP\_MA made up of surface meshes of which the normal is parallel to the direction of the vector defined by its components if the key word is used VECT\_NORMALE or with that of the first vector of the new base defined by the change of reference mark due to the nautical angles.*

*In 3D, one supposes that the surface meshes are plane facets. They are of type TRIA3, TRIA6, QUAD4, QUAD8 or QUAD9. If one calls X1, X2, and X3 the vectors position of the first three nodes tops of the element, the normal is determined by the product vectorial:  $(X2 \ X1) \ (X3 \ X1)$ .*

*In 2D, one supposes that the surface meshes are right segments. They are of type SEG2 or SEG3. If one calls X1 and X2 the vectors position of the two nodes ends of the element, the normal is defined by  $(X2 \ X1) \ Z$  where Z is the perpendicular unit vector*

*in the plan and where one has affected 0. like third component with X2 X1.*

**Note:**

*A mesh “facet” will be retained if its normal is colinéaire with the normal vector defined by VECT\_NORMALE [§ 3.3.6.2]. This condition must be checked except for a certain precision (key word ANGL\_PREC [§ 3.3.6.3]).*

*When one chooses a ANGL\_PREC (for example 30. degrees), one defines in fact the group of meshes whose normal belongs to the cone of axis VECT\_NORMALE and point angle ANGL\_PREC.*

*This can be used (for example) to gather the meshes of a half wraps spherical (ANGL\_PREC = 90.).*

### **3.4.8.1 Operand**

**ANGL\_NAUT**

**/ANGL\_NAUT**

**=**

**in 2D**

**(,) in 3D**

*The nautical angles, defined in degrees, are the angles making it possible to pass from the reference mark*

*total of definition of the co-ordinates of the nodes to a reference mark whose first vector indicates the direction according to which the normal of the surface meshes is directed which one wishes to recover.*

*For the definition of the nautical angles, to see operator AFFE\_CARA\_ELEM [U4.42.01] operand ORIENTATION.*

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### **3.4.8.2 Operand**

***VECT\_NORMALE***

*/VECT\_NORMALE = (X, y)*

*in 2D*

*(X,*

*y,*

*Z)*

*in 3D*

*Co-ordinates X, y, Z are those giving the direction according to which is directed normal of the surface meshes which one wishes to recover.*

### **3.4.8.3 Operand**

***ANGL\_PREC***

*ANGL\_PREC*

=

*It is the tolerance, in degrees, that one accepts on the angle formed by the vector provided by the user and the normal vector with the surface element to affirm that these two vectors have even direction.*

*The default value of is 0.5 degree.*

### **3.4.8.4 Operand**

***VERI\_SIGNE***

**VERI\_SIGNE**

=

/“NOT”

,

/

“YES”

,

[DEFECT]

*If one assigns the value “NOT” to VERI\_SIGNE, the GROUP\_MA will be consisted of the meshes surface whose normal is parallel to the vector given by the user.*

*If one affects the value “YES”, the GROUP\_MA will be consisted of the surface meshes of which normal is parallel and with the same orientation as the vector given by the user.*

*The default value is “YES”.*

### **3.4.9 Operand**

**OPTION = “SPHERE”**

/OPTION = “SPHERE”

*This option makes it possible to define a GROUP\_MA made up of the meshes of which at least a node belongs to a sphere (a circle in 2D) defined by its centre and its.*

#### **3.4.9.1 Operand**

**NOT**

/NOT = (X, y)

*in 2D*

(X,

y,

Z)

*in 3D*

*X y Z are the co-ordinates of the center of the sphere.*

#### **3.4.9.2 Operand /NOEUD\_CENTRE /GROUP\_NO\_CENTRE**

**/NOEUD\_CENTRE**

= **No**

**/GROUP\_NO\_CENTRE = grno**

*These two key words make it possible to indicate which is the node coinciding with the center of sphere.*

### **3.4.9.3 Operand**

**RAY**

**RAY = R**

*R is the radius of the sphere (circle in 2D).*

### **3.4.10 Operand OPTION = "CYLINDER"**

**/OPTION = "CYLINDER"**

*This option makes it possible to define a GROUP\_MA made up of the meshes of which at least a node belongs to a cylinder defined by its axis and its ray.*

*The axis is defined by a vector and a point pertaining to this axis. This option does not have a direction that in 3D.*

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### **3.4.10.1 Operand NOT**

**/NOT = (X, y, Z)**

*X y Z are the punctual coordinates located on the axis of the cylinder.*

### **3.4.10.2 Operand /NOEUD\_CENTRE /GROUP\_NO\_CENTRE**

**/NOEUD\_CENTRE**

**= No**

**/GROUP\_NO\_CENTRE = grno**

*These two key words make it possible to indicate a node located on the axis of the cylinder.*

### **3.4.10.3 Operand RAY**

**RAY = R**

*R is the ray of the cylinder.*

### **3.4.10.4 Operand ANGL\_NAUT**

**/ANGL\_NAUT**

**= ( , )**

*The nautical angles, defined in degrees, are the angles making it possible to pass from the reference mark*

*total of definition of the co-ordinates of the nodes to a reference mark whose first vector indicates direction of the axis of the cylinder.*

*For the definition of the nautical angles to see operator AFFE\_CARA\_ELEM [U4.42.01] operand ORIENTATION.*

### **3.4.10.5 Operand VECT\_NORMALE**

**/VECT\_NORMALE = (X, y, Z)**

*X y Z are the co-ordinates of a vector directing the axis of the cylinder.*

### **3.4.11 Operand OPTION = "BAND"**

**/OPTION = "BAND"**

*This option makes it possible to define a GROUP\_MA made up of the meshes of which at least a node to a "band" defined by a plan "medium belongs" (a line in 2D) and the half-width of leaves and other of this plan.*

*The plan is defined by a normal vector in this plan and a point belonging to him.*

### **3.4.11.1 Operand NOT**

*/NOT = (X, y)*

*in 2D*

*(X,*

*y,*

*Z)*

*in 3D*

*X y Z are the punctual coordinates pertaining to the plan “medium” of the band.*

### **3.4.11.2 Operand/NOEUD\_CENTRE/GROUP\_NO\_CENTRE**

*/NOEUD\_CENTRE*

*= No*

*/GROUP\_NO\_CENTRE = grno*

*These two key words make it possible to define pertaining to the plan “medium” of the band.*

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### **3.4.11.3 Operand ANGL\_NAUT**



**/ANGL\_NAUT**

=

**in 2D**

**(,) in 3D**

**The nautical angles, defined in degrees, are the angles making it possible to pass from the reference mark**

**total of definition of the co-ordinates of the nodes to a reference mark whose first vector is orthogonal in the plan “medium” of the band.**

**For the definition of the nautical angles, to see operator AFFE\_CARA\_ELEM [U4.42.01] operand ORIENTATION.**

#### **3.4.11.4 Operand VECT\_NORMALE**

**/VECT\_NORMALE = (X, y)**

**in 2D**

**(X,**

**y,**

**Z)**

**in 3D**

**X y and Z are the components of a vector perpendicular to the plan “medium” of the band.**

#### **3.4.11.5 Operand DIST**

**DIST**

=

**D**

**D is the half-width of the band.**

#### **3.4.12 Operand OPTION = “APPUI\_LACHE”**

**/GROUP\_NO = l\_gno**

**/NODE**

**= l\_no**

**This option makes it possible to recover the group of the meshes of which one (at least) of the nodes**

*belongs to  
the whole of the nodes specified by key words **NODE** and **GROUP\_NO**.*

### **3.5 Word**

*key*

**CREA\_GROUP\_NO**

*/CREA\_GROUP\_NO*

*An occurrence of this key word factor makes it possible to define a new group of nodes (for key words **GROUP\_MA** and **TOUT\_GROUP\_MA**, one creates several groups of nodes “of a blow”).*

#### **3.5.1 Operand**

**NAME**

*/NAME = gno*

*One gives here the name (with “quotes”) of the new group of nodes.*

#### **3.5.2 Operand**

**NODE**

*/NODE = lnoeu*

*This key word makes it possible to define the group of nodes in extension: the list of the nodes is given the component.*

#### **3.5.3 Operand**

**INTERSEC**

*/INTERSEC = (gno1, gno2, gno3,...)*

*The new group of nodes will be obtained by taking all the nodes of gno1 which also belong to gno2, gno3,.... The order of the nodes remains that of gno1.*

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### ***3.5.4 Operand***

#### ***UNION***

***/UNION = (gno1, gno2, gno3,...)***

***The new group of nodes will be obtained by taking all the nodes of gno1, then in adding the nodes of gno2 which do not belong to gno1, then those of gno3 which belong neither to gno1 nor with gno2, etc***

### ***3.5.5 Operand***

#### ***DIFFE***

***/DIFFE = (gno1, gno2, gno3,...)***

***The new group of nodes will be obtained by taking all the nodes of gno1 which do not belong to the other groups of the list. The order of the nodes remains that of gno1.***

### ***3.5.6 Under group of an existing group***

***: key words GROUP\_NO/POSITION/  
NUME\_INIT/NUME\_FIN***

***One can create a new group of node by selecting certain nodes of an existing group.***

***1st possibility:***

***One creates a group of only one node by specifying by the key word POSITION the required node.***

***Example:***

***CREA\_GROUP\_NO = \_F (GROUP\_NO = G1  
, POSITION = "INIT", NAME = G11)***

*Group G11 contains the 1st node of the G1 group.*

*2nd possibility:*

*One creates a group containing the nodes ranging between the rows nuini and nufin (included) in one existing group.*

*Example:*

*CREA\_GROUP\_NO=\_F (GROUP\_NO = G1, NUME\_INIT = 3  
NUME\_FIN = 7, NAME = G1P)*

*Group G1P contains node 3, 4, 5,..., 7 of G1.*

*Caution:*

*These key words use the concept of order of the nodes in a group of nodes. This order is often unknown to the user. He can depend on the preprocessor. It is the order of the nodes at the time definition of the GROUP\_NO in the file of grid Aster.*

### *3.5.7 Operand*

*OPTION = "ENV\_SPHERE"*

*/OPTION = "ENV\_SPHERE"*

*This option makes it possible to define a GROUP\_NO made up of the nodes located on the envelope of a sphere except for a precision given.*

#### *3.5.7.1 Operand*

*NOT*

*/NOT = (X, y),*

*in 2D*

*(X,*

*y,*

*Z), in 3D*

*X y Z are the co-ordinates of the center of the sphere.*

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**3.5.7.2 Operand */NOEUD\_CENTRE /GROUP\_NO\_CENTRE***

***/NOEUD\_CENTRE***

**= *No***

***/GROUP\_NO\_CENTRE = grno***

***These two key words make it possible to define the node coinciding with the center of the sphere.***

**3.5.7.3 Operand**

***RAY***

***RAY***

**= *R***

***R is the ray of the sphere.***

**3.5.7.4 Operand**

***PRECISION***

***PRECISION***

**= *eps***

***eps is the tolerance with which one defines the membership of one node in the envelope of the sphere.***

***This tolerance is to be taken with the following direction:***

***if D is the distance from a node in the center of the sphere, it is said that this node belongs to the group***

***if:***

## ***D - R eps***

### ***3.5.8 Operand***

***OPTION = "ENV\_CYLINDRE"***

***/OPTION***

***=  
"ENV\_CYLINDRE"***

***This option makes it possible to define a GROUP\_NO made up of nodes located on the envelope of one roll except for a precision given.***

***This option has direction only in 3D.***

#### ***3.5.8.1 Operand***

***NOT***

***/NOT = (X, y, Z)***

***X y Z are the punctual coordinates pertaining to the axis of the cylinder.***

#### ***3.5.8.2 Operand /NOEUD\_CENTRE /GROUP\_NO\_CENTRE***

***/NOEUD\_CENTRE***

***= No***

***/GROUP\_NO\_CENTRE = grno***

***These two key words make it possible to define a node pertaining to the axis of the cylinder.***

#### ***3.5.8.3 Operand***

***RAY***

***RAY***

***= R***

***R is the ray of the cylinder.***

#### ***3.5.8.4 Operand***

***ANGL\_NAUT***

***/ANGL\_NAUT***

***= (, )***

*The nautical angles, defined in degrees, are the angles making it possible to pass from the reference mark  
total of definition of the co-ordinates of the nodes to a reference mark whose first vector indicates  
direction of the axis of the cylinder.*

*For the definition of the nautical angles, to see operator AFFE\_CARA\_ELEM [U4.42.01]  
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*3.5.8.5 Operand*

*VECT\_NORMALE*

*/VECT\_NORMALE = (X, y, Z)*

*X y Z are the co-ordinates of a vector directing the axis of the cylinder.*

*3.5.8.6 Operand*

*PRECISION*

*PRECISION*

*= eps*

*eps is the tolerance with which one defines the membership of one node in the cylinder clothing.*

*This tolerance is to be taken with the following direction:*

*if  $D$  indicates the distance from the point running to the axis of the cylinder, it is said that the point running belongs with the cylinder clothing if:*  
 *$D - R \text{ eps}$*

### **3.5.9 Operand** **OPTION = "PLANE"**

*This option makes it possible to define a GROUP\_NO made up of nodes located on a line (in 2D) or in a plan (in 3D) except for a precision given.*

#### **3.5.9.1 Operand** **NOT**

*/NOT = (X, y),  
in 2D*

*(X, y, Z),  
in 3D*

*X y Z are the punctual coordinates pertaining to the plan (with the right-hand side).*

#### **3.5.9.2 Operand /NOEUD\_CENTRE /GROUP\_NO\_CENTRE**

**/NOEUD\_CENTRE**

**= No**

**/GROUP\_NO\_CENTRE = grno**

*These 2 key words make it possible to define a node pertaining to the plan (with the right-hand side).*

#### **3.5.9.3 Operand** **ANGL\_NAUT**

**/ANGL\_NAUT**

**=**

**, in 2D**



*(,), in 3D*

*The nautical angles, defined in degrees, are the angles making it possible to pass from the reference mark*

*total of definition of the co-ordinates of the nodes to a reference mark whose first vector is orthogonal in the plan “medium” of the band.*

*For the definition of the nautical angles, to see operator AFFE\_CARA\_ELEM [U4.42.01] operand ORIENTATION.*

#### **3.5.9.4 Operand**

**VECT\_NORMALE**

*/VECT\_NORMALE = (X, y),*

*in 2D*

*(X,*

*y,*

*Z), in 3D*

*X y and Z are the components of a vector perpendicular to the plan (with the right-hand side).*

#### **3.5.9.5 Operand**

**PRECISION**

**PRECISION**

*= eps*

*eps is the tolerance with which one defines the membership of a node in the plan (or with the right-hand side).*

*This tolerance is to be taken with the following direction:*

*if D indicates the distance from the node in the plan (or the right-hand side), it is said that this node belongs to it*

*plan (or on this line) if:*

*D eps*

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### ***3.5.10 Operand OPTION = "SEGM\_DROI\_ORDO"***

***This option is used to order a whole of nodes roughly located on a segment of right-hand side AB.***

***/NODE =***

***lno2,***

***/***

***GROUP\_NO***

***=***

***gno2,***

***One defines the whole of the nodes which one wants to order.***

***/NOEUD\_ORIG =***

***noA***

***,/NOEUD\_EXTR =***

***noB,***

***/***

***GROUP\_NO\_ORIG***

***=***

***gnoA***

***,***

***/***

***GROUP\_NO\_EXTR***

***= gnoB,***

***One defines nodes A and B, origin and end of segment AB.***

***PRECISION***

**= prec,**  
**CRITERION =/“RELATIVE”,**

**/“ABSOLUTE”,**

*These two arguments are parapets, they are used to check that the nodes that one seek to order (lno2 or gno2) are well on segment AB. If the variation of a node with AB is higher than prec the code stops in fatal error.*

*If the selected criterion is “RELATIVE”, the distance from a node with AB will be divided by the length AB.*

### **3.5.11 Operand OPTION = “NOEUD\_ORDO”**

*This option is used to create an ordered group\_no containing the nodes of a whole of meshes formed segments (SEG2, SEG3 or SEG4). The whole of these meshes must form a continuous line, opened having two ends.*

**GROUP\_MA**  
**= gmaAB**

*Name of the group\_ma which one wants to order the nodes.  
The meshes of gmaAB must form an open line.*

**/NOEUD\_ORIG =**  
**noA**  
**,/NOEUD\_EXTR =**  
**noB**

**,**  
**/**  
**GROUP\_NO\_ORIG**  
**=**  
**gnoA**

**,**  
**/**  
**GROUP\_NO\_EXTR**  
**= gnoB,**

*The key words make it possible to define nodes A and B, origin and end of line AB.*

*Node A will be numbered in first, then one is useful oneself of the topology of the meshes of gmaAB for*

*to number the nodes gradually.*

*If node A is not provided by the user, the program will choose like node “origin”, the first node of gmaAB which belongs only to only one mesh segment. The origin is thus arbitrary: program could just as easily have fallen on the other end.*

*It is checked that the last numbered node is well B (if this one is given).*

### **3.5.12 Operand OPTION = “TUNNEL”**

*This option is used to create the formed group\_no of the nodes located inside a “tunnel” which one provides the axis and the ray. The nodes selected will be those whose distance to the axis is lower than the ray.*

*The axis of the “tunnel” is defined by the linear meshes provided via key words MAILLE\_AXE and GROUP\_MA\_AXE.*

*The axis of the tunnel must have a “origin” defined by key words NOEUD\_ORIG and GROUP\_NO\_ORIG.*

*The key word RAY is used to define the “ray” of the tunnel.*

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*One can limit the tunnel by giving his length by the key word LENGTH. This length is measured starting from the origin of the tunnel.*

*The nodes candidates to belong to the tunnel are those carried by the meshes defined by the words keys: TOUT=' OUI', GROUP\_MA and MESH.*

### **3.5.13 Operands GROUP\_MA and NAME**

*/GROUP\_MA = lgma*

*For each group of meshes of the list lgma, one creates a group of nodes formed of nodes carried by the meshes of this group of meshes.*

*NAME = lgn*

*If lgn is provided by the user, this list must be of the same length than lgma. It are the names which one wants to give to the new groups of nodes.*

*If lgn is not provided, the groups of nodes will bear the same names as them groups of meshes which gave them birth.*

**CRIT\_NOEUD**

*=  
/“ALL” [DEFECT]  
: all the nodes of each mesh are taken.*

*/“SUMMIT”: one takes only the nodes “top” of the meshes (i.e. them ends of stop).*

*/“MEDIUM”: one does not take that the nodes “medium” of stop meshes.*

*/“CENTER”: one takes only the nodes which are neither “top” nor “medium” i.e. nodes in the center of the facets or the elements voluminal.*

### **3.5.14 Operand TOUT\_GROUP\_MA**

*/TOUT\_GROUP\_MA = “YES”*

*This key word with the same significance as the precedent, except that one creates groups of nodes for all the existing groups of meshes of the grid.*

### **3.5.15 Operand ALARMS = “YES” [DEFECT]/“NOT”**

*if ALARM = “NOT”, the code does not emit alarm; for example when one asks him to create one GROUP\_NO and that this group is empty. The default value of this key word is “YES”.*

### **3.5.16 Operand INFORMATION**

*if INFORMATION = 1, one prints in the file “MESSAGE”, the number of groups create and for each group, the name of the group and the number of entities the component.*

*if INFORMATION = 2, one prints in the file “MESSAGE”, the number of groups create and for each group, the name of the group, the number of entities the component then the list of the entities constituting it or groups.*

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### **4 Examples**

*Example 1 (topological criteria and logics):*

*That is to say a my grid containing the groups of meshes already:*

*M1 m2 m3*

*and groups of nodes:*

***N1 N2 N3***

*my = DEFINI\_GROUP (reuse = my, GRID = my,*

*CREA\_GROUP\_MA = (\_F (NAME = NM1,  
NET = (MA7, MA9,...)*

*),  
\_F  
(  
NAME  
=  
NM2, UNION  
=  
(M1,  
NM1)  
)  
\_F  
(  
NAME  
=  
NM3, DIFFE  
=  
(NM2,  
M2)  
),),*

*CREA\_GROUP\_NO = \_F (TOUT\_GROUP\_MA = "YES"),*

*)*

*my = DEFINI\_GROUP (reuse = my, GRID = my,*

*CREA\_GROUP\_MA = \_F (NAME = NM4,  
NET = (MA7, MA11, MA13))*

$CREA\_GROUP\_NO = (_F (NAME = NN1,$   
 $INTERSEC = (NM1, N1)),$   
 $_F ($   
 $GROUP\_MA = NM4)))$

After these two calls to order *DEFI\_GROUP*, the grid contains then:

.

groups of meshes:

-  
 $M1, m2, m3$  (initial)

-  
 $NM1 =$  (meshs:  $MA7, MA9, \dots$ )

-  
 $NM2 = M1$  “union”  $NM1$

-  
 $Nm3 = NM2$  “minus”  $m2$

-  
 $NM4 =$  (MESHs:  $MA7, MA11, MA13$ )

.

groups of nodes:

-  
 $N1, N2, N3$  (initial)

-  
 $M1, m2, m3, NM1, NM2, Nm3$ : group\_no containing the nodes of the group\_ma of **same names**. These group\_no is created by 1st order *DEFI\_GROUP*.

-  
 $NN1 = NM1$  “intersection”  $N1$

-  
 $NM4 =$  (nodes of group\_ma  $NM4$ )

### **Example 2 (geometrical criteria):**

$my = DEFI\_GROUP$  (reuse =  $my$ ,  $GRID = my$ ,  
 $CREA\_GROUP\_MA =$   
 $(_F$   
 $(NAME = facesup, OPTION = “FACE\_NORMALE”,$

$VECT\_NORMALE$

=  
 $(0,$



0.,

1.)),

*\_F*  
(*NAME = S01*,  
*OPTION = "SPHERE"*,

*NOT = (0. , 0. , 0.), RAY = 1.),*

*CREA\_GROUP\_NO = (\_F (NAME = BO\_S01*  
*, OPTION = "ENV\_SPHERE"*,

*POINT= (0. , 0. , 0.), RAYON=1., PRECISION=0.01),*

*\_F*  
(  
*NAME*  
*=*  
*S01\_1*  
*, GROUP\_MA*  
*= S01),*

*\_F*  
(

*NAME*

=  
*S01\_2*  
, *OPTION* = "ENV\_SPHERE",

*POINT*= (0. , 0. , 0.), *RAYON*=0.5, *PRECISION*=0.5),),

)

*After DEFI\_GROUP the grid my will contain 2 new GROUP\_MA and 3 new GROUP\_NO:*

.

*facesup contains the facets whose normal is directed according to OZ (towards Z > 0),*

.

*S01 contains **all the** meshes of which **one of the nodes** belongs to the sphere of ray 1. and centered out of O (origin of the axes),*

.

*B0\_S01 is the group of the nodes which are in the vicinity of the envelope of the sphere the preceding one (S01),*

.

*S01\_1 is the group of all the nodes of the meshes of the group of S01 meshes; caution: certain nodes of this group can be outside the sphere!*

.

*S01\_2 is the group of the nodes included in the S01 sphere: D (M, O) - 0.5 0. 5*

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## ***1 Goal***

***To define a grid using macronutrients for calculations of static under-structuring.***

***This order makes it possible to define a new grid starting from macronutrients produced by operator MACR\_ELEM\_STAT [U4.62.01]. This new grid (containing only the supports geometrical of the macronutrients) can then “be assembled” with another grid (containing by example of the “traditional” meshes thanks to order ASSE\_MAILLAGE [U4.23.03] and the clean option with the under-structuring.***

***Product a structure of data of the grid type.***

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## ***2 Syntax***

***my (grid) = DEFI\_MAILLAGE (***

***DEFI\_MAILLE***

***=***

***(\_F***

***(***

**MACR\_ELEM\_STAT**

=

***l\_se***

,  
**[l\_macr\_elem\_stat]**

**NET**

=

***l\_mail***

,  
**[l\_maille]**

**/ TRAN**

=/(X, y), or (X, y, Z), [l\_R]

/

(0.,0.)

**or**

(0.,0.,0.),

**[DEFECT]**

**/ ANGL\_NAUT**

=/(), or (,),

**[l\_R]**

/

(0.),

**or**

**(0. , 0. , 0.), [DEFECT]**

**CENTER**

=/(px, py)

**or**

(px, py, pz),

**[l\_R]**

/

(0.,0.),

**or**

**(0.,0.,0.),**  
**[DEFECT]**  
**),),**

**/RECO\_GLOBAL =**  
**(\_F**  
**(**

**/ALL = “YES”**  
**,**

**/MESH**  
**=**  
**l\_maille**  
**,**  
**[l\_maille]**

**/CRITERION =/“ABSOLUTE”,**  
**/**  
**“RELATIVE”**

**,**  
**[DEFECT]**  
**/**  
**PRECISION**  
**=**  
**/**  
**prec**

**,**  
**[R]**  
**/**  
**1.D-3**  
**,**  
**[DEFECT]**

), ),  
/  
**RECO\_MAILLE**  
=  
(**\_F**  
(

**NET**  
=  
**l\_mail**  
,  
**[l\_maille]**

**GROUP\_NO**  
=  
**l\_gno**  
,  
**[l\_group\_no]**

**/OPTION**  
= **“GEOMETRICAL”**  
,  
**[DEFECT]**

**/ CRITERION =/“ABSOLUTE”,**  
**/**  
**“RELATIVE”**  
,  
**[DEFECT]**  
**/**  
**PRECISION**



=  
/  
**prec**  
,  
**[R]**  
/  
**1.D-3**  
,  
**[DEFECT]**  
/  
**OPTION**  
=  
**“NOEUD\_A\_NOEUD”**  
,  
/  
**OPTION**  
=  
**“OPPOSITE”**  
,  
,),

**DEFI\_NOEUD**  
=  
**\_F**  
(

**/ALL =**  
**“YES”,**

**PREFIXES**  
=  
**pref**  
,  
**[KN]**

## **INDEX**

=  
**(DM, Fm, dn, fn),**  
**[l\_I]**

/  
**NOEUD\_FIN**

=  
**no\_fin**  
,  
**[node]**

**NET =**  
**email,**

**[mesh]**

**NOEUD\_INIT**

=  
**no\_ini**  
,  
**[node]**  
,),

**DEFI\_GROUP\_NO = \_F (**

**//ALL =**  
**“YES”,**  
/  
**NET**  
=

*email*

,

*[mesh]*

***PREFIXES***

=

*pref*

,

*[KN]*

***INDEX =***

*(DM, Fm, dn, fn),*

*[l\_I]*

/

***GROUP\_NO\_FIN***

=

*gno\_fin,*

*[group\_no]*

***NET***

=

*email*

,

*[mesh]*

***GROUP\_NO\_INIT=***

*gno\_ini,*  
*[group\_no]*  
*),),*

)  
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### *3 General information*

*In the documentation of this order, one will speak about:*

- .*
- macronutrient: object of the macr\_elem\_stat type [U4.62.01],*
- .*
- super-mesh: geometrical entity supporting one macro\_élément,*
- .*
- initial grid when one indicates the grid which was used to generate a macronutrient,*

.  
**final** grid to indicate the grid produced by this order.

By extension these adjectives **initial/final** will apply to the entities attached to the grids: node, net, group of nodes.

Practically, to build the final grid:

.  
one defines super-meshes while positioning in the space (2D or 3D) of the macronutrients existing (same a `macr_elem_stat` can generate several super-meshes),

.  
one resticks the super-meshes between them,

.  
one re-elects, if it is wanted, certain nodes,

.  
one creates, if it is wanted, certain groups of nodes.

**Note:**

One can note that the grid created by this order is made only of super-meshes.

One thus cannot (for example), to draw it with the usual post-processors.

possibilities of curing it will be able to exist with order `DEFI_SQUELETTE` [U4.24.01].

To mix finite elements “traditional” and substructures, it is necessary to use the operator of “concatenation” of grids [U4.23.03]: `mag = ASSE_MAILLAGE ( MAILLAGE= (m1, m2))`

A grid resulting from operator `DEFI_MAILLAGE` contains:

.  
super-meshes,

.  
nodes,

.  
groups of nodes.

The super-meshes are defined by translation/rotation of macronutrients.

As a “traditional” mesh, a super-mesh is entirely defined by the list of its nodes.

coordinated nodes of the meshes are those of the external nodes of the macronutrients transforms by the geometrical transformation: translation, rotation...

If one does not carry out a sticking together (cf `RECO_GLOBAL/RECO_MAILLE`), the grid has as much of

*nodes that the sum of the nodes of the super-meshs.*

### ***CI convention:***

*When one “resticks” the super-meshs, one eliminates certain nodes. By convention, at the time of one elimination of coinciding nodes, one preserves the node (and thus its co-ordinates) which comes from first mesh of the list l\_mail (cf RECO\_GLOBAL/RECO\_MAILLE).*

*As in any grid Aster, the nodes **are named**. By defect, the names of the nodes are given by the program in the form: NOijklmn where ijklmn is a number ranging between 000001 and 999999.*

*Key words DEFI\_NOEUD and DEFI\_GROUP\_NO make it possible the user to re-elect certain nodes and to define groups of nodes.*

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## ***4 Operands***

### ***4.1 Word***

***key***

***DEFI\_MAILLE***

***DEFI\_MAILLE =***

***This key word factor makes it possible to define the super-meshs of the grid using macr\_elem\_stat.***

#### **4.1.1 Operand**

**MACR\_ELEM\_STAT**

**MACR\_ELEM\_STAT = l\_se**

*l\_se is the list of the names of the macronutrients which will generate the meshes.*

#### **4.1.2 Operand**

**NET**

**NET = l\_mail**

*l\_mail is the list of the names which one wants to give to the meshes. This argument is optional. In sound*

*absence, one will give to the meshes the names macronutrients (this is obviously impossible if one wants to use several times the same macronutrient).*

#### **4.1.3 Geometrical operands of transformations**

**/TRAN**

=

*This key word defines the translation to be applied to the macr\_elem\_stat:*

.

*if one is in 2D, one awaits 2 realities: (tx, ty),*

.

*if one is in 3D, one awaits 3 realities: (tx, ty, tz).*

**/ANGL\_NAUT**

=

**CENTER =**

*These key words define rotation to be applied to the macr\_elem\_stat.*

*If one is in 2D, one awaits 3 realities:*

.

*is the angle (in degrees) of rotation in the plan for ANGL\_NAUT,*

.

*px and py are the co-ordinates of the centre of rotation for CENTER.*

***If one is in 3D, one awaits 6 realities:***

.  
***, and are the nautical angles of rotation (in degrees). (Cf the operator  
AFFE\_CARA\_ELEM [U4.42.01]) for ANGL\_NAUT,***  
.

*px, py and pz are the co-ordinates of the centre of rotation for CENTER.*

***Important remark:***

*It is known that the key word order is not significant for Aster. The operation of  
translation/rotation is conventionally made in the order rotation **then**  
translation. These two operations do not commute in general.*

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***4.2 Word***

***key***

***RECO\_GLOBAL***

*/ RECO\_GLOBAL*

*=*

*/ALL = "YES",*



/MESH = l\_maille,

/ CRITERION =/"ABSOLUTE",

/  
"RELATIVE"

,  
[DEFECT]

/  
PRECISION

=  
/prec,

/  
1.D-3,  
[DEFECT]

*This key word makes it possible to restick a whole of super-meshs **automatically** (indicated by the key word NETS or the key word ALL) with a criterion of proximity geometrical: 2 nodes of 2 different super-meshs m1 and m2 will be confused if outdistance which separates them is:*

<  
prec

(CRITERION  
=  
"ABSOLUTE"),

<  
prec\*min (D (m1), D (m2))  
(CRITERION  
=

“RELATIVE”).

where  $D$  (semi) note the smallest distance between 2 nodes of the semi super-mesh.

**Note:**

Two nodes of the same mesh will never be restuck.

If a mesh contains one node, the CRITERION should be used = “ABSOLUTE”.

### 4.3 Word

key

**RECO\_MAILLE**

RECO\_MAILLE

=

This key word factor makes it possible to restick “**with the hand**” certain super-meshes indicated by the user. The super-meshes which one can restick are those which were defined by the key word **DEFI\_MAILLE**. On then resticks the super-meshes via groups of nodes. To say what one wants to restick it is thus necessary to give couples (mesh, group of nodes (of the initial grid)).

**Note:**

When one gives a couple (mesh, group of nodes), one indicates the list of the nodes of group nodes which are external for the **macr\_elem\_stat** which defines the super-mesh. It is in fact the intersection of the group of nodes and the edge of the substructure. This list is ordinate as the initial group of nodes.

In theory, when one resticks 2 meshes via 2 groups of nodes, the whole of the nodes indicated must restick itself (cf the convention chosen by the key word **OPTION**). A message of alarm will be emitted if it is not the case.

#### 4.3.1 Operands

**NET/GROUP\_NO**

NET

=

One gives the list of the meshes here to be restuck. In general, one resticks meshes 2 by 2.

For the “corners”, it can be pleasant to restick all the convergent meshes in only once (for example the 4 super-cubic ones which divides the same edge).

GROUP\_NO

=

*One gives here the list of the groups of nodes to be restuck. This list is of the same length than list meshes.*

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### **4.3.2 Operand**

#### **OPTION**

*OPTION*

*=*

*This word makes it possible to choose the convention of sticking together of the lists of nodes defined by groups of nodes.*

*.*

**“GEOMETRICAL”:**

*The program will confuse the nodes by considerations of geometrical proximity.*

*(Cf key word: RECO\_GLOBAL)*

*.*

**“OPPOSITE” “NOEUD\_A\_NOEUD”/:**

*That is to say:  $G1 = \{A1, B1,\}$*

*C1*

*$G2 = \{A2, B2,$*

```
}  
C2  
G3 = {A3, B3,  
}  
C3
```

If *OPTION* = “*NOEUD\_A\_NOEUD*”, *GROUP\_NO* = (*G1*, *G2*, *G3*)

*one will restick:*

*A1 with*  
*A2 with*  
*A3*  
*B1 with*  
*B2 with*  
*B3*  
*C1 with C2 with C3*

If *OPTION* = “*OPPOSITE*”

,  
*GROUP\_NO* = (*G1*, *G2*, *G3*)

*one will restick: C1 with A2 with A3*

*B1 with*  
*B2 with*  
*B3*  
*A1 with C2 with C3*

***Caution:***

*For “OPPOSITE” option, only the first group of nodes of the list of the GROUP\_NO is “turned over”.*

***4.4 Word***

***key***  
***DEFI\_NOEUD***

***DEFI\_NOEUD***

***=***

*This key word factor makes it possible to re-elect whole or part of the nodes of the grid.*

## **4.4.1 Operands**

### **ALL/PREFIX/INDEX**

/  
*ALL* = "YES",

= *pref* *PREFIXES*,

*INDEX* = (*DM*, *Fm*, *dn*, *fn*),

*These key words make it possible to re-elect all the nodes of the grid. The convention of renaming is as follows (in pseudo FORTRAN):*

*no\_fin* (*K8*) = *pref//no\_mail* (*DM: Fm*) *//no\_ini* (*dn: fn*)

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*What wants to say that the name of a node will be formed while concaténant:*

.

*the prefix possibly given by the user,*

.

*under-chains of characters extracted the name of the mesh which carries this node (cf CI convention of elimination of the nodes stated above [§ 3]). One takes the characters of row ranging between DM and Fm. If DM > Fm, this*

*under-chains is empty,*

.

*under-chains of characters extracted the name of the node (in its grid initial). One takes the characters of row ranging between  $dn$  and  $fn$ . If  $dn > fn$ , this under-chain is empty.*

*It is necessary thus that:  $ltot = \text{length}(\text{prefix}) + (Fm-dm+1) + (fn-dn+1) 8$*

*It is pointed out that 2 nodes cannot have the same name in the same grid. The goal “play” for the user is to manage to re-elect certain nodes (without too many efforts of its share) in a conventional way without this convention leading to names identical.*

*A frequent case is as follows:*

*if the grids which gave rise to the macronutrients come from one preprocessor which generates names of nodes of the  $NOijklmn$  form and if the user gives to his super-meshs names with 2 characters: SA, SB,.... the sequence:*

*DEFI\_NOEUD = \_F (TOUT= “YES”, INDEX= (1, 2, 3, 8,))*

*will generate nodes of names: SA000001, SA000002,... , SB000001,*

#### **4.4.2 Operands**

**NOEUD\_FIN/MESH/NOEUD\_INIT**

/

**NOEUD\_FIN**

= *no\_fin*,

**NET**

=

*email*,

**NOEUD\_INIT**

=

*no\_ini*,

*These key words make it possible to re-elect nodes **one by one**:*

.

*no\_fin is the name which one wants to give to the node grid that one creates*

*(final).*

*email and no\_ini identify the node to be re-elected: email is the name of super-mesh which carries the node, no\_ini is the name of the node in the grid who was used to create the macr\_elem\_stat which defined the super-mesh email.*

#### **4.5 Word**

**key**

**DEFI\_GROUP\_NO**

*DEFI\_GROUP\_NO*

=

*This paragraph is almost identical to precedent (DEFI\_NOEUD) by replacing word NOEUD\_ by word GROUP\_NO.*

*This key word factor makes it possible to define groups of nodes starting from groups existing in initial grids of the macronutrients.*

#### **Note:**

*An initial group of nodes can contain nodes which do not belong to the edges of macronutrients. These internal nodes thus do not exist in the final grid. By convenience, one takes convention nevertheless to create the group reduced to its intersection with the edge of the macronutrient.*

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*Date:*

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*Author (S):*

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### 4.5.1 Operands

#### *ALL/MESH/PREFIX/INDEX*

/  
/ALL = "YES",

/MESH = email,

= pref PREFIXES,

INDEX = (DM, Fm, dn, fn),

*These key words make it possible to create all the groups of nodes corresponding to groups of the initial grid associated the mesh email or all the meshes if:*

TOUT= "YES".

*The convention of renaming is as follows (in pseudo FORTRAN):*

*gno\_fin (k8) = pref//no\_mail (DM: Fm) //gno\_ini (dn: fn)*

*What wants to say that the name of a group of nodes will be formed while concaténant:*

.  
*the prefix possibly given by the user,*

.  
*under-chains of characters extracted the name of the mesh,*

.  
*under-chains of characters extracted the name of the group\_no of the initial grid.*

*It is necessary thus that:*

*ltot= length (prefix) + (Fm-dm+1) + (fn-dn+1) 8*

*A frequent case is as follows*

*: the grids which gave rise to*

*macronutrients come from a preprocessor which generates names of the form*

*GRNOijkl. If the user gives to his super-meshes names with 2 characters: SA,*

*SB,...., the sequence:*

*DEFI\_GROUP\_NO=\_F (TOUT= "YES", PREFIXE=' GN', INDEX= (1,2,5,8))*



*Will generate groups of nodes of names:*

*GNSA0001, GNSA0002,... , GNSB0001.*

#### **4.5.2 Operands**

**GROUP\_NO\_FIN/MESH/GROUP\_NO\_INIT**

/  
*GROUP\_NO\_FIN = gno\_fin,*

*NET = email,*

*GROUP\_NO\_INIT  
= gno\_ini,*

*These key words make it possible to create groups of nodes **one by one**:*

- 
- gno\_fin is the name which one wants to give to the GROUP\_NO,*
- 
- email and gno\_ini identify the initial GROUP\_NO:*
- 
- email is the name of the super-mesh which carries the GROUP\_NO,*
- 
- gno\_ini is the name of the GROUP\_NO of the initial grid.*

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**5 Example**

***That is to say the grid m1:***

***N9***  
***N8***  
***N7***  
***E***  
***D***  
***N10***  
***N6***  
***grma1***  
***N5 N19***  
***N18***  
***F***  
***N11***  
***N17***  
***C***  
***N4***  
***grma2***  
***N12***  
***N16***  
***N15***  
***N1***  
***N2***  
***N3***  
***N13***  
***N14***  
***With***  
***B***  
***G***  
***3***

***GROUP\_NO***  
***: GROUP\_MA***  
***:***

***AB***  
***=***

*(N1*  
*N2*  
*N3)*  
*grma1*  
*BC*  
*=*  
*(N3*  
*N4*  
*N5)*  
*grma2*

*CD = .....*  
*.....*

*On this grid m1 one defines 2 macr\_elem\_stat.*

*mo1 = AFFE\_MODELE*  
*(AFFE = \_F (GROUP\_MA = grma1)...)*   
*mo2 = AFFE\_MODELE*  
*(AFFE = \_F (GROUP\_MA = grma2)...)*

*S1 =*  
*MACR\_ELEM\_STAT*  
*(DEFINITION = \_F (MODEL = mo1...)*

*OUTSIDE*

*=*  
*\_F*  
*(GROUP\_NO*  
*=*  
*(AB, BC, CD, OF, EA))*

*...)*  
*S2 =*  
*MACR\_ELEM\_STAT*  
*(DEFINITION = \_F (MODEL = mo2...)*

*OUTSIDE*

*=*  
*\_F*  
*(GROUP\_NO*  
*=*  
*(BC, BG, FG, CF))*

...)

**One can then define the grid m2:**

**S1**

**S2**

**S3**

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**m2 =**

**DEFI\_MAILLAGE**

**(**

**DEFI\_MAILLE = (\_F (MACR\_ELEM\_STAT = S1),**

**\_F**

**(MACR\_ELEM\_STAT = S2**

**, MESH = S2,),**

**\_F**

**(MACR\_ELEM\_STAT = S2**

**, MESH = S3, TRAN = 3.),),**

**RECO\_MAILLE= (\_F (MAILLE= (S1, S2), GROUP\_NO= (BC, BC), OPTION='**

**NOEUD\_A\_NOEUD'),**

**\_F**

**(MAILLE=  
(S2, S3), GROUP\_NO=  
(FG, BC), OPTION=  
"OPPOSITE"),),**

**DEFI\_NOEUD=\_F  
(ALL = "YES", INDEX = (1, 2, 2, 3))**

**\_F (NOEUD\_FIN = A, MESH = S1,  
NOEUD\_INIT = N1),),**

**DEFI\_GROUP\_NO =\_F (GROUP\_NO\_FIN = FG, MESH = S3, GROUP\_NO\_INIT = FG),)**

**The grid obtained contains:**

**.  
3 super-meshes: S1, S2, S3  
.  
26 nodes: With, S12,..., S317  
.  
1 GROUP\_NO: FG = (S315, S316, S317)**

**S16  
S15  
S217  
S317  
S1  
S2  
S3  
S316  
With  
S315  
S12  
S213  
S313**

**Note:**

**The sticking together of the super-meshes could have been made more simply by:  
RECO\_GLOBAL = \_F (ALL = "YES").**

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*Organization (S): EDF-R & D /AMA, CS IF*

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## ***1 Goal***

***To create a structure of data of the grid type starting from an other grid. New grid contains all information of the old grid (if they still exist): nodes, meshes, groups of nodes and groups of meshes. The new grid is created starting from a grid existing while duplicating, while destroying, while transforming or while bursting,..., of the meshes.***

***Product a structure of data grid.***

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## ***2 Syntax***

***ma\_2 (grid) =***

***CREA\_MAILLAGE***

***(***

***GRID***

***= ma\_1,***

***[grid]***



// **CREA\_GROUP\_MA**  
**= \_F (**

**NOM=**  
**noma,**  
**[K8]**

**/ NET**  
**=**  
**lmail,**  
**[l\_maille]**

**/ GROUP\_MA**  
**=**  
**lgma,**  
**[l\_group\_ma]**

**/ ALL = "YES",**

***PREF\_MAILLE***

=

***pre\_ma, [kN]***

***PREF\_NUME***

= *ind*

,

***[I]***

),

***/CREA\_MAILLE = \_F (***

***/NET***

**=**

***lmail,***

***[l\_maille]***

***/GROUP\_MA***

**=**

***lgma,***

***[l\_group\_ma]***

***/ALL = "YES",***

***PREF\_MAILLE***

**=**

***pre\_ma, [kN]***

***PREF\_NUME***

**= ind**

**,**

***[I]***

),

**/DETR\_GROUP\_MA**  
**= \_F (**

**GROUP\_MA**  
**=**  
**lgma,**  
**[l\_group\_ma]**

**NB\_MAILLE**  
**= /**  
**0,**

**[DEFECT]**

/  
*nbmail, [I]*

),

/ *MODI\_MAILLE = \_F (*

/  
*ALL = "YES",*

**/ GROUP\_MA**

=

**lgma,**

**[l\_group\_ma]**

**/ NET**

=

**lmail,**

**[l\_maille]**

**/**

**OPTION**

=

**/**

**“TRIA6\_7”,**

**/**

**“QUAD8\_9”,**

/  
**“SEG3\_4”,**

/  
**“QUAD\_TRIA3”,**

**PREF\_NOEUD =/“NS”,**  
**[DEFECT]**

*/pre\_nd, [kN]*

***PREF\_NUME***  
*=/ind, [I]*

*/ 1,*

***[DEFECT]***

*/*  
***OPTION***  
*=*  
***“QUAD\_TRIA3”***,



***PREF\_MAILLE*** =/"MS",  
***[DEFECT]***

***/pre\_ma, [kN]***

***PREF\_NUME***  
***=/ind, [I]***

***/ I,***

**[DEFECT]**

),  
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**/ LOCATE**

**= \_F (**

***COUNT***

***=***

***,***  
***[tabl\_cara\_geom]***

***NOM\_ORIG =/"CDG",***  
***[DEFECT]***

***/"TORSION",***

***NOM\_ROTA =/"INERTIA", [DEFECT]***

***GROUP\_MA = gma***

***,***  
***[group\_ma]***

),

*/ CREA\_POII*  
*= \_F (*

*/ ALL = "YES",*

*/ GROUP\_MA*  
*=*  
*lgma,*  
*[l\_group\_ma]*

*/ NET*

=  
*lmail,*  
*[l\_maille]*

*/GROUP\_NO*  
=  
*lno,*  
*[l\_group\_no]*

*/NODE*  
=  
*lnoeud, [l\_noeud]*

*NOM\_GROUP\_MA*  
=*nom\_ma*  
*, [group\_ma]*

),

***/LINE\_QUAD***

***=***

***\_F (***

***/***

***ALL = "YES",***

***/GROUP\_MA***

***=***

***lgma,***

***[l\_group\_ma]***

***/NET***

***=***

***lmail,***

***[l\_maille]***

***PREF\_NOEUD =/  
“NS”,  
[DEFECT]***

***/  
pre\_nd,  
[KN]***

***PREF\_NUME  
=/  
ind  
, [I]***

***/  
1,***

**[DEFECT]**

),

**/QUAD\_LINE**  
=  
**\_F (**

**/**  
**ALL = "YES",**

**/GROUP\_MA**  
=  
**lgma,**  
**[l\_group\_ma]**



*/NET*  
=  
*lmail,*  
*[l\_maille]*

),

*/COQU\_VOLU*  
=  
*\_F (*

*NOM=*  
*noma, [TXM]*

*GROUP\_MA*  
=  
*gma,*  
*[group\_ma]*

**THICK**

=

**ep,**  
**[R8]**

**PREF\_MAILLE =/**

**“Ms”,**

**[DEFECT]**

/

**pre\_ma,**

**[KN]**

**PREF\_NOEUD =/**

**“NS”,**

**[DEFECT]**

/  
*pre\_nd,*  
*[KN]*

*PREF\_NUME*  
=  
*ind*  
,  
*[I]*

/  
*1,*  
*[DEFECT]*

/  
**PLAN** =/"**SUP**",  
**[TXM]**

/"**INF**",

/  
**PLAN**  
=  
/"**MOY**",

**TRANSLATION** =/"**SUP**",  
**[TXM]**

**/“INF”,  
[DEFECT]**

),  
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**/CREA\_FISS  
=  
\_F (**

***NOM=***  
***nogma,***  
***[TXM]***

***GROUP\_NO\_1***  
***=***  
***gno1,***  
***[group\_no]***

***GROUP\_NO\_2***  
***=***  
***gno2,***  
***[group\_no]***

***PREF\_MAILLE = pre\_ma, [kN]***

***PREF\_NUME***

= /  
**ind**  
,  
**[I]**

/  
**1,**

**[DEFECT]**

),

**/ECLA\_PG =**  
**\_F (...)**  
**#**  
**used by [U4.44.14]**

***INFORMATION =/1,***

***[DEFECT]***

***/ 2,***

***TITRATE***

***=***

***tit,***

***[TXM]***

)  
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***3 Operands***

***3.1 Operand***

***GRID***

***GRID = ma\_1***

***ma\_1 is the name of the initial grid which one wants to reproduce before “enriching it” by new meshes or nodes, or “to impoverish it”.***

***Note:***

***The key word GRID is obligatory except for the use of key word ECLA\_PG.***

***3.2 Word***

***key***

***CREA\_GROUP\_MA***

***/ CREA\_GROUP\_MA***

***An occurrence of this key word factor makes it possible to define a new group of meshes made up new meshes, being based themselves on existing nodes.***

***To duplicate several groups of meshes, one will repeat the key word factor CREA\_GROUP\_MA.***

***Contrary to the order DEFI\_GROUP [U4.22.01] for which the concept grid always preserve the same number of meshes and nodes, here the number of meshes of new grid is increased (the number of nodes remains identical because the new meshes rest on already existing nodes).***

***This can facilitate the creation of new loci to be able to apply modelings different on the same group from meshes.***

### **3.2.1 Operand**

**NAME**

**NAME = noma**

*One gives here the name (without “quotes”) of the new group of meshes which will be created.*

### **3.2.2 Operands**

**NET/GROUP\_MA/ALL**

**/NET**

**=**

**lmail,**

**/GROUP\_MA**

**=**

**lgma,**

**/ALL =**

**“YES”,**

*The whole of the meshes stipulated by the user with these three key words will be duplicated and them new meshes will be gathered in a group of meshes bearing the name stipulated by the word key NAME. If the whole of the meshes to be duplicated contains meshes in double, they are eliminated.*

### **3.2.3 Operands**

**PREF\_MAILLE/PREF\_NUME**

**PREF\_MAILLE = pre\_ma**

*This variable text makes it possible to define the name of the new meshes. One obtains the name of new mesh while adding in front of its old name, the text specified under the key word PREF\_MAILLE. If this new name has a length higher than eight characters, one stop in fatal error with an error message.*

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**PREF\_NUME**

**=/ind**

***If an entirety ind is given under key word PREF\_NUME, the number of the new meshes is built by concaténant the text capital letter given under key word PREF\_MAILLE and an entirety obtained by incrementing ind of 1 with each creation of new meshes.***

**Note:**

***The user must be careful in the choice of his prefix to prevent that the meshes news has the same name as old meshes. This collision of names is detected by the order and conduit with a program stop.***

**3.3 Word**

**key**

**CREA\_MAILLE**

**/ CREA\_MAILLE**

***An occurrence of this key word factor makes it possible to define new meshes while duplicating already existing meshes. For the use of the key words, one returns in the paragraph [§3.2]. Only difference, the meshes created are not gathered in a named group of meshes.***

**3.4 Word**

**key**

**CREA\_POII**

**/ CREA\_POII**

***An occurrence of this key word factor makes it possible to define meshes of the type “POII” (mesh in one only node) starting from nodes or groups of nodes, or nodes of meshes or group of meshes.***

**3.4.1 Operands**

**ALL/GROUP\_MA/MESH/GROUP\_NO/NODE**

**/ALL = “YES”,**  
**/GROUP\_MA**  
**= lgma,**  
**/NET**  
**= lmail,**  
**/GROUP\_NO**  
**= lno,**  
**/NODE**  
**= lnoeud,**

*All the nodes which belong to entities stipulated by the user with these five key words, generate a mesh of the type POII. The mesh created will have the same name as the node which support.*

### **3.4.2 Operand**

**NOM\_GROUP\_MA**

**NOM\_GROUP\_MA = nom\_ma**

*All meshes POII thus created can be gathered in the same group of meshes named nom\_ma.*

### **3.5 Word**

**key**

**DETR\_GROUP\_MA**

**/DETR\_GROUP\_MA**

*An occurrence of this key word factor makes it possible to destroy groups of meshes, the meshes contained in these groups are not they not destroyed.*

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### **3.5.1 Operand**

**GROUP\_MA**

**/GROUP\_MA = lgma**

*The groups of meshes stipulated in the list lgma are destroyed.*

### **3.5.2 Operand**

**NB\_MAILLE**

**NB\_MAILLE =/nb\_mail,**

**/ 0,**

*All the groups of meshes having a number of meshes lower or equal to nb\_mail are destroyed.*

### **3.6 Word**

**key**

**MODI\_MAILLE**

**/**

**MODI\_MAILLE**

*An occurrence of this key word factor makes it possible to transform:*

- respectively the meshes segment with three nodes, triangle with six nodes and quadrangle with eight nodes in segment with four nodes, triangle with seven nodes and quadrangle with nine nodes. Additional nodes are consequently added in the grid. For the triangles and the quadrangles, each additional node is obtained like geometrical barycentre of the nodes tops of the mesh considered. For the segments, the nodes mediums are placed at the third and the two-third of the segment, curve of the element being respected.*
- the meshes quadrangles in meshes triangles with three nodes.*

### **3.6.1 Operand**

**ALL**

/  
**ALL = "YES"**

*One applies the transformation to all the meshes of the grid.*

### **3.6.2 Operand**

**NET**

/  
**NET = lmail**

*This key word makes it possible to define a list of meshes setting up the group of meshes which will be transforms.*

### **3.6.3 Operand**

**GROUP\_MA**

/  
**GROUP\_MA = lgma**

*The meshes of the groups of meshes given in the list lgma are transformed.*

### **3.6.4 Operand**

**OPTION**

**OPTION =/"SEG3\_4"  
"TRIA6\_7"  
"QUAD8\_9"  
"QUAD\_TRIA3"**

*This key word indicates the transformation to be carried out:*

- *transformation of the segments with three nodes into segments with four nodes (usable by example for modeling "PIPE" of AFFE\_MODELE [U4.41.01],*
  - *transformation of the triangles with six nodes into triangles with seven nodes,*
  - *transformation of the quadrangles with eight nodes into quadrangles with nine nodes,*
  - *transformation of the quadrangles into triangles with 3 nodes:*
- transformation of meshes of the type QUAD4 into two meshes of the type TRIA3*  
*transformation of meshes of the type QUAD8 into six meshes of the type TRIA3*  
*transformation of meshes of the type QUAD9 into six meshes of the type TRIA3*

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### **3.6.5 Operands**

**PREF\_NOEUD/PREF\_MAILLE/PREF\_NUME**

**PREF\_NOEUD**

**=**

**/pre\_nd,**

**“NS”,**

***This variable text makes it possible to define the name of the new nodes. One obtains the name of new node while adding in front of its old name, the text specified under key word PREF\_NOEUD. In case where this new name has a length higher than eight characters, one stops in fatal error with an error message.***

**PREF\_MAILLE = pre\_ma**

***This variable text makes it possible to define the name of the new meshes. One obtains the name of new mesh while adding in front of its old name, the text specified under the key word PREF\_MAILLE. If this new name has a length higher than eight characters, one stop in fatal error with an error message.***

**PREF\_NUME =/ind,**

*/ 1,*

*If an entirety ind is given under key word **PREF\_NUME**, the number of the new nodes (new meshes) is built by concaténant the text capital letter given under the key word **PREF\_NOEUD** (**PREF\_MAILLE**) and an entirety obtained by incrementing ind of 1 with each creation new nodes (news meshes).*

*Note:*

*The user must be careful in the choice of his prefix to prevent that the new ones nodes (news meshes) have the same name as old nodes (news meshes). This collision of names is detected by the order and conduit with a program stop.*

*An automatic procedure of cutting of the meshes quadrangles in triangles can generate a kind of “polarization” of the grid: from a given grid **QUAD**, all them diagonals are found directed in the same direction.*

### **3.6.6 Checking**

*The meshes modified by the transformation must be of the same type as that stipulated under the key word **OPTION**.*

### **3.7 Word**

*key*

**LOCATE**

*/ LOCATE*

*An occurrence of this key word factor makes it possible to define a new grid from the old one grid by carrying out a change of reference mark.*

*This functionality is used in particular in macro-order **MACR\_CARA\_POUTRE** [U4.42.02] for the calculation of the constant of warping.*

#### **3.7.1 Operands**

**COUNT/NOM\_ORIG/NOM\_ROTA/GROUP\_MA**

**COUNT =**

*One gives here the name of the table of concept “geometrical characteristics” which contains in private individual, co-ordinates of the centre of inertia and the center of torsion, angles nautical defining the principal reference mark of inertia,... This table can be obtained by the order*



***POST\_ELEM with the key words factors CARA\_GEOM or CARA\_POUTRE [U4.81.22].***

***NOM\_ORIG***

***=/"CDG",***

***"TORSION",***

***The center of the new reference mark is indicated: the centre of gravity or the center of torsion.***

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***NOM\_ROTA***

***=/"INERTIA",***

***The direction of the new reference mark is indicated. Only one solution is possible: the directions are those of the principal reference mark of inertia.***

***GROUP\_MA***

***=***

***gma***

***If NOM\_ORIG = "CDG", one can indicate the name of the group of meshes whose centre of gravity will be the origin of the new reference mark. If one does not use GROUP\_MA, the centre of gravity of the unit***

*MODEL will be the origin of the new reference mark.*

*If NOM\_ORIG = "TORSION", key word GROUP\_MA is inoperative.*

### **3.8 Key word**

**LINE\_QUAD**

**/LINE\_QUAD**

*This functionality makes it possible to create a quadratic grid starting from a linear grid, one can to apply it only to part of the grid (attention in this case with the connection of the linear zones and quadratic).*

*The groups of meshes are preserved, the groups of nodes also, as at the time of refinement of grid the nodes created are not introduced into the groups of nodes.*

#### **3.8.1 Operands**

**NET/GROUP\_MA/ALL**

**/NET**

**=**

**lmail,**

**/GROUP\_MA**

**=**

**lgma,**

**/ALL =**

**"YES",**

*The whole of the meshes stipulated by the user with these three key words will be transformed into quadratic meshes.*

#### **3.8.2 Operands**

**PRE\_NOEUD/PREF\_NUME**

*As for MODI\_MAILLE.*

### **3.9 Key word**

**QUAD\_LINE**

**/QUAD\_LINE**

*This functionality makes it possible to create a linear grid starting from a quadratic grid, one can to apply it only to part of the grid (attention in this case with the connection of the linear zones and quadratic).*

*The groups of meshes are preserved, the groups of nodes also, as at the time of refinement of grid the nodes created are not introduced into the groups of nodes.*

### **3.9.1 Operands**

**NET/GROUP\_MA/ALL**

**/NET**

**=**

**lmail,**

**/GROUP\_MA**

**=**

**lgma,**

**/ALL =**

**“YES”,**

*The whole of the meshes stipulated by the user with these three key words will be transformed into linear meshes.*

### **3.10 Key word**

**COQU\_VOLU**

**/COQU\_VOLU**

*From the data of a group of surface meshes (QUAD, TRIA3), one builds the grid voluminal (HEXA8, PENTA6) by extrusion according to the normal of the elements (in a node, one takes the average of the normals of the convergent elements). Only one layer of elements is create.*

*The operation applies only to linear grids; if one wishes to create a grid quadratic, it is enough to use CREA\_MAILLAGE/LINE\_QUAD then.*

*Instruction manual*

*U4.2- booklet: Grid HT-62/06/004/A*

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**Code\_Aster ®**

**Version**

**8.2**

**Titrate:**

**Operator CREA\_MAILLAGE**

**Date:**

**31/01/06**

**Author (S):**

**J. PELLETT, L. VIVAN Key**

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### **3.10.1 Operands NAME**

**NAME**

= *noma*,

*Name of the group of meshes made up of the voluminal meshes create at the time of this operation.*

### **3.10.2 Operands GROUP\_MA**

**GROUP\_MA =**

*lgma*,

*Groups of meshes constituting the surface grid to extrude.*

### **3.10.3 THICK operands**

**THICK =**

*ep*,

*Thickness of the layer of elements created (thickness of the hull).*

### **3.10.4 Operands PLAN**

**PLAN =/“SUP”**,

/

“INF”

/

“MOY”

*One specifies here that surface made up of lgma will be the SUPérieur plan, INFérieur or Means of the hull.*

### **3.10.5 Operands TRANSLATION**

**TRANSLATION =/“SUP”**,

/

“INF”

*If PLAN=' MOY', one specifies if initial surface made up of lgma is relocated in higher or Lower skin.*

### **3.10.6 Operands PRE\_MAILLE/PRE\_NOEUD/PREF\_NUME**

*As for MODI\_MAILLE.*

### **3.11 Word**

**key**

**CREA\_FISS**

**/**

**CREA\_FISS**

**=**

**\_F (**

**NOM=**

**nogma,**

**[TXM]**

**GROUP\_NO\_1**

**=**

**gno1,**

**[group\_no]**

**GROUP\_NO\_2**

**=**

**gno2,**

**[group\_no]**

***PREF\_MAILLE = pre\_ma, [kN]***

***PREF\_NUME***

***= /***

***ind***

***,***

***[I]***

***/***

***1,***

***[DEFECT]***

***),***

***3.12 Key word***

***CREA\_FISS***

*Allows to create a crack with elements of joint (Doc. [R3.06.09]) or elements with discontinuity (Doc. [R7.02.12]) along a line defined by two groups of nodes laid out in glance. The two groups of node must have the same number of nodes and to be as a preliminary ordered (to use CREA\_GROUP\_NO, option=' NOEUD\_ORDO') so that their classification same side “starts” (see figure).*

*One will be able, then to affect a modeling of the type “joint” on these new meshes QUAD4 (see for example “PLAN\_JOINT”).*

*Instruction manual*

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*The meshes created will bear a name formed starting from the prefix pre\_ma followed by a number. For example, if PREF\_MAILE=' FS' and PREF\_NUME=7, the meshes create will be called: FS7, FS8,...*

*One will create also a new GROUP\_MA (called nogma) containing the whole of meshes QUAD4 created.*

### **3.12.1 Operand NAME**

*Name of the group of meshes made up of the voluminal meshes created at the time of this operation.*

### **3.12.2 Operands GROUP\_NO\_1/GROUP\_NO\_2**

*Groups of node constituting the lips of the crack. The group of node GROUP\_NO\_1 carries them local nodes 1 and 2 (the first node of the group to a local classification equalizes to 1), it GROUP\_NO\_2 carries the local nodes 3 and 4 (the first node of the group to a local classification equalize to 4). Attention it is necessary to choose these groups of nodes according to the geometry of such kind that the local classification of the elements is carried out in the trigonometrical direction:*

**Feel**

**Feel**

2

3

1

**scheduling**



4

***scheduling***

2

3

2 1

3 4

1

3

4

2

3 4

2 1

4

3

2 1

4

1

***NOOK***

***OK***

***3.12.3 Operands PREF\_MAILLE/PREF\_NUME***

*Usual significances.*

***3.13 Word***

*key*

***ECLA\_PG***

***/ECLA\_PG***

*This key word factor was not used directly. It is used by order MACR\_ECLA\_PG [U4.44.14].*

***3.14 Operand***

***INFORMATION***

***INFORMATION = inf***

*Specify the information printed in the file message (1: no impression, 2: details on a number of meshes create, modified...).*

### **3.15 Operand**

#### **TITRATE**

**TITRATE = tit**

*Allows to specify a title.*

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### **4 Examples**

#### **4.1**

#### **Duplication of meshes**

*That is to say ma\_1 a grid containing the meshes already:*

**M1 m2 m3**

*and groups it meshes:*

**hull: M1 m2**

*Each mesh is based on the following nodes:*

*M1: N1 N2 N3*

*M2: N3 N4 N5*

*M3: N4 N5 N6*

*ma\_2 = CREA\_MAILLAGE (GRID = ma\_1,  
CREA\_MAILLE*

*=*

*\_F (  
NET*

*=*

*“M3”,  
PREF\_MAILLE*

*=*

*“NEW”,  
)*

*CREA\_GROUP\_MA*

*=*

*\_F (  
NAME*

*=*

*ground,  
GROUP\_MA*

*=*

*“hull”,  
PREF\_MAILLE*

*=*

*“A”,  
PREF\_NUME*

*=*

*100,  
)*

)

*After call to order CREA\_MAILLAGE, the new grid contains then:*

.

*groups of meshes:*

-

*hull (initial)*

-

*ground = (meshs: A100 A101)*

.

*the meshes are based on the following nodes:*

-

*M1: N1 N2 N3*

-

*M2: N3 N4 N5*

-

*M3: N4 N5 N6*

-

*NEWM3: N4 N5 N6*

-

*A100: N1 N2 N3*

-

*A101: N3 N4 N5*

## **4.2**

*Transformation of triangles with 6 nodes into triangles with 7 nodes*

*ma\_2 = CREA\_MAILLAGE (GRID = ma\_1,  
MODI\_MAILLE*

=

*\_F (  
GROUP\_MA = "triangle",  
OPTION*

=

**“TRIA6\_7”,  
PREF\_NOEUD**

**=**

**“NMI”,  
PREF\_NUME**

**=**

**10,**

**),**

**)**

*Let us suppose that in **ma\_1** the **GROUP\_MA** triangle is composed of two **M1** meshes, **m2** having them following nodes:*

**M1: N1 N2 N3 N4 N5 N6**

**M2: N1 N2 N7 N4 N8 N9**

*In the grid **ma\_2**, the two meshes **M1**, **m2** will have the following nodes:*

**M1: N1 N2 N3 N4 N5 N6 NMI10**

**M2: N1 N2 N7 N4 N8 N9 NMI11**

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**4.3  
Transformation of quadrangles with 4 nodes into triangles with 3 nodes**

*This example results from test SSLV04E:  
The geometry accounting for 1/4 of a disc, be with a grid in quadrangle, one wishes that 1/8 of the disc  
that is to say with a grid in triangle.*

*my = CREA\_MAILLAGE (GRID = m0,  
MODI\_MAILLE*

*=  
\_F (  
GROUP\_MA = "S2",  
OPTION*

*=  
"QUAD\_TRIA3",  
PREF\_MAILLE*

*=  
"Ms",  
PREF\_NUME*

*=  
1,  
)*

*)*

**4.4 Bursting of the initial grid to visualize a field of result**

*at the points of Gauss*

*ma2*  
*= CREA\_MAILLAGE*  
*(GRID*  
*=m,*

*ECLA\_PG= \_F (MODELE= Mo,*  
*SHRINK= 0.90,)*

*u2b=*  
*CREA\_RESU*  
*(*  
*TYPE\_RESU=*  
*“evol\_noli”,*  
*ECLA\_PG=*  
*\_F (*  
*MODELE\_INIT= Mo,*  
*RESU\_INIT= u2,*  
*MAILLAGE=*  
*ma2,*  
*NOM\_CHAM=*  
*(“SIEF\_ELGA”,*  
*“VARI\_ELGA”),*

*),*

*)*  
  
*IMPR\_RESU (RESU = \_F (*  
*GRID = ma2,*  
*RESULT*

=  
**u2b**  
, )  
)

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***7.4***

***Titrate:***

***Operator ASSE\_MAILLAGE***

***Date:***

***19/01/05***

***Author (S):***

***C. DURAND, J. Key PELLET***

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***Organization (S): EDF-R & D /AMA***

***Instruction manual***

***U4.2- booklet: Grid***

***Document: U4.23.03***

***Operator ASSE\_MAILLAGE***

## ***1 Goal***

***To assemble 2 grids to form new.***

***The two grids to be assembled can come from the operators: LIRE\_MAILLAGE [U4.21.01], DEFI\_MAILLAGE [U4.23.01], ASSE\_MAILLAGE [U4.23.03],...***

***I.e. they can contain ordinary meshes and/or super-meshes carrying macronutrients.***

***Product a structure of data of the grid type.***

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***Author (S):***

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## ***2 Syntax***

***mac (grid) = ASSE\_MAILLAGE***

***(***

*% names of the 2 grids to be assembled:*

***MAILLAGE\_1***

=

***ma1***

,

***[grid]***

***MAILLAGE\_2***

=

***ma2***

,

***[grid]***

*% “to restick” the 2 grids*

/

***OPERATION***

=

***“JOINING”,***

**COLLAGE**=\_F (  
**GROUP\_MA\_1** = *gma1*, [*gr\_maille*]  
**GROUP\_MA\_2** = *gma2*, [*gr\_maille*]),

*% “to superimpose” the 2 grids*

/  
**OPERATION**  
=  
**“SUPERIMPOSES”**,

*% to assemble grids containing of  
% macronutrients (substructures)*

/  
**OPERATION**  
=  
**“SOUS\_STR”**,

)

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Author (S):  
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***3 Operands  
MAILLAGE\_1 and MAILLAGE\_2***

***MAILLAGE\_1 = ma1, MAILLAGE\_2 = ma2,***

***ma1 and ma2 are the names of the 2 grids to be assembled.***

***4 Operation  
=  
“SUPERIMPOSES”***

***With this choice: “SUPERIMPOSES”, all the entities (meshs, nodes, group\_ma and group\_no) of 2 grids are preserved. The only problem to be regulated relates to the name as of the these entities (conflict of names possible because the 2 grids can contain, for example, of the of the same nodes name).***

***To solve these possible problems of names:  
• The nodes and the meshs are always famous. That wants to say that the user cannot***

*to know the name of the nodes and meshes of the grid result. It will have in general to use (it who is always advised) the names of group\_no and group\_ma. Or it will have to print it grid to know the selected names.*

*· The names of the group\_no and group\_ma are preserved within the limit of the possible one. If 2 group\_ma (or 2 group\_no) has the same name in the 2 grids, the group coming from 2nd grid is famous automatically and the renaming is indicated in the file of message.*

## **5 Operation**

### **= “JOINING”**

*The operation “JOINING” is used to connect 2 grids which would have been with a grid independently in 2 distinct files (for example by 2 different teams).*

*If the 2 grids are not coherent on their interface (different discretization), the user will not have not other choice to use functionality AFFE\_CHAR\_XXX/LIAISON\_MAILLE “to bind” them degrees of freedom of the 2 grids which will remain topologically disjointed. It will have to then use the operation “SUPERIMPOSES”.*

*If on the other hand, the 2 grids were envisaged to be restuck, it will use the operation “JOINING”. For that, it will have to take the precaution to name the 2 groups of meshes (of interface) which will allow to restick the 2 grids. Moreover these 2 groups of meshes must be geometrically coincidents. The user will write then:*

*OPERATION=' COLLAGE', COLLAGE=\_F (GROUP\_MA\_1=' gma1', GROUP\_MA\_2=' gma2'),*

*The group\_ma gma1 and gma2 will then be amalgamated. More precisely:*

- the meshes of gma1 and gma2 will be removed*
- the nodes of gma2 will subisteront (but will be orphan)*
- the nodes of gma1 will connect the 2 grids.*

*Before “amalgamating” the 2 group\_ma gma1 and gma2, the program will check that the nodes of these*

*2 group\_ma are well coincidents (with a tolerance of 0.001 times the length of the smallest edge of the 2 grids).*

*The conflicts of names of the entities of the 2 grids are regulated in the same way that for the operation*

*“SUPERIMPOSES” (see above).*

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**6 Operation**

**=**

**“SOUS\_STR”**

*To mix in the same model of the ordinary finite elements and macronutrients (or under structures), it is necessary to have a grid containing at the same time ordinary meshes and (super) meshes. Operator ASSE\_CHAMP/OPERATION = “SOUS\_STR” makes it possible to constitute it*

*“mixed” grid by assembling a grid ordinary (or mixed) and a grid containing of (super) meshes (coming from DEFI\_MAILLAGE).*

*The direction of the assembly is as follows:*

**.**

*All entities of the 2 grids arguments ma1 and ma2 (meshs, super-meshs, nodes, group meshes and groups nodes) are recopied in the grid result: mac.*

**.**

*The only shared entities are the nodes same names. These are the nodes which allow to assemble the 2 grids.*

**.**

*Treatment of the entities bearing the same name:*

**-**

*nodes: nodes of the second grid bearing an existing name in the first grid, are not added: it is supposed that they are the same ones. Co-ordinates of preserved node are those of the node of the first grid. An alarm is emitted when the distance between the two confused nodes is higher than:*

**10 6**  
**- .d\_refe**

*where d\_refe is a length characteristic of the grid:*

**d\_refe**  
**=**  
**(D**  
**max (O**  
**, NR)**

*where D (O*  
*, NR*  
*) is the distance from the node NR at the origin of the total reference mark.*

-  
*meshs (or super-meshs): if the grid ma2 contains of the same meshs name than meshs of the first grid ma1, the program stops in fatal error.*

-  
*group meshs (or groups of nodes): if the grid ma2 contains a group of of the same meshs name than a group of mesh of ma1, this one is ignored and it program transmits a message of alarm.*

## **7 Examples**

### **7.1 ex2**

*One wants to create a grid (matot) containing static substructures and an ordinary grid.*

**ma1**

**= LIRE\_MAILLAGE ()**

**macro1 =**

**MACR\_ELEM\_STAT (...)**

**macro2 =**

**MACR\_ELEM\_STAT (...)**

**masss = DEFI\_MAILLAGE (DEFI\_MAILLE = \_F (MACR\_ELEM\_STAT = macro1...))**

**matot = ASSE\_MAILLAGE (OPERATION=' SOUS\_STR',**

**MAILLAGE\_1 = ma1, MAILLAGE\_2 = masss)**



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***Operator MODI\_MAILLAGE***

***Date:***

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***Author (S):***

***J. Key PELLETT***

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***Organization (S): EDF-R & D /AMA***

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U4.23.04 document***

***Operator MODI\_MAILLAGE***

## ***1 Goal***

***To carry out modifications on an existing grid. The possibilities of modifications are:***

- .  
to reorientate meshes of edge being used to apply a pressure,***
- .  
to reorientate meshes HEXA8 of modeling SHB8,***
- .  
to check the orientation of the normals on the elements of hull,***
- .  
to reorientate the meshes of full-course of elements of joint,***
- .  
to reactualize the grid starting from a deformation calculated previously,***
- .  
to transform a grid of plate into grid of tube, then possibly of elbow,  
(macro order MACR\_ASCOUF\_MAIL),***
- .  
to transform a grid of square into grid of pricking (MACR\_ASPIC\_MAIL),***
- .  
in a grid with bottom of crack, to move the nodes mediums of the edges touching it  
melts of crack to the quarter of these edges,***
- .  
to relocate a grid,***
- .  
to impose one or more rotations of unspecified axes on a grid,***
- .  
to generate a symmetrical grid compared to a plan in 3D or a line in 2D.***

***Product a structure of data of the grid type or modifies the structure of data (operator réentrant).***

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**2 Syntax**

**netted [grid] = MODI\_MAILLAGE**

**(reuse = netted,**

**GRID = my,**

**[grid]**

**MODEL**

**= Mo,**

**[model]**

**ORIE\_FISSURE = \_F (GROUP\_MA**

**= l\_gm [l\_gr\_ma]**

**),**

**ORIE\_SHB8 = \_F (GROUP\_MA**

**= l\_gm [l\_gr\_ma]**

**),**

**DEFORME=**

**\_F (/OPTION**

**= "TRAN"**

**,**

**/OPTION**

**= "TRAN\_APPUI",**

**GROUP\_NO\_APPUI**

=

**lgno, [l\_gr\_no]**

**GROUP\_NO\_STRU = lgno, [l\_gr\_no]**

**DEPL**

=

**depl,  
[cham\_no\_depl\_r]**

),

**ORIE\_PEAU\_2D**

=\_F

**(GROUP\_MA = lgrma)**

**[l\_gr\_ma]**

**ORIE\_PEAU\_3D**

=\_F

(

**GROUP\_MA**

=

*lgrma*)

[*l\_gr\_ma*]

**ORIE\_NORM\_COQUE=\_F (**

**GROUP\_MA**

=

*lgrma,*

[*l\_gr\_ma*]

**VECT\_NORM**

= (*n1, N2, [n3]*),

[*l\_R*]

**/NODE = No, [node]**

/

**GROUP\_NO=**

*grno,*

[*gr\_no*]

),

***MODI\_MAILLE =  
\_F (  
OPTION  
= "NOEUD\_QUART",***

***// GROUP\_MA\_FOND=  
lma\_fo,  
[l\_gr\_ma]***

***/  
MAILLE\_FOND = lma\_fo, [l\_maille]***

***// GROUP\_NO\_FOND=  
lgn\_fo,  
[l\_gr\_no]***

/  
*NOEUD\_FOND = lno\_fo, [l\_noeud]*

),

*/EQUE\_PIQUA = \_F (GROUP\_NO = square, [gr\_no]*  
*E\_BASE*  
*= thickness,*  
*[R]*

*DEXT\_BASE*  
*= diameter, [R]*

*L\_BASE*  
*=*  
*length,*  
*[R]*

*L\_CHANF =*  
*length,*  
*[R]*

*H\_SOUD*  
*=*  
*height,*  
*[R]*

*ANGL\_SOUD*  
*=*  
*angle,*  
*[R]*

*JEU\_SOUD*

= *play*

,  
[R]

*E\_CORP*

=  
*thickness*, [R]

*DEXT\_CORP*

=  
*diameter*,  
[R]

*AZIMUTH*

=  
*angle*,  
[R]

*X\_MAX*

=  
*length*,  
[R]

*RAFF\_MAIL*

=  
*raff*,  
[Txm]

*TYPE*

=  
/"*TYPE\_1*"

,  
[Txm]  
/"*TYPE\_2*",

),  
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Version

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Titrate:

Operator *MODI\_MAILLAGE*

Date:

11/03/05

Author (S):

**J. Key PELLET**

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*/| PLAQ\_TUBE*

= *\_F (*

*DEXT*

=

*Of,*

*[R]*

*THICK*

=

*E,*

*[R]*

*AZIMUTH*

=  
/  
*Q*,  
*[R]*

/ 90.,  
*[DEFECT]*

*L\_TUBE\_P1*  
= *l\_tube\_p1*, *[R]*

*SEAM* =/"YES",  
*[DEFECT]*  
/  
"NOT",

),

*/ TUBE\_COUDE = \_F (*  
*ANGLE*

=

,  
*[R]*

*R\_CINTR*

= *Rc*,

*[R]*

*L\_TUBE\_P1*

= *l\_tube\_p1*, *[R]*

),

*TRANSLATION = (n1, N2, [n3]),*  
*[l\_R]*

*ROTATION = \_F*

*(POIN\_1*

= *(n1, N2, [n3]),*

*[l\_R]*

*/POIN\_2*

= (n1, N2, [n3]),

[l\_R]

/

DIR

=

(n1, N2, [n3]),

[l\_R]

ENG

=

/

has,

[R]

/0.,

[DEFECT]

),

SCALE = n1,

[R]

MODI\_BASE

=\_F

(VECT\_X

= (n1, N2, [n3]),

[l\_R]

VECT\_Y

= (n1, N2, [n3]),

[l\_R]

),

*SYMMETRY =\_F*  
*(NOT = (n1, N2, [n3]),*  
*[l\_R]*  
*/AXE\_1*  
*= (n1, N2, [n3]),*  
*[l\_R]*  
*/AXE\_2*  
*= (n1, N2, n3),*  
*[l\_R]*

),

*INFORMATION*  
*=*  
*/*  
*1,*  
*[DEFECT]*

/ 2,

)

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### *3 Operands*

#### *3.1 Operand*

##### *GRID*

*GRID = my,*

*Grid of the type [grid] on which will amend and/or checks.*

#### *3.2 Operand*

##### *MODEL*

*MODEL = Mo,*

*Concept produced by AFFE\_MODELE [U4.41.09] where the types of affected finite elements are defined on the grid. This operand is obligatory for key words.*

#### *3.3 Operand*

##### *INFORMATION*

*INFORMATION*

*=*

*Indicate the level of impression of the results of the operator,*

*1 = no impression,*

*2 = impression of the meshes whose connectivity was modified, including the impression of old and new connectivities.*

*The impressions are made in the file "MESSAGE".*

### **3.4 Key word** **ORIE\_FISSURE**

#### **ORIE\_FISSURE**

=

*This key word is used to reorientate (if necessary) the meshes of a group forming “full-course” elements. It functions in 2D and 3D [Figure 3.4-a].*

*Appear 3.4-a*

*Currently, this key word is useful only in 2D to reorientate the elements of joint (modelings **AXIS\_FISSURE** and **PLAN\_FISSURE**).*

*The user specifies (with key word **GROUP\_MA**) which are the meshes candidates with reorientation (the “full-course one”).*

*These meshes must be “prisms” (**QUAD** in 2D, **HEXA** and **PENTA** in 3D).*

*The “transverse” direction with the layer is given in a topological way (and not according to a criterion*

*of flatness): the facets connecting the elements of the layer are declared “transverse”. This algorithm imposes that the layer is made of several contiguous meshes.*

*Note:*

*The “reorientation” about which one speaks here actually consists in modifying the definition of connectivity*

*meshes. For example, in 2D, convention is that sides 2 and 4 of the quadrangles are transverses with the layer.*

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***GROUP\_MA=***

***l\_gm,***

***List groups of meshes which one wishes the checking (and possibly modification) orientation.***

***3.5 Key word***

***ORIE\_SHB8***

***ORIE\_SHB8***

***=***

***The purpose of this key word factor is to correctly reorientate meshes HEXA8 of the finite elements SHB8.***

***The connectivity of the meshes thus is possibly modified by this operator.***

***GROUP\_MA=***

***l\_gm,***

***List groups of meshes which one wishes the modification of the orientation.***

***3.6 Key word***

***DEFORMATION***

***DEFORM***

***/***

***OPTION***

***= ' TRAN'***

*Option allowing to add to the initial geometry of the grid the my values of Translation (dx, Dy (+ dz in 3D)) field of depl displacement given by key word DEPL.*

/  
**OPTION**  
**= ' TRAN\_APPUI'**

*Option allowing in addition to “TRAN” to reactualize the position of the supports by holding account deformation of the structure. More precisely:*

*Initial grid:*

*support*  
*support*

*structure*

*The supports are blocked for mechanical calculation, only the structure becomes deformed:*

*Deformation*

*support*  
*support*

*structure*

*One reactualizes the supports by adding to their co-ordinates the displacement of the nodes of structure which are to them in opposite. This gives then:*

*Reactualization*

*support*  
*support*

*structure*

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*The grid at exit of MODI\_MAILLAGE takes into account the deformation of the structure and reactualization of the supports as explained above*

**GROUP\_NO\_STRU = lgrno,**

**GROUP\_NO\_APPUI = lgrno,**

*These obligatory key words make it possible to inform the groups of nodes structure and support whose nodes must be in opposite (for the contact).*

**DEPL = depl,**

*Field of displacement being used to reactualize the geometry*

**3.7 Key words**

**ORIE\_PEAU\_2D/ORIE\_PEAU\_3D**

**ORIE\_PEAU\_2D**

**=**

**ORIE\_PEAU\_3D**

**=**

*These key words are used to reorientate meshes of edge being used to apply a pressure in 2D and 3D.*

**GROUP\_MA**

**= lgrma,**

**[l\_gr\_ma]**

***Groups of meshes to be reorientated.***

***The meshes are directed in such way that the normal is outgoing. For each mesh of edge (edge or face), one seeks the voluminal mesh which corresponds to him. One directs it in such way that its normal is direction opposed to the vector connecting its first node to the barycentre of the mesh.***

***The MODEL key word is obligatory with these key words.***

### **3.8 Key word**

**ORIE\_NORM\_COQUE**

**ORIE\_NORM\_COQUE**

=

***This key word is used to check that in a group of surface meshes (hulls), the normals are of the same direction (at least for the convex components). In the contrary case, the meshes are reorientated according to the direction of the found first.***

**GROUP\_MA**

= lgrma,

**[l\_gr\_ma]**

***Surface groups of meshes to reorientate.***

***One can impose a direction using the key word:***

**VECT\_NORM = (n1, N2, [n3]), [l\_R]**

***nor: 2 or 3 components (according to dimension) of the normal vector. It is also necessary to specify it node support of this normal:***

**/NODE = node,**

**[node]**

**/**

**GROUP\_NO**

=

**grno,**

**[gr\_no]**

**The MODEL key word is obligatory with ORIE\_NORM\_COQUE.**

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**3.9 Key word**

**MODI\_MAILLE**

**OPTION = "NOEUD\_QUART",**

**Activate the displacement of the nodes mediums of the edges touching the bottom of crack to the quarter of these edges (towards the bottom of crack).**

**//**

**GROUP\_MA\_FOND = lgma\_fo, [l\_gr\_ma]**

**/**

**MAILLE\_FOND = lma\_fo, [l\_maille]**

/

/

**GROUP\_NO\_FOND = lgn<sub>o</sub>\_fo, [l<sub>gr</sub>\_no]**

/

**NOEUD\_FOND = lno<sub>fo</sub>, [l<sub>noeud</sub>]**

*In 2D, one returns the node of the bottom of crack (by NOEUD\_FOND or GROUP\_NO\_FOND).  
In 3D, one returns either the nodes of the bottom of crack, or meshes SEG3 of the bottom of crack  
(and not meshes of the lips of the crack or the matter meshes leaned with the bottom).*

### **3.10 Key word PLAQ\_TUBE**

#### **Caution**

*This functionality is called by macro-order MACR\_ASCOUF\_MAIL.*

/ /

**PLAQ\_TUBE =**

*Key word factor for the transformation of the grid of a plate thickness  $E$  and width  $2Rm$   
in a grid of tube per rolling up around axis (Z), rotation of an angle given around  
axis (Z) and change of reference mark:*

**Z**  
**Rm**  
**l<sub>tube</sub>\_p2**  
**E**  
**Rc**  
**Y**  
**0**  
**Rm**  
**E**  
**Y (right side)**  
**l<sub>tube</sub>\_p1**  
**2 Rm**  
**X (side left**  
**if = 0)**  
**X (suction face)**

**Z**

***DEXT =***  
***Of,***  
***Diameter external of the tube (2R***  
***E***  
***m +).***

***THICK =***  
***E,***  
***Thickness of the tube or the plate.***

***AZIMUTH***  
***=***  
***Q,***

***Swing angle in degrees (counted positively starting from the suction face to the under-surface in passing by the left side) applied to the tube starting from initial rolling up (useful for positioning of a crack defined on the plate). The angle = 90° corresponds to a crack located at the center of the plate and consequently on the left side of the tube.***

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***L\_TUBE\_P1***

=

***l\_tube\_p1,***

***Length of the lower end (intervenes in the change of reference mark). It is recommended to take an end length higher than the length of damping of the wave of***

***3 R3m***

***inflection being propagated since the part bends and being worth Lamor =***

.

2

***E***

***SEAM***

=

/

***“YES”,***

***[DEFECT]***

***/“NOT”,***

***In the case of a grid of a quarter of structure (key word SYME of MACR\_ASCOUF\_MAIL for a grid with only one under-thickness), this key word SEAM is used to prevent it sticking together (“NOT”) at the time of the transformation into tube.***

***3.11 Key word***

***TUBE\_COUDE***

***Caution***

***This functionality is called by macro-order MACR\_ASCOUF\_MAIL.***

/

***TUBE\_COUDE =***

***Key word factor for the transformation of the grid of tube into a grid of elbow.***

***suction face***

***l\_tube\_p2***

***bend***

***Rc***

***under-surface***



**Y**  
***l\_tube\_p1***  
***right side***  
**X**  
***left side***  
**Z**

**ANGLE =**

***Angle in degrees of the elbow.***

**R\_CINTR =**

**Rc,**

***Value of the ray of bending of the elbow.***

**L\_TUBE\_P1**

**=**

***l\_tube\_p1,***

***Length of the lower end of the tube (intervenes in the change of reference mark). It is recommended to take an end length higher than the length of damping of***

***3 R3m***  
***the wave of inflection being propagated since the part bends and being worth  $Lamor =$***

***.***  
***2***

**E**

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**3.12 Key word**

**EQUE\_PIQUA**

**Caution**

***This functionality is called by macro-order MACR\_ASPIC\_MAIL.***

**EQUE\_PIQUA =**

***Key word factor for the transformation of the grid of thick square into a grid of pricking.***

**GROUP\_NO**

**=**

***square,***

***[gr\_no]***

***Group nodes undergoing the transformation.***

**E\_BASE**

**= *thickness, [R]***

***Value thickness of the pipe in the zone of connection with the body.***

**DEXT\_BASE**

**=**

***diameter,***

***[R]***

***Value of the diameter external of the pipe in the zone of connection with the body.***

**L\_BASE**

**=**

***length,***

***[R]***

*Value length of the base of the pipe counted starting from surface external of the body.*

*L\_CHANF = length,  
[R]*

*Value length of the chamfer.*

*H\_SOUD  
=  
height,  
[R]*

*Value height of the welding counted starting from surface external of the body.*

*ANGL\_SOUD  
=  
angle,  
[R]*

*Value of the angle of the welding in degrees.*

*JEU\_SOUD = play  
,  
[R]*

*Value of the space located between the body and the pipe representing the play of the welding.*

*E\_CORP  
=  
thickness, [R]*

*Value thickness of the body.*

*DEXT\_CORP  
=  
diameter,  
[R]*

*Value of the diameter external of the pipe with the top of the chamfer.*

*AZIMUTH  
=  
angle,  
[R]*

*Position of the center of the crack, counted positively starting from axis X of the body.*

*X\_MAX*  
=  
*length,*  
*[R]*

*Value length of the body on both sides of the origin of the reference mark specifying the localization of torque of effort. This value must correspond to the computed value with a relative precision of thousandths.*

*RAFF\_MAIL*  
=  
/“*LARGE*”,

/“*FINE*”,

*Is used to indicate if one wants a grid coarse or fine around the crack.*

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*The maximum dimensions of the body (X max) and the pipe (Zmax) are calculated starting from the maximum*

*3 R3*

*of the two lengths of damping max*

*m, 3 R × E*

*2nd*

*m*

*noted respectively LX max and*

*LZmax. These lengths of damping are counted starting from the foot of welding (according to X) and with*

*above chamfer (according to Z).*

*In the pipe, one will take for LZmax the maximum of maximum calculated with Rm and the E corresponding respectively to the base of the pipe or the current part of the pipe, with above chamfer.*

*One thus obtains:*

*X*

*= LX*

*max*

*max + 1/2DEXT\_BASE*

*Z*

*= LZ*

*max*

*max + 1/2DEXT\_CORP + L\_BASES + L\_CHANF*

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***Zmax***

***LZmax***

***1/2 DEXT\_TUBU***

***E\_TUBU***

***chamfer***

***L\_CHANF***

***1/2 DEXT\_BASE***  
***extra thickness or***

***under - thickness***

***E\_BASE***

***L\_BASE***

***ANGL\_SOUD***

***saddle***

***H\_SOUD***

***E\_CORP***

***Center***

***pipe***  
***½ DEXT\_CORP***

***JEU\_SOUD***  
***LXmax***

***O***

***Xmax***

***Center body***

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***TYPE =/"TYPE\_1", [Txm]***

***/"TYPE\_2",***

***Defines the position of the welding, cf [U4.PC.10].***

***/"TYPE\_1"***

***the bevel of the welding is located in the body***

***/"TYPE\_2"***

***the bevel of the welding is located in the pipe***

### ***3.13 Key word***

#### ***TRANSLATION***

##### ***Caution***

***One can combine this functionality with ROTATION, but these operations are not commutative.***

***One cannot combine this functionality with SYMMETRY.***

***TRANSLATION = (n1, N2, [n3]),***

***[l\_R]***

***Single-ended spanner word for the translation of a grid following a vector.***

### ***3.14 Key word***

#### ***ROTATION***

##### ***Caution***

***One can combine this functionality with TRANSLATION, but these operations are not***



*commutative. On the other hand, it is not authorized to use ROTATION, MODI\_BASE and SYMMETRY at the same time.*

**ROTATION =**

*Key word factor for the unspecified rotation of axis of a grid.*

**POIN\_1**  
= (nor, N2, [n3]),  
[l\_R]

*Co-ordinates of the first point to define the axis of rotation.*

**/POIN\_2**  
= (nor,  
N2,  
[n3]),  
[l\_R]  
/  
**DIR**

= (nor, N2, [n3]),  
[l\_R]

*Co-ordinates of the second point or direction to define the axis of rotation completely.*

**ENG = has,**  
[R]

*Swing angle expressed in degrees.*

*Rotation is done in the direct direction, compared to its directed axis. This axis passes by the point POIN\_1 and its orientation are given, either by vector DIR, or by the vector of origin POIN\_1 and of end POIN\_2.*

*Rotation is defined by:*

*Either M (X, y, Z) a point of space, one imposes a rotation of angle to him (in radians) of which the axis passes by P (px, py, pz) and has as a direction D (dx, Dy, dz). Then M becomes Me after rotation:*

$$M = P + \cos PM + (1 - \cos) (PM D) D + \sin (D PM)$$

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### **3.15 Key word**

**SCALE**

#### **Caution**

*This functionality is usable with TRANSLATION and ROTATION with which it commutates. One cannot combine this functionality with SYMMETRY.*

*SCALE = n1,*  
*[R]*

*Single-ended spanner word for the scaling of a grid following a reality.*

*Either  $M(X, y, Z)$  a point of the grid, it will become, by this transformation of report/ratio  $n1$ :  $Me(n1.x, n1.y, n1.z)$ .*

### **3.16 Key word**

**MODI\_BASE**

#### **Caution**

*This functionality is not authorized with ROTATION and SYMMETRY.*

*MODI\_BASE =*

*Key word factor for the basic change in which one expresses the co-ordinates of one grid.*

$VECT\_X = (n1, N2, [n3]),$   
 $[l\_R]$

*Coordinated first vector of the new base, unspecified standard.*

$VECT\_Y = (n1, N2, [n3]),$   
 $[l\_R]$

*Coordinated second vector of the new base (not used in 2D), also of standard unspecified.*

*In 2D, it is enough to give axis  $VECT\_X$ , and Code\_Aster builds the second automatically vector to define a direct orthogonal base. A test checks if  $VECT\_X$  is of standard not null.*

*In 3D, one checks that  $VECT\_X$  and  $VECT\_Y$  are of nonnull standard and one checks that they are orthogonal. The third vector which supplements the base is built as being the product vectorial of  $VECT\_X$  with  $VECT\_Y$ . One thus secures construction of an orthogonal base direct.*

*Then, in all the cases (2D and 3D), the vectors of the base are normalized to 1, the user does not have thus not to be concerned with it. There is thus finally a direct orthonormée base.*

*In 3D, one thus awaits the data of  $VECT\_X$  and  $VECT\_Y$ , the first two vectors of new base. Then the basic change is defined as:*

$VECT\_Z (X, y, Z) = VECT\_X (X, y, Z) VECT\_Y (X, y, Z)$

$B = (VECT\_X, VECT\_Y, VECT\_Z)$

by

formed

stamp

:

base

of

vectors

***M (VECT\_X, VECT\_Y, VECT\_Z) BT***

=

***M (X, y, Z)***

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### ***3.17 Key word***

***SYMMETRY***

#### ***Caution***

*One cannot combine this functionality with TRANSLATION, ROTATION, SCALE and MODI\_BASE.*

*NOT*

*= (n1, N2, [n3])*

*[l\_R]*

*Punctual coordinates pertaining to the right-hand side in 2D or the plan in 3D.*

*AXE\_1 = (n1, N2, [n3])*

*[l\_R]*

*Directing vector of the right-hand side in 2D or 1st vector allowing to describe the plan.*

*AXE\_2*

=

*(n1,*

*N2,*

*n3)*

*[l\_R]*

*2nd vector allowing to describe the plan.*

*In 2D, symmetry is done compared to a line, which is in plan OXY. To define this line it is necessary to give the directing vector of the right-hand side (AXE\_1) and a point (NOT) pertaining on this line.*

*In 3D, symmetry is done compared to a plan. To define this plan, it is necessary to give 2 vectors of the plan (AXE\_1, AXE\_2) and a point (NOT) pertaining to this plan.*

*In all the cases (2D or 3D), symmetry is carried out compared to a plan. In 2D, the 2nd vector necessary to the definition of the plan at AXE\_2 is fixed = (0.0, 0.0, -1.0).*

*The algebraic distance enters a point **M** (X, y, Z) and a plan passing by the point **Mo** (xo, yo, zo) with for perpendicular vector **V** = AXE\_1 ^ AXE\_2 = (has, B, c) is:*

*has (X - xo) + B (y - yo) + C (Z - zo)*

=

*2*

*2*

*2*

*+ B has + C*

*The co-ordinates of the symmetrical point **Me** of the point **M** compared to the plan are given by:*

*V*

*M*

*O = - 2.*

*+ OM*

*V*

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***Phase of checking/execution***

*No additional checking.*

*One checks the existence of the groups of meshes to be reorientated in the grid.*

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*Operator DEF1\_PART\_FETI*

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31/01/06

*Author (S):*

***A. ASSIRE, P. the Key GALLOU***

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*Organization (S): EDF-R & D /AMA*



***Instruction manual***

***U4.0- booklet: Use of the orders***

***Document: U4.23.05***

***Operator DEFIN\_PART\_FETI***

***1 Goal***

***This operator allows to carry out the partitioning of a model or a grid.***

***In the case of a model, the structure of data SDFETI is generated, authorizing a resolution with solver FETI.***

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***Code\_Aster*** ®

***Version***

***8.2***

***Titrate:***

***Operator DEFIN\_PART\_FETI***

***Date:***

***31/01/06***

***Author (S):***

***A. ASSIRE, P. the Key GALLOU***

***:***

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**2 Syntax**

***SDFETI = DEFI\_PART\_FETI (***

***/***

***GRID***

***=***

***grid,***

***[grid]***

***/MODEL***

***=***

***model, [model]***

***NBPART***

***=***

***nbpart***

***[I]***

***METHOD =***

***/***

***“SCOTCH TAPE” [DEFECT]***

***/“PMETIS”***

**/“KMETIS”**

**SOFTWARE**

**=**

**“chemin.exe”**

**[TXM]**

**NOM\_GROUPE\_MA =/“SD”,**

**[DEFECT]**

**TRAITER\_BORDS**

**=**

**/**

**“YES”**

**[DEFECT]**

**/**

**“NOT”**

**\_CONNEX =/“NOT”**

**[DEFECT]**

*/“YES”*

***GROUPING***

=

***\_F***

(

***GROUP\_MA = grma,)***

***EVALUATION =***

***\_F***

(

***GROUP\_MA = grma,  
WEIGHT  
= I,)***

***NOM\_GROUPE\_MA\_BORDS  
=  
/***

***“name”  
[TXM]***

***EXCIT  
=  
\_F  
(  
CHARGE = char\_meca or  
char\_cine\_meca,)***

***INFORMATION***

=

/

1,

***[DEFECT]***

/2,

)

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### **3 Operands**

#### **3.1 Operand**

**GRID**

**/GRID = grid**

**Name of the grid with partitionner.**

**In this case, the structure of data SDFETI is not generated. Calculation with solver FETI is thus not possible.**

#### **3.2 Operand**

**MODEL**

**/**

**MODEL**

**=**

**model**

**Name of the model with partitionner.**

**In this case, the structure of data SDFETI is generated, authorizing a resolution with solver FETI**

#### **3.3 Operand**

**METHOD**

**METHOD =/**

**“SCOTCH TAPE”**

**/“PMETIS”**

## ***/"KMETIS"***

*Allows to define the partitionnor used.*

*Mongrel is developed per G. Karypis and V. KUMAR at the university of Minesota, in Mineapolis:  
<http://www-users.cs.umn.edu/~karypis/metis>*

*Two algorithms are available.*

*Scotch tape is developed at the University of Bordeaux-I by F. Pellegrini:  
[http://www.labri.fr/Perso/~pelegrin/scotch/scotch\\_fr.html](http://www.labri.fr/Perso/~pelegrin/scotch/scotch_fr.html)*

## ***3.4 Operand SOFTWARE***

***SOFTWARE = chemin.exe***

*This order is optional. If it is omitted, the achievable ones will be taken in the repertory tools of Aster. If it is present, then it defines the complete way towards the achievable one partitionnor, on the object computer.*

***Note:***

*It is taken into account only for the method MONGREL bus SCOTCH TAPE is integrated into Code\_Aster in the shape of a bookshop at the compile time.*

## ***3.5 Operand NBPART***

***NBPART = nbpart***

*A number of under-fields wished by the user. The number of under-fields is an entirety equal to or higher than 2.*

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## ***Operator DEF1\_PART\_FETI***

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***Author (S):***

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### ***3.6 Operand***

***NOM\_GROUP\_MA***

***NOM\_GROUP\_MA***

***= `txm `***

***Defined the prefix of the names of the groups of meshes defining the under-fields. By defect, this one is “SD”.***

### ***3.7 Operand***

***TRAITER\_BORD***

***TRAITER\_BORD***

***=/“YES”***

***/“NOT”***

***Allows geometrically to carry out a particular treatment with the meshes of edges (to the direction include in another mesh) before partitioning: those are withdrawn from the grid with partitionner then reinjected after partitioning. This treatment allows stage some difficulties of the partitionnor, who can in certain cases separate a mesh from edge of his mesh father.***

### ***3.8 Operand***

***VERIF\_CONNEX***

***CORRECTION\_CONNEX =/“YES”***

***/“NOT”***

***A not-connexity of a under-field can generate difficulties convergence of seeing plantings of the algorithm of resolution of FETI.***

***Option CORRECTION\_CONNEX makes it possible to check the connexity of the under-fields. In the case***

***of one or more under-field not-related, under additional fields are generated from each not-related block. The under-fields thus obtained can to be unbalanced in terms of a number of elements.***

### ***3.9 Operand GROUPING***

***GROUPING***

***=  
\_F  
(***

***GROUP\_MA = grma,)***

***Allows partitionement to generate one in which meshes of the group of meshes “grma” will be obligatorily placed in the same under-field.***

### ***3.10 Operand EVALUATION***

***POIDS\_MAILLES***

=  
***\_F***  
(

***GROUP\_MA = grma,***  
***WEIGHT***  
***= I***  
***, )***,

***By defect, all the meshes have a weight of 1. This key word factor makes it possible to affect to meshes defined by a group of meshes a weight given by the user. This option allows to generate under-fields of which the number of meshes is not equivalent. One of interests is to be able to generate smaller under-fields where one predicts than calculation will be more difficult (zone of plasticization, etc...).***

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### **3.11 Operand**

#### **NOM\_GROUP\_MA\_BORD**

#### **NOM\_GROUP\_MA\_BORDS**

**=/"name"**

**[TXM]**

*If TRAITER\_BORDS = "YES" (the meshes of edges are withdrawn from the grid with partitionner), this key word optional makes it possible, if it is present, not to reinject the meshes of edges in the under-fields, but to only create other groups of meshes containing meshes of edges of each under-fields.*

*The use of this functionality leads to a SD FETI which is not compatible with solvor FETI, and has only one role of graphic checking of the edges of the under-fields.*

### **3.12 Operand EXCIT**

#### **EXCIT**

**= \_F (**

**CHARGE = char\_meca or char\_cine\_meca,)**

*List loadings applied to the model. These loadings are necessary for creation of the structure of data SDFETI used in solvor FETI.*

### **3.13 Operand**

#### **INFORMATION**

*Level of impression.*

*If: INFORMATION: 2:*

- *times calculations,*
- *the number of meshes of edges,*
- *the number of meshes by under-fields,*

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**Titrate:**

**Operator** *DEFI\_PART\_FETI*

**Date:**

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**Author (S):**

**A. ASSIRE, P. the Key GALLOU**

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#### **4 Example**

```
SDFETI = DEFI_PART_FETI (  
MODEL = model  
NB_PART = 16,  
EXCIT  
= (  
_F (CHARGE=CH1),  
_F (CHARGE=CH2),),  
METHODE=' SCOTCH',  
CORRECTION_CONNEX=' OUI',  
INFO=2,  
)
```

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*Titrate:*

*Operator* **DEFI\_SQUELETTE**

*Date:*

31/01/05

*Author (S):*

**O. NICOLAS, E. BOYERE** *Key*

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*Organization (S):* **EDF-R & D /AMA**

***Instruction manual***

***U4.2- booklet: Grid***

***Document: U4.24.01***

***Operator*** **DEFI\_SQUELETTE**

***1 Goal***

***To define the grid of visualization of the results of a dynamic under-structuring.***

*In the case of the cyclic dynamic under-structuring, the grid is created by using whole or part meshes (grid of visualization) of the structure sector then by repeating it in a cyclic way to reconstitute the total structure.*

*In the case of the general dynamic under-structuring, the grid is created by using all or part of the meshes (grid of visualization) of the various substructures then by associating them of manner to reconstitute the total structure.*

*The meshes used (called meshes of visualization) are not necessarily support of one finite element. This makes it possible to use meshes of visualization in a reduced number, different from meshes of calculation, and representing coarsely the form of the structure (skeleton).*

*One can also create a skeleton starting from an other skeleton which one will amalgamate certain nodes interfaces according to a criterion of proximity.*

*Restriction: The meshes of visualization must be defined starting from nodes supporting of the degrees of freedom of calculation (there is no interpolation of the results).*

*This operator creates a structure of data of the skeleton type.*

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*Operator DEFI\_SQUELETTE*

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*2 Syntax*

***skeleton [skeleton] =***  
***DEFI\_SQUELETTE***

***(/MODE\_CYCL = mocy,***  
***[mode\_cycl]***

***SECTOR***  
***=***  
***\_F (/ MESH***  
***=***

***filed,***  
***[l\_maille]***

***/***  
***GROUP\_MA = grma,***  
***[l\_gr\_maille]***

***/***  
***ALL***  
***=***  
***“YES”,***





/  
***ALL = "YES",***

)

/  
***SKELETON***  
***=***  
***skeleton, [skeleton]***

***RECO\_GLOBAL=***  
***\_F (***  
***/ALL = "YES",***  
***[DEFECT]***

***/GROUP\_NO\_1 = grno1,***  
***[group\_no]***

***SOUS\_STRUC\_1=nom\_sstru1, [kN]***

***GROUP\_NO\_2 = grno2,  
[group\_no]***

***SOUS\_STRUC\_2=nom\_sstru2, [kN]***

***PRECISION =/prec,  
[R]  
/  
1.D-3,  
[DEFECT]***

***CRITERION*** =/“***RELATIVE***”, [***DEFECT***]  
/  
“***ABSOLUTE***”,

***DIST\_REFE*** = *dist\_refe*, [***R***]

***/NOM\_GROUP\_MA***  
= ***\_F*** (

***NAME*** = “*named*”,

***[KN]***

***SOUS\_STRUC*** = *nomsst*,

**[KN]**

**GROUP\_MA =**  
**grma,**

**[l\_gr\_maille]**

**/**  
**GRID**  
**=**  
**grid, [grid]**

**//**  
**NET**  
**=**  
**“mesh”,**  
**[l\_maille]**

**/**  
**GROUP\_MA**  
**=**  
**grma**  
**,**  
**[l\_gr\_maille]**  
**/**  
**ALL**  
**=**  
**“YES”,**

## **TRANS**

=

(has,

B,

c),

[l\_R]

ANGL\_NAUT = (,), [l\_R]

## **TITRATE**

=

“title”

[KN]

)

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## **3 Operands**

### **3.1 Under-structuring cyclic**

#### **3.1.1 Operand**

**MODE\_CYCL**

*MODE\_CYCL = mocy*

*Concept mode\_cycl resulting from a calculation in cyclic under-structuring.*

### **3.1.2 Word**

*key*

**SECTOR**

*SECTOR*

*Key word factor for the creation of a skeleton starting from a result of the mode\_cycl type produced by MODE\_ITER\_CYCL [U4.52.05]. Allows to define on the basic sector the list of the meshes of visualization which will be repeated in a cyclic way.*

#### **3.1.2.1 Operands**

**ALL/MESH/GROUP\_MA**

*/*

*ALL*

*All the meshes of the grid of the basic sector will be meshes of visualization.*

*/| MESH*

*=*

*filed*

*List meshes of visualization of the basic sector.*

*/*

*GROUP\_MA = grma*

*List groups of meshes of visualization of the basic sector.*

### **3.2 Under-structuring traditional**

#### **3.2.1 Operand**

**MODELE\_GENE**

*MODELE\_GENE = mogene*

*Name of the concept modele\_gene resulting from DEFI\_MODELE\_GENE [U4.65.02] defining the structure*

*total on which one wishes to define the skeleton.*

#### **3.2.2 Word**

**key**  
**SOUS\_STRUC**

**SOUS\_STRUC**

*Key word factor for the creation of a skeleton following a calculation by dynamic under-structuring traditional.*

*Allows to define on each substructure of the model generalized the list of the meshes of visualization.*

### **3.2.2.1 Operand**

**NAME**

*NAME = nom\_struc*

*Name of the substructure. It must be identical to the one of the names of the substructures defining it generalized model (see **DEFI\_MODELE\_GENE** [U4.65.02]).*

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### **3.2.2.2 Operands**

**ALL/MESH/GROUP\_MA**

/

**ALL**

*All the meshes of the grid of the substructure will be meshes of visualization.*



*/| MESH*

*=*

*filed*

*List meshes of visualization of the substructure.*

*/*  
*GROUP\_MA = grma*

*List groups of meshes of visualization of the substructure.*

### **3.3 Word**

*key*

**GRID**

*It is about a functionality for the Aster/CADYRO interface (software of dynamic analysis of the lines of revolving shaft). That makes it possible to visualize a modal deformation on whole or part grid given under the key word GRID.*

#### **3.3.1 Operands**

**NET/GROUP\_MA/ALL**

*These key words specify the parts of the grid on which one wants to visualize the modal deformation.*

#### **3.3.2 Operand**

**TRANS**

*List of 3 realities giving the co-ordinates of the vector translation applied to the characterized structure by the grid given (if this one has a final position different from its initial position).*

#### **3.3.3 Operand**

**ANGL\_NAUT**

*List of 3 realities giving the 3 nautical angles allowing to make a rotation of the grid of structure if necessary.*

**Note:**

*When one wishes to print the skeleton thereafter with the order IMPR\_MACR\_ELEM with format CADYRO, only triplattes of nautical angles (0, 0, 0), (0, 90, 0) or (0, 90, 180) are accepted.*

### **3.4 Words**

## **keys**

### ***SKELETON and RECO\_GLOBAL***

*The key word SKELETON defines an initial concept of skeleton type where one will amalgamate the nodes of*

*interfaces by key word RECO\_GLOBAL, either all these nodes (ALL = "YES"), or selectively one group nodes grno1 (operand GROUP\_NO\_1) of the substructure nom\_sstru1 (operand SOUS\_STRUC\_1) with a group of nodes grno2 (operand GROUP\_NO\_2) of the substructure nom\_sstru2 (operand SOUS\_STRUC\_2).*

*These substructures must belong to the concept of the modele\_gene type informed by the operand MODELE\_GENE.*

*The skeleton modified by fusion will be the result of operator DEFI\_SQUELETTE.*

### **3.4.1 Operands DIST\_REFE/CRITERION/PRECISION**

*Fusion will be made according to a criterion of proximity either absolute (compared to dist\_ref) or relative (by report/ratio with dist\_ref\*prec).*

## **3.5 Word**

### **key**

#### ***NOM\_GROUP\_MA***

*If one modifies an initial concept of skeleton type (entered by the key word SKELETON) by a fusion of the nodes of the interfaces (by means of key word RECO\_GLOBAL), one can then recover groups of meshes (entered by operand GROUP\_MA) in the substructure nomsst (entered by operand SOUS\_STRUC) in their naming new of group of meshes (operand NAME) in the skeleton result.*

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#### 4 Example

*The command file which follows calculates, by two methods of under-structuring, the modes of inflection of a plate embedded in its center =*

*.  
cyclic method,*

*.  
traditional method.*

*Then by order DEFI\_SQUELETTE, there is creation of a grid of visualization (grid skeleton). After having expressed the results in physical space, grid of visualization and results are versed in a file RESULT with format IDEAS.*

#### 4.1

##### Command file

...

```
#
# CALCULATION BY CYCLIC SOUS-STRUCTURATION
#
# CALCULATION OF THE CYCLIC CLEAN MODES
#
mod_cy = MODE_ITER_CYCL (BASE_MODALE= bamo,
NB_MODE = 5, NB_SECTEUR = 4,
CONNECTION = _F (RIGHT = ' DROITE', LEFT = ' GAUCHE'),
CALCULATION = _F (TOUT_DIAM = ' OUI', NMAX_FREQ = 2),
INFORMATION = 1)
#
# CREATION OF THE GRID OF CALCULATION
#
squel1 = DEFI_SQUELETTE (MODE_CYCL= mod_cy,
SECTOR = _F (GROUP_MA= "CALCULATION"))
#
# CREATION OF THE GRID OF VISUALIZATION
#
squel2 = DEFI_SQUELETTE (MODE_CYCL= mod_cy,
SECTOR = _F (GROUP_MA= "VISUAL"))
#
# RESTITUTION OF THE RESULTS ON THE GRIDS SKELETONS
```

#  
*modgl1 = REST\_BASE\_PHYS (RESU\_GENE= mod\_cy, SQUELETTE= squel1)*  
*modgl2 = REST\_BASE\_PHYS (RESU\_GENE= mod\_cy, SQUELETTE= squel2)*  
#

...

**# CALCULATION BY TRADITIONAL SOUS-STRUCTURATION**  
#  
**# CALCULATION OF THE MACRONUTRIENT**

#  
*macele = MACR\_ELEM\_DYNA (BASE\_MODAL= bamo)*  
#

**# CALCULATION OF THE MODEL GENERALIZES**

#  
*modege = DEFI\_MODELE\_GENE (SOUS\_STRUC=\_F (NOM=' CARRE1',*  
*MACR\_ELEM\_DYNA= macele),*  
*SOUS\_STRUC= (NOM=' CARRE2',*  
*MACR\_ELEM\_DYNA= macele,*  
*ANGL\_NAUT= (90. , 0. , 0.)),*  
*SOUS\_STRUC= (NOM=' CARRE3',*  
*MACR\_ELEM\_DYNA= macele,*  
*ANGL\_NAUT= (180. , 0. , 0.)),*  
*SOUS\_STRUC= (NOM=' CARRE4',*  
*MACR\_ELEM\_DYNA= macele,*  
*ANGL\_NAUT= (270. , 0. , 0.)),*  
*LIAISON=\_F (SOUS\_STRUC\_1=' CARRE1', SOUS\_STRUC\_2=' CARRE2',*  
*INTERFACE\_1 = ' GAUCHE', INTERFACE\_2 = ' DROITE'),*

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*Author (S):*  
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:

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```
LIAISON=_F (SOUS_STRUC_1=' CARRE2', SOUS_STRUC_2=' CARRE3',  
INTERFACE_1 = ' GAUCHE', INTERFACE_2 = ' DROITE'),  
LIAISON=_F (SOUS_STRUC_1=' CARRE3', SOUS_STRUC_2=' CARRE4',  
INTERFACE_1 = ' GAUCHE', INTERFACE_2 = ' DROITE'),  
LIAISON=_F (SOUS_STRUC_1=' CARRE4', SOUS_STRUC_2=' CARRE1',  
INTERFACE_1 = ' GAUCHE', INTERFACE_2=' DROITE'))
```

**#**

**...**

### **# CREATION OF THE GRID OF VISUALIZATION**

```
squel = DEFI_SQUELETTE (MODELE_GENE=MODEGE  
SOUS_STRUC=_F (NAME = ' CARRE1', GROUP_MA= "VISUAL"),  
SOUS_STRUC=_F (NAME = ' CARRE2', GROUP_MA= "VISUAL"),  
SOUS_STRUC=_F (NAME = ' CARRE3', GROUP_MA= "VISUAL"),  
SOUS_STRUC=_F (NAME = ' CARRE4', GROUP_MA= "VISUAL"))
```

**#**

### **# RESTITUTION OF THE RESULTS ON THE GRID SKELETON**

**#**

```
modglo = REST_BASE_PHYS (RESU_GENE= resgen, SQUELETTE= squel)
```

**#**

## **4.2 Results**

### **graphs**

**Deformation of mode 2**

**Deformation of mode 2**

**on the grid of calculation**

**on the grid skeleton**

**Grid of calculation**

**Grid skeleton**

**One presents above the grids of calculation and skeleton of the plate embedded with respectively modal deformations of the second mode.**

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**8.2**

***Titrate:***  
***Operator DEF1\_FLUI\_STRU***

***Date:***  
***31/01/06***  
***Author (S):***  
***A. Key ADOBES***  
***:***  
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***Organization (S): EDF-R & D /MFTT***

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***Document: U4.25.01***

***Operator DEF1\_FLUI\_STRU***

***1 Goal***

***To define the characteristics necessary to the dynamic study of a structure under flow.***

***By the choice of one of the key words factors, the user specifies the type of configuration “structure-flow” studied: beam of tubes under transverse or axial flow, bunch of***

*order, coaxial hulls.*

*According to the type of configuration, the provided data make it possible to realize downstream:*

*.  
a fluid study of coupling/structure: estimate of the coefficients of forces fluid-rubber bands and calculation of the new modal parameters of the structure using the operator CALC\_FLUI\_STRU [U4.66.02],*

*.  
projection on the modal basis under flow of one or several excitations turbulent defined by their (S) density (S) spectral (S): operators DEFI\_SPEC\_TURB [U4.44.31] and PROJ\_SPEC\_BASE [U4.63.14]. One can then calculate the answer of structure with the turbulent excitation, as well into temporal as into frequential.*

*Operator “DEFI\_FLUI\_STRU” produces a concept of the type flui\_stru type intended to be used downstream by operators FONC\_FLUI\_STRU [U4.35.02], CALC\_FLUI\_STRU [U4.66.02] or, indirectly, PROJ\_SPEC\_BASE [U4.63.14].*

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*Operator DEFI\_FLUI\_STRU*

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*A. Key ADOBES*

*:*

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*2 Syntax*

*typeflui [type\_flui\_stru] = DEFI\_FLUI\_STRU*

*(*

*/FAISCEAU\_TRANS: \_F*

**COUPLING**

=  
/  
"YES"  
/  
"NOT"  
,

**CARA\_ELEM**

=  
*will cara*  
,  
[*cara\_elem*]

**PROF\_VITE\_FLUI = profv**  
, [function, formula]

**PROF\_RHO\_F\_INT**

=  
*profrhoi*,  
[function, formula]

**PROF\_RHO\_F\_EXT**

=  
*profrhoe*,  
[function, formula]



***NOM\_CMP =***

***/***

***“DX”***

***[KN]***

***/***

***“DY”***

***/***

***“DZ”***

***,***

***COEF\_MASS\_AJOU = cm***

***,***

***[R]***

***CSTE\_CONNORS***

***=***

***cste***

***,***

***[l\_R]***

***RHO\_TUBE***

***=***

***rho***

***,***

***[R]***

***NB\_CONNORS = Nb***

***,***

***[I]***

/  
**TYPE\_PAS**  
=  
/  
“**CARRE\_LIGN**”  
/  
“**TRIA\_LIGN**”  
,

**TYPE\_RESEAU**  
=  
/  
**tr**  
**[I]**

**NOT**  
=  
**not**  
,  
**[R]**

),

**/BUNCH**  
=

*\_F*  
(

*COUPLING*

=

/

*“YES”*

*[KN]*

/

*“NOT”*

,

*/GRAPPE\_2*

=

/

*“ASC\_CEN”*

*[KN]*

/

*“ASC\_EXC”*

/

*“DES\_CEN”*

/

*“DES\_EXC”*

,

*NODE*

=

*No*

,

*[node]*

*CARA\_ELEM*  
=  
*will cara*  
,  
*[cara\_elem]*

*MODEL*  
=  
*model*  
,  
*[model]*

*COEF\_MASS\_AJOU=*  
*cm1*  
,  
*[R]*

*RHO\_FLUI*  
=  
*rho\_f*  
, *[R]*

),  
/  
*FAISCEAU\_AXIAL*  
=  
*\_F*  
(

*/GROUP\_MA*  
=  
*l\_grma, [l\_gr\_ma]*  
/  
*TRI\_GROUP\_MA*  
=  
/  
“*racine\**”  
/  
“*\*racine\**”  
/  
“*\*racine*”  
,

*VECT\_X*  
=  
*l\_comp, [l\_R]*

*PROF\_RHO\_FLUI = profrho*  
,  
*[function]*

*PROF\_VISC\_CINE = profvisc,*  
*[function, formula]*

*/CARA\_ELEM*

=

*will cara*

,  
*[cara\_elem, formula]*

/  
*RAYON\_TUBE =*

*ray*  
, *[R]*

*COOR\_TUBE*

=

*l\_coor*

,  
*[L\_R]*

*GRAVITY*

=

*l\_g*

,  
*[L\_R]*

*ROUGHNESS*

=

*rug*

,  
*[R]*

*CARA\_PAROI =*  
*will l\_cara*  
,  
*[l\_TXM]*

*VALE\_PAROI =*  
*l\_vale*  
,  
*[l\_R]*

*ANGL\_VRIL*  
=  
*alpha*  
, *[R]*

),  
/  
*COQUE\_COAX*  
=  
*\_F*  
(

*MASS\_AJOU*  
=  
/  
"YES"

[DEFECT]

/

“NOT”

,

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*GROUP\_MA\_INT*

=

*gr\_ma\_i*

,

[*gr\_ma*]

*GROUP\_MA\_EXT*

=

*gr\_ma\_e*

,

[*gr\_ma*]



*VECT\_X*

=

*l\_comp*

,

*[l\_R]*

*CARA\_ELEM*

=

*will cara*

,

*[cara\_elem]*

*MATER\_INT*

=

*mater\_i*

,

*[to subdue]*

*MATER\_EXT*

=

*mater\_e*

,

*[to subdue]*

*RHO\_FLUI*

=

*rho\_f*

, *[R]*

*VISC\_CINE*

=

*visco*  
, [R]

*ROUGHNESS*  
=  
*rug*  
,  
[R]

*PDC\_MOY\_1*  
=  
*cde*  
,  
[R]

*PDC\_DYN\_1*  
=  
*cdep*  
,  
[R]

*PDC\_MOY\_2*  
=  
*cds*  
,  
[R]

*PDC\_DYN\_2*  
=  
*cdsp*  
,

[R]

),

*INFORMATION*

=

/

1

[DEFECT]

/ 2 ,

[I]

)

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### **3 Operands**

#### **3.1 Key word**

**FAISCEAU\_TRANS**

**/FAISCEAU\_TRANS**

*Key word factor allowing to characterize a configuration of the type “beam of tubes under transverse flow”. If the study is based on the definition of several zones of excitation, it as many occurrences of the key word factor FAISCEAU\_TRANS of zones is necessary.*

**COUPLING = “YES” or “NOT”**

*Indicator of the type text [TXM] specifying the taking into account or not forces fluid-rubber bands. This operand must appear in at least one of the occurrences of key word factor FAISCEAU\_TRANS, and can be omitted in the others.*

**CARA\_ELEM = will cara**

*Concept of the type [cara\_elem] allowing to provide all the data relative to geometry of the elements of the structure: useful for the estimate of the hydraulic diameter. This operand must appear in at least one of the occurrences of the key word factor FAISCEAU\_TRANS, and can be omitted in the others.*

**PROF\_VITE\_FLUI = profv**

*Concept of the type [function] allowing to provide the adimensionné profile speed transverse along the tube. The parameter of the function is the curvilinear X-coordinate. This operand must appear in all the occurrences of the key word factor FAISCEAU\_TRANS.*

**PROF\_RHO\_F\_INT = profrhoi**

*Concept of the type [function] allowing to provide the profile of density of fluid interns with the tube, along the tube. The parameter of the function is the X-coordinate curvilinear. This operand must appear in at least one of the occurrences of the word key factor FAISCEAU\_TRANS, and can be omitted in the others.*

*PROF\_RHO\_F\_EXT = profrhoe*

*Concept of the type [function] allowing to provide the profile of density of external fluid with the tube, the tube. The parameter of the function is the X-coordinate curvilinear. This operand must appear in at least one of the occurrences of the word key factor FAISCEAU\_TRANS, and can be omitted in the others.*

*NOM\_CMP = "DX" or "DY" or "DZ"*

*Indicator of the type text [TXM] specifying the direction according to which the forces act fluid-rubber bands and/or turbulent forces. This operand must appear in with less one of the occurrences of the key word factor FAISCEAU\_TRANS, and can be omitted in the others.*

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*COEF\_MASS\_AJOU = cm*

*Value of the coefficient of added mass cm. This operand, if it is used, can not be defined that in one of the occurrences of the key word factor FAISCEAU\_TRANS, and can to be omitted in the others.*

*CSTE\_CONNORS*

=

*cste*

*List of two realities defining the interval of the constants of Connors for the method of even name (see R4.07.04).*

*RHO\_TUBE*

=

*rho*

*Density of the tube for the method of Connors*

*NB\_CONNORS = Nb*

,

*[I]*

*Poins of discretization inside the interval numbers defined by the key word CSTE\_CONNORS presented above.*

/

*TYPE\_PAS = “CARRE\_LIGN” or “TRIA\_LIGN”*

*Indicator of the type text [TXM] allowing to specify the type of step of beam, defined by the arrangement of the tubes the ones compared to the others and by the direction of the flow compared to the beam. This operand can appear only in one of the occurrences of the key word factor FAISCEAU\_TRANS, and can be omitted in the others.*

*“CARRE\_LIGN” = not square line.*

*“TRIA\_LIGN” = not triangular line.*

*TYPE\_RESEAU = tr*

*Whole indicator strictly lower than 1000 and positive defining experimental configuration for which coefficients of coupling used for the study were obtained [bib1]. This operand must appear in all occurrences of the key word factor FAISCEAU\_TRANS.*

**Note:**

*“tr” must appear in two files “cd.70” and “ck.71” which allows to describe the evolution of damping and the stiffness added by the flow according to the fallback speed Vr, the latter being calculated from speed inter-tubes.*

*The files “cd.70” and “ck.71” are read by the logical units 70 and 71. They have both the following structure:*

***Line 1 of the file:*** a number of correlations present as a whole of file (whole)

*\*\*\* then, for each one of these correlations, a block made up of \*\*\**

***Line 1 of the block:*** type of step of the network associated with the correlation (1 if TYPE\_PAS= “CARRE\_LIGN”, 2 if TYPE\_PAS= “TRIA\_LIGN”)

***Line 2 of the block***

*: tr (whole well informed on the level of the operand “TYPE\_RESEAU”)*

***Line 3 of the block:*** nbplages (a number of contiguous beaches fallback speed on which added damping and the stiffness were interpolated by the user in polynomial form)

**Line 4 of the block:** *nbplages real, followed from two real A and B; nbplages the first realities correspond to the values fallback speed - ordinates by order ascending - lower limits of the contiguous nbplages; two realities With and B are respectively smallest and largest values speed*

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*reduced for which added damping and the stiffness were given in experiments on a test bench in thermohydraulic similarity; they thus delimit the beach fallback speeds inside which correlation can be interpolated starting from the values identified on test bench. In general, one thus chooses the first of the real nbplages equal to A and the last real nbplages equal to B.*

**Nbplages following lines**

*: each line corresponds to the interpolation*

*polynomial of the correlation of damping or the stiffness added in beach considered, the first beach fallback speeds extending between first and the second of the real nbplages. On each line, 11 coefficients are to inform. These coefficients are them (I)  $l_i$  11*

*defining the polynomial used*

*for the interpolation in the beach considered. Thus, for the example, indicating  $C_d$  the damping added by the flow. The expression which will be taken by it in count according to the fallback speed  $V_r$  is as follows (the expression for added stiffness is similar):*

$C_d(V_r)$  11

*(i-4)*



= I Vr

i=1

Following line: a line allowing to delimit the blocks associated with each correlation, in general of the form: “\*\*\*\*\*”

\*\*\* fine of the block \*\*\*

If there are other correlations, Ligne 1 of the block corresponding to the correlation following.

On the basis of number certain of tests, EDF worked out and validated a unit correlations fluid-rubber bands allowing to simulate damping and stiffness added to a structure by a flow. Supply of these correlations in the shape of two files of a format conforms with that specified Ci high will be studied on a case-by-case basis according to the request.

NOT = not

Step value reduced of the beam: report/ratio enters, on the one hand the distance between centres between 2

close tubes, and in addition the diameter external of the tubes. This operand can appear only in one of the occurrences of the key word factor FAISCEAU\_TRANS, and can be omitted in the others.

### **3.2 Key word**

#### **BUNCH**

/BUNCH

Key word factor allowing to characterize a configuration of the type “control rod”.

COUPLING = “YES” or “NOT”

Indicator of the type text [TXM] specifying the taking into account of the forces fluid-rubber bands. The coupling fluid-rubber band, if it is taken into account, utilizes the coefficients adimensional of forces fluid-rubber bands identified on model GRAPPE2, which are used to represent a resulting force and a moment [bib2].

If COUPLING = “YES”, it is necessary to inform the following operands obligatorily, with exception of COEF\_MASS\_AJOU which remains optional.

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*/GRAPPE\_2 = "ASC\_CEN" or "ASC\_EXC" or "DES\_CEN" or "DES\_EXC"*

*Four possible choices corresponding to the various configurations experimental for which the coefficients of forces fluid-rubber bands have summer identified:*

.

*ascending flow stem of Centered order;*

.

*ascending flow stem of Offset order;*

.

*flow Descending stem from Centered order;*

.

*flow Descending stem from Offset order.*

*NODE = No*

*Identifier of the node (concept of the type [node]) where are applied the force and moment resulting representing the action from the forces fluid-rubber bands.*

*CARA\_ELEM = will cara*

*Concept of the type [cara\_elem] providing all the data relative to geometry of the elements of the structure: useful for the estimate of the diameter of stem of order. This concept brings inter alia relative information with the orientations of the elements.*

*MODEL = model*

*Concept of the type [model] providing information relating to the types of elements of the structure.*

$COEF\_MASS\_AJOU = cm1$

*Value of the coefficient of added mass due to the local containment of the stem of order on the level of the plate of housing. If modal characteristics out of water at rest of the structure were calculated with the density equivalent.*

2

$D$   
 $eq =$   
 $water + beam$   
 $4S$

*The coefficient  $cm1$  of mass added due to local containment to the level of plate housing is given by the relation:*

$(D$   
 $-$   
 $2H$   
 $)$   
 $cm1 =$

2

*where  $D$  indicates the diameter external of the stem;  $S$  is the surface of the cross-section tube and  $H$  represent the thickness of fluid film on the level of containment.*

**Note:**

*When the user does not inform operand  $COEF\_MASS\_AJOU$ ,  $cm1$  is estimated automatically using this expression with  $= 1$ .*

$RHO\_FLUI = rho\_f$

*Value of the density of the fluid surrounding the structure.*

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### **3.3 Key word**

**FAISCEAU\_AXIAL**

*/FAISCEAU\_AXIAL*

*Key word factor allowing to characterize a configuration of the type “beam of tubes under axial flow” [bib2].*

**Note:**

*If the study is carried out using a representation of the complete beam, one authorize only one occurrence for this key word factor.*

*If the study is based on a simplified representation, one needs as many occurrences as there is tubes in the simplified beam. Each tube of the simplified beam defines a class of equivalence for the tubes of the real beam. Characteristics of the tubes of the beam reality for the same class of equivalence (common ray, positions) are the subject of one occurrence of the key word factor.*

*To be able to use a simplified representation of the beam, it is necessary that the modal base calculated in air is equivalent to the modal base in air complete of the real beam; each tube of the simplified beam must thus be a tube equivalent to each class of real tubes. For example, for a class of NR real tubes, Young modulus E and of density, a possible equivalent tube is characterized by a Young modulus And a density NR.*

*/GROUP\_MA = l\_grma*

*If the study relates to the complete beam: list groups of meshes corresponding to the tubes of the beam (concepts of the type [group\_ma]).*

*If the study is based on a simplified representation: the use of this operand is obligatory and excludes the recourse to TRI\_GROUP\_MA. One is awaited concept of the type [group\_ma] corresponding to the one of the equivalent tubes of simplified beam.*

/

*TRI\_GROUP\_MA = "racine\*" or "\*racine\*" or "\*racine"*

*Argument of the type text [TXM] defining the root of the names of the groups of meshes corresponding to the tubes of the beam. The use of this operand is not sell by auction that if the study is carried out using a representation of the beam complete. The root can be a prefix, an intermediate character string or a suffix.*

*VECT\_X = l\_comp*

*List of three realities giving the components of the directing vector of the beam in total reference mark. The beam having to be directed according to one of the axes of the total reference mark, only three sets of components are acceptable: (1. , 0. , 0.) , (0. , 1. , 0.) or (0. , 0. , 1.). This operand is obligatory if the study relates to the complete beam, and must appear with less in one of the occurrences of the key word factor if the study rests on one simplified representation.*

*PROF\_RHO\_FLUI = profrho*

*Concept of the type [function] defining the profile of density of the fluid surrounding the tubes. The parameter of the function is the co-ordinate of space corresponding to the axis of the total reference mark directing the beam of tubes. This operand is obligatory if the study relates to the complete beam, and must appear at least in one occurrences of the key word factor if the study is based on a simplified representation.*

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*PROF\_VISC\_CINE = profvisc*

*Concept of the type [function] defining the kinematic profile of viscosity of the fluid surrounding the tubes. The parameter of the function is the co-ordinate of space corresponding to the axis of the total reference mark directing the beam of tubes. This operand is obligatory if the study relates to the complete beam, and must appear at least in one occurrences of the key word factor if the study is based on a simplified representation.*

*/CARA\_ELEM = will cara*

*Concept of the type [cara\_elem] providing all the data relative to geometry of the elements of the structure: ray of each tube. This concept is to be provided only if the study relates to the complete beam.*

*/*  
*RAYON\_TUBE = ray*

*Ray of the tubes of the real beam for the same class of equivalence. This operand is used only if the study rests on one simplified representation.*

*COOR\_TUBE = l\_coor*

*List co-ordinates of the centers of the tubes of the real beam pertaining to the same class of equivalence. This operand is used only in the case where the study is based on a simplified representation.*

*GRAVITY = l\_g*

*List of four realities defining the standard and the orientation of the vector gravity **G** in total reference mark. It is necessary to provide in the order the data (G, ap, LP, CP) such as:*

*p X + LP Y has + CP Z*  
***G** = G*

*a2*  
*2*  
*2*  
*p + B p + C p*

*The default values are: G = 9.81; ap = 0. ; LP = 0. ; CP = 1.*

*RUGO\_TUBE = rug*

*Value of the absolute roughness of the walls of the tubes, being used for the estimate of the coefficient of axial friction. This operand is obligatory if the study relates to the beam complete, and must appear at least in one of the occurrences of the key word factor if the study is based on a simplified representation. A characteristic value for one smooth steel is 105 meter.*

*CARA\_PAROI = will l\_cara*

*List arguments of the type text [TXM] giving the names of the characteristics geometrical of the enclosure wrapping the beam. The licit arguments are them following:*

*.  
“YC”, “ZC” and “R” in the case of a circular enclosure: “YC”, “ZC”  
co-ordinates of the center in any plan  $X = x_0$  along the axes of the total reference mark perpendiculars with the beam and ordered such as (X, Y, Z) is direct if X is the axis of the total reference mark directed according to the beam. “R” ray.*

*.  
“YC”, “ZC”, “HY” and “HZ” in the case of a rectangular enclosure: “YC”,  
Coordinated “ZC” of the center in any plan  $X = x_0$ . “HY”, “HZ” dimensions of sides of the enclosure parallel respectively with the directions Y and Z.*

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*VALE\_PAROI = l\_vale*

*List realities giving the values of the geometrical characteristics, in correspondence with the list of the names received for CARA\_PAROI.*

$ANGL\_VRIL = \alpha$

*Swing angle (in degrees) around the directing axis of the beam for an enclosure rectangular. This operand is obligatory if one defines a rectangular enclosure by CARA\_PAROI and VALE\_PAROI. It is prohibited in the case of a circular enclosure.*

**Note:**

*Operands CARA\_PAROI and VALE\_PAROI are obligatory when the study carries on the complete beam. When the study is based on a simplified representation, these operands must appear together in at least one of the occurrences of key word factor FAISCEAU\_AXIAL. Operand ANGL\_VRIL must also be present under the same occurrence if a rectangular enclosure is defined.*

**Example:**

Total reference mark (X, y,)

Z beam axis y

X

HY

HZ

ZC

alpha

YC

Z

**Note:**

*If the study is carried out with the taking into account of the grids of the beam tubes, the user must inform each of the eight operands which follow. One recall that the geometry of a grid is a prismatic network at square base. It can exist several types of grid; for example, grids of end and them grids of mixture in the fuel assemblies. Grids of the same type are characterized by identical dimensions and coefficients.*

$LONG\_TYPG = l\_hg$

*List realities giving the lengths of each type of grid of the beam of tubes. length of a grid is its dimension according to the direction of the beam.*

$LARG\_TYPG = l\_dg$

*List realities giving the widths of each type of grid. The width of a grid is its*



*dimension in the plan perpendicular to the beam axis (i.e. the length of dimensioned network).*

$$EPAIS\_TYPG = l\_tg$$

*List realities giving the thicknesses of each type of grid. What is called thickness of grid, it is the thickness of the network constituting the grid in a section perpendicular with the beam axis.*

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***Example of grid:***

*Total reference mark (X, y,)*

**Z beam axis y**

**y**

**dg**

**Hg**

**tg**

**roast**

$$RUGO\_TYPG = l\_rugg$$

*List realities giving the height of roughness of each type of grid. These roughnesses are used for the estimate of the coefficient of axial friction of each grid.*

*COEF\_TRAI\_TYPG = l\_cdg*

*List realities giving the coefficient of drag of each type of grid. These coefficients of trail allow to calculate the efforts of trail exerted by each grid on the axial flow of the fluid.*

*COEF\_DPOR\_TYPG = l\_cpg*

*List realities giving the slope (with null incidence) of the coefficient of bearing pressure of each type of grid, which one supposes slightly tilted. These coefficients allow to calculate the efforts of bearing pressure exerted by each grid on the flow of the fluid.*

*COOR\_GRILLE = l\_zg*

*List co-ordinates “y” (along the beam axis) of the points of discretization of each grid. These co-ordinates correspond to the points mediums (with semi-length) grids.*

*TYPE\_GRILLE = l\_itypg*

*List entreties defining the type of each grid.*

### **3.4 Key word**

**COQUE\_COAX**

*/COQUE\_COAX*

*Key word factor allowing to characterize a configuration made up of two hulls cylindrical coaxial separated by an annular play in which a fluid [bib2] runs out.*

*MASS\_AJOU = “YES” or “NOT”*

*Indicator of the type text [TXM] by which the user specifies the taking into account or not effects of added mass, in addition to the effects of added damping and stiffness.*

*GROUP\_MA\_INT = gr\_ma\_i*

*Identifier of the group of meshes (concept of the type [group\_ma]) corresponding to internal hull.*

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*GROUP\_MA\_EXT = gr\_ma\_e*

*Identifier of the group of meshes (concept of the type [group\_ma]) corresponding to external hull.*

*VECT\_X = l\_comp*

*List of three realities giving the components of the directing vector of the axis of revolution of the two hulls in the total reference mark. The axis of revolution of the hulls having to be one axes of the total reference mark, only three sets of components are acceptable: (1. , 0. , 0.) , (0. , 1. , 0.) or (0. , 0. , 1.).*

*CARA\_ELEM = will cara*

*Concept of the type [cara\_elem] bringing all the geometrical characteristics of elements.*

*MATER\_INT = mater\_i*

*Concept of the type [to subdue] bringing all the physical sizes characteristic of material constitutive of the internal structure.*

*MATER\_EXT = mater\_e*

*Concept of the type [to subdue] bringing all the physical sizes characteristic of material constitutive of the external structure.*

*RHO\_FLUI = rho\_f*

*Density of the fluid.*

*VISC\_CINE = visco*

*Kinematic viscosity of the fluid.*

*ROUGHNESS = rug*

*Absolute roughness of wall of the hulls. A characteristic value for a smooth steel is 105 meter.*

*PDC\_MOY\_1 = cde*

*Stationary part (average) of the singular loss ratio of load of entry.*

*PDC\_DYN\_1 = cdep*

*Non stationary part (dynamic) of the singular loss ratio of load of entry.*

*PDC\_MOY\_2 = cds*

*Stationary part (average) of the singular loss ratio of load of exit.*

*PDC\_DYN\_2 = cdsp*

*Non stationary part (dynamic) of the singular loss ratio of load of exit.*

*Instruction manual*

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**Code\_Aster** ®

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8.2

*Titrate:*

*Operator DEFI\_FLUI\_STRU*

*Date:*

31/01/06

*Author (S):*

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**Note:**

1)

*Values of the various average singular loss ratios of load and*

dynamic are given, in complements, for various configurations geometrical usual of entry and exit (see hereafter [§6]).

2) By convention, a mean velocity of flow positive means that the flow is done in the direction growing of the parameter of space along the axis of revolution of the structures. Contrary, a mean velocity of flow negative means that the flow is done in the direction decreasing of the parameter of space. The sign mean velocity of flow thus fixes the positions of entry and exit. So that there is no ambiguity on these positions, one will take care in `CALC_FLUI_STRU` [U4.80.03] to define a beach of the same speeds signs.

3)  
Model `MOCCA_COQUE` used for the resolution of the coupling fluid-structure require, for each mode selected, to identify the order of hull on the deformation.

`NR`  
The identifiable orders of hull  $k_i$  are such as:  $k_i$   
where `NR` indicates it

2  
a number of nodes of the grid on a circumference, i.e at a fixed altitude.

`NR`  
orders of hull  $k_i$  precisely identified are such as  $k_i$   
, with the same one

4  
definition for `NR`.  
One advises to use a grid with at least 20 nodes on the circumferences hulls. A minimum number of 8 nodes is necessary.

### **3.5 Key word INFORMATION**

`INFORMATION` = 1 or 2

Level of impression.  
If `INFORMATION` = 2 one prints the characteristics of the configuration in the file `MESSAGE`.  
If `INFORMATION` = 1 step of impression.

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**Code\_Aster** ®

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8.2

Titrate:  
Operator `DEFI_FLUI_STRU`

*Date:*

*31/01/06*

*Author (S):*

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## ***4 Complements concerning the configurations of the type “beams of tubes under transverse flow”***

### ***4.1***

#### ***Definition of the characteristics of the beam***

*Four operands TYPE\_PAS, TYPE\_RESEAU, NOT and COEF\_MASS\_AJOU are optional. None value is not taken by defect. At the time of the definition of these characteristics, three use potential are offered:*

*.*

***TYPE\_PAS, TYPE\_RESEAU and NOT are present. COUPLING = “YES”***

*The forces fluid-rubber bands will be taken into account during a dynamic calculation. The coefficient of mass added is calculated according to the step and of the type of step.*

*.*

***TYPE\_PAS, TYPE\_RESEAU, NOT and COEF\_MASS\_AJOU are present. COUPLING = “YES”***

*The forces fluid-rubber bands will be taken into account during a dynamic calculation. The coefficient of mass added is defined by the user.*

*.*

***COEF\_MASS\_AJOU is present. COUPLING = “NOT”***

*Only the added mass due to the fluid is taken into account (not coupling).*

*Instruction manual*

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**Code\_Aster** ®

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***Complements concerning the configurations "hulls  
cylindrical coaxial "***

*One provides hereafter the values of the singular loss ratios of load for some particular geometrical configurations of input-output.*

5.1

***Singular loss ratios of load of entry***

*R*

*0*

***Configuration (1)***

***cde = 0,5***

***cdep = 0***

*Hull*

*Hull*

*intern*

*external*

*Z*

*R1*

*H1*

*0*

*R*  
**Configuration (2)**

**R H**  
H2  
**cde = 0,5 I -**  
2  
2

**R H**  
1  
1  
R2  
**cdep = 0**  
Z

*Instruction manual*  
*U4.2- booklet: Grid HT-62/06/004/A*

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*Version*  
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*Titrate:*  
*Operator DEFI\_FLUI\_STRU*

*Date:*  
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*Author (S):*  
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*R*  
**Configuration (3)**  
**cde = 0**  
**cdep = 0**  
Z



*R1*

*H1*

*R*

*0*

***Configuration (4)***

***R H2 R H2***

***R H***

*2*

***cde = 1 -***

*1*

***1 2 2 = 2 2 -***

*1*

***R H***

*2*

***2 R H***

*1*

*1*

***R H***

*1*

*1*

***cdep = 0***

*H2*

*R2*

*Z*

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*R1*  
*H1*  
*0*  
*R*  
***Configuration (5)***

***R H***  
***cde = 0,5 1 -***  
***2***  
***2***  
***H2***

***R H***  
***1***  
***1***  
***R2***  
***cde***  
***cdep =***  
***Z***  
***H1***

## ***5.2*** ***Singular loss ratios of load of exit***

*Hull*  
*Hull*  
*external*  
*intern*  
***Configuration (1)***  
***cds = 1***  
***cdsp = 0***  
***L***  
***R***  
***Z***

*Instruction manual*

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***Code\_Aster*** ®

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*Titrate:*

*Operator* ***DEFI\_FLUI\_STRU***

*Date:*

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*Author (S):*

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***Configuration (2)***

***R H2***

*R2*

***cds = 1 -***

*2*

*2*

***R H***

*3*

*3*

*H*

***cdsp = 0***

*2*

*L*

*R*

***H3***

***R3***

***Z***

***Configuration (3)***

***cds = 0***

***cdsp = 0***

***L***

***R***

***Z***

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*Titrate:*

*Operator DEFI\_FLUI\_STRU*

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*Author (S):*

***A. Key ADOBES***

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***Configuration (4)***

***2***

***R***

***R H R H***

***2***

***3***

***3***

***2***

***2***

***cds = 0,5 1 -***

***R H***

***2***

***2 R H***

***3***

**3**  
**H2**  
***cdsp = 0***  
**L**  
**R**  
**H3**  
**R3**  
**Z**

### ***Configuration (5)***

**R H2**  
**2**  
**2**  
***cds = 1 -***

**R H**  
**3**  
**3**  
**R**  
**- Cd**  
**2 S**  
**2**  
***cdsp =***  
**H3**  
**H2**  
**L**  
**R**  
**H3**  
**R3**  
**Z**

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**8.2**

***Titrate:***

*Operator* **DEFI\_FLUI\_STRU**

*Date:*

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*Author (S):*

**A. Key ADOBES**

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## **6 Bibliography**

[1]

**NR. GAY: Flustru Version 2.0 - general Presentation. Note of use - source FORTRAN of software. Note technical EDF/DER HT-32/93.05A.**

[2]

**L. PEROTIN, Mr. LAINET: Integration of various models of excitations fluid-rubber bands in Code\_Aster: specifications HT-32/96/014/A.**

*Instruction manual*

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**Code\_Aster** ®

**Version**

**7.4**

*Titrate:*

**Operator** **DEFI\_CONSTANTE**

*Date:*

**10/12/04**

*Author (S):*

**COURTEOUS Mr., J.P. LEFEBVRE Key**

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*Organization (S):* **EDF-R & D /AMA**

***Instruction manual  
U4.3- booklet: Function  
Document: U4.31.01***

***Operator DEFI\_CONSTANTE***

***1 Goal***

***To define the value of an invariant size.***

***This operator is a facility offered each time a concept of the function type is awaited and that the data to be introduced is constant. That makes it possible to define, for example, of materials of characteristics independent of the temperature for orders which make it possible to treat variable materials of characteristics with the temperature.***

***Attention not to be confused with the definition of a real parameter (ex: has = 3.).***

***Instruction manual  
U4.3- booklet: Function  
HT-66/04/004/A***

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***Code\_Aster ®  
Version  
7.4***

**Titrant:**  
**Operator** *DEFI\_CONSTANTE*

**Date:**  
**10/12/04**  
**Author (S):**  
**COURTEOUS Mr., J.P. LEFEBVRE Key**  
**:**  
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**2 Syntax**

**F [function] =**  
**DEFI\_CONSTANTE**

**(**  
**NOM\_RESU**  
**= /**  
**“TOUTRESU”,**  
**[DEFECT]**  
**/**  
**NR**  
**,**  
**[K8]**

**VALE**  
**=**  
**v**  
**,**  
**[R]**



**TITRATE**

**= Ti**

**[l\_Kn]**

)  
**Instruction manual**  
**U4.3- booklet: Function**  
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**Code\_Aster** ®

**Version**

**7.4**

**Titrate:**

**Operator DEF1\_CONSTANTE**

**Date:**

**10/12/04**

**Author (S):**

**COURTEOUS Mr., J.P. LEFEBVRE Key**

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**3 Operands**

**3.1 Operand**

**NOM\_RESU**

**NOM\_RESU = NR**

**Indicate the name of the result, the function thus created is a function whose value is of name NR (8 characters).**

*In fact, this operand is not useful systematically for checks of coherence, in execution of the code. These checks of coherence are made by the order CALC\_FONCTION.*

### **3.2 Operand**

**VALE**

**VALE = v**

*Value of the constant (a real number).*

### **3.3 Operand**

**TITRATE**

**TITRATE = Ti**

*Titrate attached to the concept produced by this operator [U4.03.01].*

### **4 Examples**

.

*To define the constant function “1.” :*

**F\_UN = DEFI\_CONSTANTE (  
VALE = 1. )**

*Function F\_UN represents “any kind of result” (TOUTRESU) per DEFECT*

.

*To define a constant function representing a constant YOUNG modulus*

**F\_YOUNG =  
DEFI\_CONSTANTE  
(**

**VALE = 2.1E11,  
NOM\_RESU**

**=  
“E”  
)**

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*Titrate:*

*Operator DEFI\_CONSTANTE*

*Date:*

*10/12/04*

*Author (S):*

***COURTEOUS Mr., J.P. LEFEBVRE*** *Key*

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**Code\_Aster** ®

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*Titrate:*

*Operator* **DEFI\_FONCTION**

*Date:*

02/03/06

*Author (S):*

*Key* **COURTEOUS Mr.**

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*Organization (S):* **EDF-R & D /AMA**

***Instruction manual***

***U4.3- booklet: Function***

***Document: U4.31.02***

***Operator*** **DEFI\_FONCTION**

## ***1 Goal***

***To define a real or complex function of a real variable. This operator allows to define, by example, of the characteristics materials function of the temperature, or the boundary conditions which depend on a variable of space or time.***

***The concept produced by this operator is of function type.***

### ***Instruction manual***

***U4.3- booklet: Function***

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***Code\_Aster*** ®

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***Titrate:***

***Operator DEF1\_FONCTION***

***Date:***

***02/03/06***

***Author (S):***

***Key COURTEOUS Mr.***

***:***

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## ***2 Syntax***

***F [function] =***

***DEF1\_FONCTION***

***(NOM\_PARA***

***= Np,***

***NOM\_RESU***  
***=/“TOUTRESU”,***  
***[DEFECT]***  
***/***  
***NR,***  
***[K8]***

***/***  
***VALE***  
***=***  
***lv,***  
***[l\_R]***  
***/***  
***VALE\_C***  
***=***  
***lv,***  
***[l\_C]***  
***/***  
***VALE\_PARA***  
***=***  
***,***  
***[listr8]***

***VALE\_FONC = lo, [listr8]***  
***/***  
***NOEUD\_PARA***  
***=***  
***lno, [l\_noeud]***

**GRID**

=

**my,**  
**[grid]**

**VALE\_Y = ly, [l\_R]**

**PROL\_DROITE =/"CONSTANT",**

**/"LINEAR",**

**/"EXCLUDED", [DEFECT]**

**PROL\_GAUCHE =/"CONSTANT",**

**/"LINEAR",**

**/"EXCLUDED",**

**[DEFECT]**

**Interpol**

**= / "FLAX",**



**[DEFECT]**

**/“LOG”,**

**/“NOT”,**

**INFORMATION**

**=**

**/**

**1,**

**[DEFECT]**

**/ 2,**

**VERIF =**  
**/“GROWING”,**  
**[DEFECT]**

**/“NOT”,**

**TITRATE =**  
**Ti,**  
**[l\_Kn]**

)

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***Titrate:***

***Operator DEFI\_FONCTION***

***Date:***

***02/03/06***

***Author (S):***

***Key COURTEOUS Mr.***

**:**

**3 Operands**

**3.1 Operand**

**NOM\_PARA**

**NOM\_PARA =  $N_p$**

**Indicate the name of the parameter (variable or X-coordinate) of the function.**

**The possible values for  $N_p$  are:**

**“TEMP”**

**“INST”**

**“EPSI”**

**“SIGM” “META”**

**“X”**

**“Y”**

**“Z”**

**“FREQ”**

**“PULS”**

**“AMOR”**

**“ABSC” “DSP”**

**“DX”**

**“DY”**

**“DZ”**

**“DRX”**

**“DRY”**

**“DRZ”**

**“HYDR”**

**“SECH”**

**“PORO”**

**“SAT” “PGAZ”**

**“PCAP”**

**“QUICKLY” “ENDO”**

**“NORM”**

*This list is not exhaustive, the user can choose the name of its parameter (cf notices in NOM\_RESU).*

### **3.2 Operand**

**NOM\_RESU**

**NOM\_RESU = NR**

*Indicate the name of the result (8 characters). The function thus created is  $NR = F(Np)$ .*

**Note:**

*Certain orders (CALC\_FONCTION, DEFI\_MATERIAU...) check coherence names of the parameter and result according to their context. For example, one a traction diagram defined by a function waits of which  $NOM\_PARA = 'EPSI'$  and  $NOM\_RESU = 'SIGM'$ .*

### **3.3 Operand**

**VALE**

**/VALE = lv**

*lv is the list of values ( $x1, y1, \dots, xn, yn$ ) with in the order:*

*.  
X  
(the first value of the parameter and the corresponding value of the result),  
1, y1  
... ,  
.  
X  
(the last value of the parameter and the corresponding value of the result).  
N, yn*

**Note:**

*The list lv of values must be described in the order of the X-coordinates (X) increasing.*

### **3.4 Operand**

**VALE\_C**

**/VALE\_C = lv**

*lv is the list of the values (X, y, Z,..., xn, yn, Zn) with:*

*.  
xi values of the parameter*

*... ,*

*.*

*y*

*the real part and the imaginary part of the function complex for it*

*I, zi*

*parameter.*

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**3.5 Operand**

**VALE\_PARA**

**/VALE\_PARA =**

*is the list of the values of the parameter Np (X-coordinates): it is a concept of the listr8 type created previously by order DEFI\_LIST\_REEL [U4.34.01].*

**3.6 Operand**

**VALE\_FONC**

***/VALE\_FONC = lo***

*lo is the list of the values of the parameter NR (ordered): it is a concept of the listr8 type created previously by order DEFI\_LIST\_REEL [U4.34.01].*

*VALE\_PARA and VALE\_FONC must be identical cardinals if not the order stops in error.*

### **3.7 Operand**

***NOEUD\_PARA***

***/NOEUD\_PARA = lno***

*lno list of nodes allowing to define the values of the X-coordinates of the function to be defined.*

*The X-coordinates will be equal to the curvilinear X-coordinates of the nodes on the curve that they define.*

### **3.8 Operands**

***PROL\_DROITE and PROL\_GAUCHE***

***PROL\_DROITE and PROL\_GAUCHE =***

*Define the type of prolongation on the right (on the left) of the field of definition of the variable:*

•  
*“CONSTANT” for a prolongation with the last (or first) value of function,*

•  
*“LINEAR” for a prolongation along the first definite segment (PROL\_GAUCHE) or of the last definite segment (PROL\_DROITE),*

•  
*“EXCLUDED” if the extrapolation of the values apart from the field of definition of parameter is prohibited (in this case if a calculation requires a value function out of the field of definition, the code will stop in fatal error).*

*For example:*

•  
***PROL\_DROITE = “CONSTANT”, PROL\_GAUCHE = “CONSTANT”***

*y*  
*X*

*X*  
*X*  
*X*  
*X*  
*1*  
*2*  
*n-1*  
*N*

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*Key COURTEOUS Mr.*  
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*.*  
*PROL\_DROITE = "LINEAR", PROL\_GAUCHE = "EXCLUDED"*

*y*  
*X*  
*X*  
*X*  
*X*  
*1*  
*x2*  
*n-1*  
*N*

*Note:*

*The type of prolongation and interpolation are independent one of the other.*

### **3.9 Operand**

#### **Interpol**

#### **Interpol**

=

*Type of interpolation of the function enters the values of the field of definition of the function: one type for the interpolation of the parameter and for the interpolation of the function. This is obtained in*

*providing a list of texts among:*

#### **Interpol**

=

*(“FLAX”,  
“LOG”)*

*“FLAX”: linear,*

*“LOG”: logarithmic curve,*

*“NOT”: one does not interpolate (and thus the program will stop if for the value is asked function for a value of the parameter where it was not defined).*

*Note:*

*If only one value is specified, it is taken into account at the same time by the interpolation of parameter and of the function. Interpol = “LOG” is equivalent to (“LOG”, “LOG”).*

### **3.10 Operand**

#### **INFORMATION**

#### **INFORMATION**

=

*Specify the options of impression on the file MESSAGE.*

*1: no the impression (default option)*

*2: impression of the parameters plus the list of the first 10 values in the ascending order parameter*

### **3.11 Operand**

#### **VERIF**

#### **VERIF**

=



**Operator *DEFI\_FONCTION* checks that the values of the X-coordinates are strictly increasing. If it is not the case, an error is started. This is the behavior by defect, *VERIF* is worth "GROWING".**

**The user with the possibility of not making this checking by indicating *VERIF*='NON'. In it case, one does not start an error and the function is reordered by increasing X-coordinates.**

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**Key *COURTEOUS* Mr.**

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**3.12 Operand**

***TITRATE***

***TITRATE* = *Ti***

***Titrate* attached to the concept produced by this operator [U4.03.01].**

**3.13 Operands**

***GRID* and *VALE\_Y***

**These two key words should be informed if one defines the function starting from *NOEUD\_PARA*.**

***GRID* = *my***

**Name of the grid associated with the list with node *lno*.**

***VALE\_Y* = *lv***

*List values of the ordinates of the function to be defined.*

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*:*

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*4*

*Definition of a function depending on time*

*4.1*

*Function and variables entered in the form of realities*

*.*

*Definition of a function (linear by pieces) depends on time (parameter INST).*

*EX 1 = CHALLENGE FUNCTION (*

*NOM\_PARA=' INST',*

*VALE = (0. , - 1. ,*

*1. , 0., -*

*2*

*3. , 1.,*

*6. , 2., ),*

*1*

*PROL GAUCHE=' CONSTANT',*

*0*

*1*

*3*

*6*

**T**  
**-1**  
**PROL DROITE=' LINEAIRE',**  
**);**

#### **4.2**

**Function and variables entered in the form of concepts listr8**

.

**It is possible to define this function using concepts of the listr8 type created by the intermediary of operator *DEFI\_LIST\_REEL* [U4.34.01]:**

***X-COORDINATE = DEFI\_LIST\_REEL (BEGINNING = 0. ,***

***INTERVAL = (\_F (JUSQU\_A = 1. , A NUMBER = 1),***

***\_F***  
***(***  
***JUSQU\_A***  
***=***  
***3.,***  
***NUMBERS***  
***=***  
***1),***

***\_F***  
***(***  
***JUSQU\_A***  
***=***  
***6.,***  
***NUMBERS***  
***=***  
***1,))***

)

*ORDINATE = DEFI\_LIST\_REEL (BEGINNING = -1. ,*

*INTERVAL = (\_F (JUSQU\_A = 0. , A NUMBER = 1),*

*\_F  
(JUSQU\_A  
=  
1.,  
NUMBERS  
=  
1),*

*\_F  
(JUSQU\_A  
=  
2.,  
NUMBERS  
=  
1),)*

)

**EX\_2 = DEFI\_FONCTION**  
**(NOM\_PARA = "INST",**  
**VALE\_PARA**

**=**  
**X-COORDINATE,**  
**VALE\_FONC**

**=**  
**ORDINATE,**  
**PROL\_DROITE**

**=**  
**"CONSTANT",**  
**PROL\_GAUCHE**

**=**  
**"LINEAR",**

)

**Note:**

*The second example is obviously quite complicated to define the function suggested. We wanted only to highlight the principle of use of the possibility offered.*

*This one becomes interesting when one uses functions defined in large a number of points.*

*Another reason to use the definition by DEFI\_LIST\_REEL is when the lists are necessary like argument for another operator: (list of the moments of a calculation evolutionary THER\_LINEAIRE, DYNA\_LINE\_TRAN,...), this avoids duplication then information.*

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**Version**

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**Titrate:**

**Operator *DEFI\_FONCTION***

**Date:**

**02/03/06**

**Author (S):**

**Key *COURTEOUS Mr.***

**:**

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***Code\_Aster* ®**

**Version**

**7.4**

**Titrate:**

**Operator** *DEFI\_NAPPE*

**Date:**

*27/01/05*

**Author (S):**

*COURTEOUS Mr., J.P. LEFEBVRE Key*

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**Organization (S):** *EDF-R & D /AMA*

**Instruction manual**

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**Document:** *U4.31.03*

**Operator** *DEFI\_NAPPE*

**1 Goal**

*To define a real function of two real variables. This operator allows to define, for example, of boundary conditions depending on a variable on space and time or two variables on space*

*or of the data materials (for example of the traction diagrams function of the temperature).*

*The concept produced by this operator is of tablecloth type.*

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*Titrate:*

*Operator DEFI\_NAPPE*

*Date:*

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*Author (S):*

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*2 Syntax*

*nf [tablecloth]*

*= DEFI\_NAPPE*

*(*

*NOM\_PARA*

*= /*

*Np*

*,*

*[KN]*

*NOM\_RESU*

*= /*

*“TOUTRESU”,*

*[DEFECT]*



/  
**NR**  
,  
**[K8]**

**PARA**  
=  
**LP**  
,  
**[L\_R]**

**PROL\_DROITE**  
=  
/  
**“CONSTANT”**  
,  
/  
**“LINEAR”**  
,  
/  
**“EXCLUDED”**  
,  
**[DEFECT]**

**PROL\_GAUCHE**  
=  
/  
**“CONSTANT”**  
,  
/  
**“LINEAR”**  
,  
/  
**“EXCLUDED”**  
,

**[DEFECT]**

**Interpol**  
**= / "FLAX"**  
**, [DEFECT]**

**/ "LOG"**  
**,**

**/ "NOT"**  
**,**

**INFORMATION**  
**=**  
**/**  
**1**  
**,**  
**[DEFECT]**

/2,

**VERIF**  
= "GROWING"

,

**/FUNCTION**  
= *lf*  
*[l\_fonction]*

/  
**NOM\_PARA\_FONC** = *npj*

**DEFI\_FONCTION** =

**\_F (**  
**VALE**  
=  
*lv*  
*[l\_R]*

***PROL\_DROITE***

=

***/“CONSTANT”***

,

/

***“LINEAR”***

,

/

***“EXCLUDED”***

,

***[DEFECT]***

***PROL\_GAUCHE***

=

***/“CONSTANT”***

,

/

***“LINEAR”***

,

/

***“EXCLUDED”***

,

***[DEFECT]***

***INTERPOL = / “FLAX”***

***, [DEFECT]***

/“**LOG**”

,

/“**NOT**”

,

),

**TITRATE**

=

**Ti,**

**[l\_Kn]**

)

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### **3 Operands**

#### **3.1 Operand**

**NOM\_PARA**

**NOM\_PARA = Np**

**Indicate the name of the parameter of the tablecloth (second variable) cf example with [§4.1].**

**The values currently authorized for Np are:**

**/“TEMP”**

**/“INST”**

**/“X”**

**/“Y”**

**/“Z”**

**/“FREQ”**

**/“PULS”**

**/“AMOR”**

**/“THICK”**

**/“TSEC”**

**/“HYDR”**

**/“SECH”**

#### **3.2 Operand**

## ***NOM\_RESU***

***NOM\_RESU = NR***

***Name of the result, the values of the tablecloth.***

***In fact, this operand is not useful systematically for checks of coherence, in execution of the code. These checks of coherence are made by the order CALC\_FONCTION [U4.32.04].***

## ***3.3 Operand***

***PARA***

***PARA = LP***

***List values of the parameter characteristic of the tablecloth: para1, para2,... the cardinal of this list must be equal to the number of functions defined then.***

## ***3.4 Operands***

***PROL\_DROITE and PROL\_GAUCHE***

***PROL\_DROITE and PROL\_GAUCHE =***

***Define the type of prolongation on the right (on the left) of the field of definition of the variable:***

***“CONSTANT”***

***for a prolongation with the last (or first) value of the tablecloth,***

***“LINEAR”***

***for a prolongation along the first definite segment (LEFT PROL)***

***or of the last definite segment (PROL\_DROITE), this prolongation does not hold not account of a possible interpolation logarithmic curve,***

***“EXCLUDED”***

***if the extrapolation of the values apart from the field of definition of parameter  $N_p$  is prohibited (in this case if a calculation requires a value function out of the field of definition, the code will stop in error fatal).***

## ***3.5 Operand***

***Interpol***

***Interpol***

***=***

***Type of interpolation of the function enters the values of the field of definition of the function: one type for the interpolation of the parameter and for the interpolation of the function. This is obtained***

*in*  
*providing a list of 2 texts among:*

*Interpol*  
=  
("FLAX",  
"LOG")  
"FLAX": linear,  
"LOG": logarithmic curve,  
"NOT": one does not interpolate (and thus the program will stop if for the value is asked  
function for a value of the parameter where it was not defined).

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*Note:*  
*If only one value is specified, it is taken into account at the same time by the interpolation of  
parameter and of the function. Interpol = "LOG" is equivalent to ("LOG", "LOG").*

*3.6 Operand*  
*INFORMATION*

*INFORMATION*  
=

*Specify the options of impression on the file message (unit 6).*



**1 :**

*no the impression (default option)*

**2 :**

*impression of the parameters plus the list of the first 10 values of each function in the order ascending of the the first 10 parameter*

### **3.7 Operand**

**VERIF**

**VERIF**

=

*Operator **DEFI\_NAPPE** reorders the values of the parameters  $N_p$  in the ascending order. If **VERIF** is worth "GROWING" the operator stops the execution if the values of the parameter  $N_p$  do not have summer given in this order.*

### **3.8**

*Definition of the functions of the tablecloth*

*Two modes of definition of the tablecloth are possible:*

.

*starting from a list of existing functions [§3.8.1],*

.

*by directly defining the various functions of the tablecloth [§3.8.2].*

#### **3.8.1 Operand**

**FUNCTION**

**FUNCTION = lf**

*List concepts of the function type created by orders **DEFI\_FONCTION** [U4.31.02], **DEFI\_CONSTANTE** [U4.31.01], **CALC\_FONC\_INTERP** [U4.32.01],...*

*lf is the list of the names of concepts of the function type corresponding to the values of the parameter.*

*All the functions of the list must have the same name of variable (that we will call  $npf$ ) and to have the same name  $NR$  for name of result.*

*nf is a tablecloth of the variable of name  $N_p$  and variable of name  $npf$  and whose value is of name  $NR$ .*

#### **3.8.2 Definition**

*direct of the functions*

### **3.8.2.1 Operand**

**NOM\_PARA\_FONC**

**NOM\_PARA\_FONC**

**= npf**

**Name of the parameter characteristic of the functions constituting the tablecloth.**

**The values currently authorized for npf are:**

**/“TEMP”**

**/“INST”**

**/“X”**

**/“Y”**

**/“Z”**

**/“EPSI”**

**/“FREQ”**

**/“PULS”**

**/“AMOR”**

**/“THICK”**

**/“SAT”/“PGAL”**

**/“PCAP”**

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### 3.8.2.2 Word

*key*

***DEFI\_FONCTION***

***DEFI\_FONCTION =***

*Direct definition of the functions constituting the tablecloth.*

### 3.8.2.3 Operand

***VALE***

***VALE = lv***

*lv is the list of value (x1, y1, ..., xn, yn) with in the order:*

***X***

*(the first value of the parameter and the corresponding value of the result),*

***1, y1***

***...***

***X***

*(the last value of the parameter and the corresponding value of the result).*

***N, yn***

### 3.8.2.4 Operands

***PROL\_DROITE and PROL\_GAUCHE***

***PROL\_DROITE***

***and PROL\_GAUCHE =***

*Define the type of prolongation on the right (on the left) of the field of definition of variable:*

***“CONSTANT”***

*for a prolongation with the last (or first) value of function,*

***“LINEAR”***

*for a prolongation along the first definite segment*

*(PROL\_GAUCHE) or of the last definite segment (PROL\_DROITE),*

***“EXCLUDED”***

*if the extrapolation of the values apart from the field of definition of*

*parameter npf is prohibited (in this case if a calculation requires one value of the function out of the field of definition, the code will stop in fatal error).*

*function nf  
parameter Np  
function f2  
parameter para2  
function f1  
parameter para1  
variable npf*

### **3.8.2.5 Operand Interpol**

*Interpol  
=*

*Type of interpolation of the function enters the values of the field of definition of the function: one type for the interpolation of the parameter and for the interpolation of the function. This is obtained in providing a list of texts among:*

*Interpol  
=  
("FLAX",  
"LOG")  
"FLAX": linear,  
"LOG": logarithmic curve,  
"NOT": one does not interpolate (and thus the program will stop if for the value is asked function for a value of the parameter where it was not defined).*

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**Note:**

**If only one value is specified, it is taken into account at the same time by the interpolation of parameter and of the function. Interpol = “LOG” is equivalent to (“LOG”, “LOG”).**

**3.9 Operand**

**TITRATE**

**TITRATE = Ti**

**Titrate attached to the concept produced by this operator [U4.03.01].**

**4 Examples**

**4.1**

**Definition of the tablecloth after definition of the function**

**FCT2**

**=**

**DEFI\_FONCTION**

**(NOM\_PARA = “EPSI”, PROL\_DROITE =**

**“LINEAR”,**

**PROL\_GAUCHE**

**=**

**“LINEAR”,**

**VALE**

**=**

**(1.25E-5,**

**3.75,**

**3.75E-5,**

**7.5),**

)  
**FCT3**  
=  
**DEFI\_FONCTION**

(**NOM\_PARA** = "EPSI", **PROL\_DROITE** =  
"LINEAR",  
**PROL\_GAUCHE**  
=  
"LINEAR",  
**VALE**  
=  
(1.25E-5,  
2.50,  
3.75E-5,  
5.0),  
)

**SIG**  
=  
**DEFI\_NAPPE** (**NOM\_PARA** = "TEMP", **PROL\_DROITE** =  
"CONSTANT",  
**PROL\_GAUCHE**  
=  
"CONSTANT",  
**PARA**  
=  
(20.0,  
30.0),  
**FUNCTION**  
=  
(**FCT3**,  
**FCT2**,)  
,)

## 4.2 *Direct definition of the tablecloth and the constitutive functions*

**FCT2 = DEFI\_NAPPE**  
**(NOM\_PARA = "TEMP",**  
**PROL\_DROITE =**  
**"CONSTANT",**  
**PROL\_GAUCHE**  
**=**  
**"CONSTANT",**  
**PARA**  
**=**  
**(20.0,**  
**30.0),**  
**NOM\_PARA\_FONC**  
**=**  
**"EPSI",**  
**DEFI\_FONCTION**  
**=**  
**(**  
**\_F (PROL\_DROITE = "LINEAR",**  
**PROL\_GAUCHE**  
**=**  
**"LINEAR",**  
**VALE**  
**= (1.25E-5,**  
**3.75,**  
**3.75E-5,**  
**7.5),**

),

*\_F (PROL\_DROITE = "LINEAR",*

*PROL\_GAUCHE*

=

*"LINEAR",*

*VALE*

*= (1.25E-5,*

*2.5,*

*3.75E-5,*

*5.0),*

),

),



)

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***Date:***

**31/01/06**

***Author (S):***

***C. Key DURAND***

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***Organization (S): EDF-R & D /AMA***

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## ***Operator FORMULATES***

### ***1 Goal***

***To define a real formula starting from its mathematical expression.***

***The formula will be usable in a further order like argument of the function type/formula or evaluated with particular values of the variables.***

***In many applications, one can tabuler this formula for particular values by order CALC\_FONC\_INTERP [U4.32.01] which produces a concept of the function type like DEFI\_FONCTION [U4.31.02] or DEFI\_NAPPE [U4.31.03].***

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***31/01/06***

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### ***2 Syntax***

***F = FORMULA (***

***NOM\_PARA***

***=***

***name***

***parameters***

***[l\_K8]***

***VALE***

***= "" definition of the function ""***

***[K]***

***)***

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### **3 Operands**

#### **3.1**

**Definition of the function, key word VALE**

**The body of the function is an algebraical expression PYTHON represented by a chain of characters. It must be appraisable in the context: thus to respect syntax PYTHON and not to use that functions, methods or constants defined before the moment of its evaluation.**

**In the event of error of syntax, it is the language PYTHON which transmits the error message and not Code\_Aster itself.**

#### **3.2 Functions**

**standards**

**For a formula represented by an ordinary algebraic function, to refer to:**

**“Using PYTHON have has calculator”, paragraph [§3.1.1]**

**<http://docs.python.org/tut/tut.html>**

**In addition to the ordinary algebraical signs + -/\*\*\*, functions standards are also available (buildins): min, max, ABS, float...**

**Attention, the sign of division indicates real division here:**

$$1 / 2 = 0.5$$

**If one wishes to make a whole division operation, should be used the // operator:**

$$1 // 2 = 0$$

#### **3.3 Functions**

**mathematics**

**The principal functions of the module maths of PYTHON are imported by defect. They are thus directly usable in the body of the formulas.**

**<http://docs.python.org/lib/module-math.html>**

**sin sinh**

**cos cosh**

**tan tanh**

**atan sqrt**

**atan2 log**

*asin log10*  
*acos exp*

*Moreover, constant pi, same module, is also available.*

**Caution:**

*The goniometrical functions are thus those of PYTHON and await angles expressed in radians. It is necessary to be vigilant on coherence with single-ended spanner words ANGL\_\* of the language of order which requires angles in degrees in general.*

*One can use others of them by taking care to before import them the declaration of formulate. Example of redefinition of the exponential one:*

```
from maths importation E, pow  
f_exp = FORMULA (NOM_PARA=' X', VALE=' pow (E, X) ')
```

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**4 Examples  
of use**

*For various examples one will refer to the case test ZZZZ100A.*

**4.1**

***A formula is used like a tabulée function***

*Definition of the Sia formula:*

$Sia = FORMULA (NOM\_PARA=' X', VALE=' sin (X) ')$

$LR = DEFI\_LIST\_REEL (BEGINNING = 0. ,$   
 $INTERVAL = \_F (JUSQU\_A = pi, NOT = 0.01))$

*Equivalent tabulée function IF:*

$IF = CALC\_FONC\_INTERP (FUNCTION = Sia,$   
 $LIST\_PARA = LR,$   
 $NOM\_PARA = "X",$   
 $NOM\_RESU = "DEPL",)$

*To thus define a function tabulée starting from an interpretable formula, to see CALC\_FONC\_INTERP [U4.32.01].*

*Use of IF or of Sia in a single-ended spanner word awaiting a function or a formula:*

$champ=CREA\_CHAMP (... AFFE = \_F (... VALE\_F = IF or Sia,))$

## 4.2

***A formula can be evaluated like a reality***

*In the body of the command file:*

$Sia = FORMULA (NOM\_PARA=' X', VALE=' sin (X) ')$

$X = Sia (1.57)$

$print Sia (1.57)$

*Behind a single-ended spanner word awaiting a reality:*

$LR = DEFI\_LIST\_REEL (BEGINNING = Sia (0.),$   
 $INTERVAL = \_F (JUSQU\_A = Sia (pi/2.), NOT = 0.01))$

*In another formula:*

$Sib = FORMULA (NOM\_PARA=' X', VALE=' X*Sia (5.)')$

## 4.3

***To call upon a formula in another formula***

$SIa = FORMULA (NOM\_PARA=' X', VALE=' \sin (X) ')$

$SIb = FORMULA (NOM\_PARA=' X', VALE=' X*SIa (X) ')$

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## **4.4**

### ***Formulate with several parameters***

$NAP = FORMULA (NOM\_PARA = ("FREQ", "AMOR"),$

$VALE = " (1. /((2. *pi * FREQ) ** 2 - OMEGA ** 2) ** 2$

$+ (2. *AMOR * 2. *pi * FREQ * OMEGA) ** 2) "$ )

*In this example, one defines a formula in 3 parameters. Taking into account the length of the expression, it is written for more convenience on several lines with triple dimensions to delimit it.*

*constant pi is constant a standard (cf paragraph [§3.2]), the OMEGA constant will have been defined higher by the user.*

*In the current state, only the formulas of RN in R are possible: only one produced reality.*

## **4.5**

### ***Formulate resulting from programming of function PYTHON***

*One can refer in a formula to functions programmed in PYTHON, which authorizes formulas much more complex than of simple algebraical expressions.*

*For example a function of Heavyside:*

*0 if X*

*.*

*<*

*0*

*HEAVYSIDE (X) =*

*1 if X*

*.*

*0*

*The method python is programmed as follows:*

*def HEAVYSIDE (X):*

*yew x<0. : return 0.*

*Yew x>=0. : return 1.*

*F\_HVS = FORMULA (NOM\_PARA = "INST",*

*VALE = "HEAVYSIDE (INST)")*

***Caution:***

*The use of programming PYTHON in the command file (here method HEAVYSIDE) is incompatible with the edition of this file with EFICAS.*

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*Operator* **DEFI\_PARA\_SENSI**

*Date:*

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*Author (S):*

**G. Key NICOLAS**

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*Organization (S):* **EDF-R & D /SINETICS**

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***Document: U4.31.06***

***Operator*** **DEFI\_PARA\_SENSI**

## ***1 Goal***

***To define the value of a significant parameter.***

***This operator allows to declare a parameter of calculation like which can be useful in calculations of sensitivity. That results in:***

***.  
a real numerical value is assigned to the size created,***

***.  
the size created is of type `para_sensi`, sub-type of the function type.***

***The size is used like any function; for example in the definition of materials or of loading.***

***To obtain the derivative of a result compared to the size, the sequence is inserted `SENSITIVITY = (size)` in the order. One will refer to [U4.50.01] for the details and with [U2.08.02] for a note of use.***

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***Titrate:***

***Operator `DEFI_PARA_SENSI`***

***Date:***

***08/02/05***

***Author (S):***

***G. Key NICOLAS***

***:***

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## ***2 Syntax***

***F [`para_sensi`] = `DEFI_PARA_SENSI`***

(  
*NOM\_RESU*  
=  
“*TOUTRESU*” [*DEFECT*]  
/  
*NR*  
[*K8*]

*VALE*  
=  
*v*  
[*R*]

*TITRATE*  
= [*l\_Kn*]

)  
*Instruction manual*  
*U4.3- booklet: Function*  
*HT-66/05/004/A*

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*Code\_Aster* ®  
*Version*  
*7.4*

***Titrate:***

***Operator DEF1\_PARA\_SENSI***

***Date:***

***08/02/05***

***Author (S):***

***G. Key NICOLAS***

***:***

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***3 Operands***

***3.1 Operand***

***NOM\_RESU***

***NOM\_RESU = NR***

***Indicate the name of the result, the significant parameter thus created is a function whose value is its name NR (8 characters).***

***In fact, this operand is not useful systematically for checks of coherence, in execution of the code. These checks of coherence are made by the order CALC\_FONCTION.***

***3.2 Operand***

***VALE***

***VALE = v***

***Value of the constant (a real number).***

***3.3 Operand***

***TITRATE***

***TITRATE = Ti***

***Titrate attached to the concept produced by this operator [U4.03.01].***

***4 Examples***

```
Young = DEFI_PARA_SENSI (  
VALE = 2.1E11  
)
```

*The Young size is a constant being worth 2.1E11. One then uses it in the definition of one material:*

```
naked = DEFI_CONSTANTE (VALE = 0.3)  
chechmate = DEFI_MATERIAU (ELAS_FO = _F (E = Young, NAKED = naked  
))
```

*One will calculate the field of displacement and his derivative compared to this Young modulus:*

```
resu = MECA_STATIQUE (...  
SENSITIVITY  
=  
(Young),  
...  
)
```

*Instruction manual*  
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*Code\_Aster* ®  
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*7.4*

*Titrate:*  
*Operator DEFI\_PARA\_SENSI*

*Date:*  
*08/02/05*  
*Author (S):*  
*G. Key NICOLAS*  
*:*  
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***Code\_Aster*** ®

***Version***

***7.4***

***Titrate:***

***Operator MEMO\_NOM\_SENSI***

***Date:***

***09/02/05***

***Author (S):***

***G. Key NICOLAS***

***:***

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***Organization (S): EDF-R & D /SINETICS***

***Instruction manual  
U4.3- booklet: Function  
Document: U4.31.07***

***Operator MEMO\_NOM\_SENSI***

***1 Goal***

***To memorize the names of the concepts related to calculations of sensitivity.***

***This operator allows to file:***

***.  
for each significant parameter, couples with the name of the simple structure and the name of  
the associated derived structure, as well as the key words by which this derivation appears,  
.  
the name of a function always being worth 0,  
.  
the name of a function always being worth 1.***

***Note:***

***A priori, this procedure should never be employed directly by an end-user.  
It is activated by the automatic mechanism of piloting of the sensitivities.***

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U4.3- booklet: Function HT-66/05/004/A***

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***Code\_Aster ®  
Version  
7.4***



***Titrate:***

***Operator MEMO\_NOM\_SENSI***

***Date:***

***09/02/05***

***Author (S):***

***G. Key NICOLAS***

***:***

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***2 Syntax***

***MEMO\_NOM\_SENSI (***

***# memorizing of the derived concepts***

***NOM= (***

***# name of the structure to be derived***

***NOM\_SD***

***=***

***nom\_sd***

***[TXM]***

***# the parameter by report/ratio to which one derives***

***PARA\_SENSI = para\_sensi/[para\_sensi]***

***/***

***[theta\_geom]***

***# the name of the derived structure nom\_sd compared to para\_sensi***

***NOM\_COMPOSE***

***=***

***nom\_compose***

**[TXM]**

*# couples of key word and value where the derivation of nom\_sd by*

*report/ratio with para\_sensi intervenes*

**L MOT\_CLE**

=

**l\_mot\_simp [l\_K]**

**L**

**VALUE**

=

**l\_val**

**[l\_K]**

**L**

**MOT\_FACT**

=

**l\_mot\_fact**

**[l\_K]**

)

*# an always null function*

**NOM\_ZERO = f0 [function]**

*# a function always being worth 1*

**NOM\_UN**

=

**f1**

**[function]**

)

**Instruction manual**

**U4.3- booklet: Function HT-66/05/004/A**

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**Code\_Aster ®**

## **Version**

**7.4**

## **Titrate:**

**Operator MEMO\_NOM\_SENSI**

## **Date:**

**09/02/05**

## **Author (S):**

**G. Key NICOLAS**

**:**

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## **3 Operands**

### **3.1 Operand**

**NAME**

***This key word factor makes it possible to file the characteristics of the derivation of a structure: under which***

***name is known the derived structure, which are the key words which engage derivation.***

#### **3.1.1 Operand**

**NOM\_SD**

***NOM\_SD = nom\_sd***

***It is the name of the structure to be derived. Attention, this name is to be provided in the form of a chain of***

***characters and not in the form of concept. Indeed at the moment when procedure***

***MEMO\_NOM\_SENSI is called upon, the concept to be derived does not exist obligatorily. It can be product later and is thus unknown analyzer of order.***

#### **3.1.2 Operand**

**PARA\_SENSI**

***PARA\_SENSI = para\_sensi/theta\_geom***

***It is the concept of the para\_sensi type or theta\_geom by report/ratio to which one derives.***

#### **3.1.3 Operand**

**NOM\_COMPOSE**

***NOM\_COMPOSE = nom\_compose***

*One gives here the name of the concept resulting from derivation of nom\_sd compared to para\_sensi. Here still, it is a character string because the concept is not obligatorily known.*

***3.1.4 Operand  
MOT\_CLE***

***MOT\_CLE = l\_mot\_simp***

*The derivation of nom\_sd compared to para\_sensi is carried out by an order which can be a definition of material, a loading, a resolution,... When in this order, that is done through key words, one gives the list of it here.*

***3.1.5 Operand  
VALUE***

***VALUE = l\_val***

*If key words were indicated by operand MOT\_CLE, the list of the values here is given corresponding in the form of character string. The two lists l\_mot\_simp and l\_val function in parallel.*

***3.1.6 Operand  
MOT\_FACT***

***MOT\_FACT = l\_mot\_fact***

*If key words were indicated by operand MOT\_CLE, one gives the list here of key words corresponding factors. The two lists l\_mot\_simp and l\_mot\_fact function in parallels.*

***3.2 Operand  
NOM\_ZERO***

***NOM\_ZERO = f0***

*One gives here the concept of an always null function.*

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***Code\_Aster ®***

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*7.4*

*Titrate:*

*Operator MEMO\_NOM\_SENSI*

*Date:*

*09/02/05*

*Author (S):*

*G. Key NICOLAS*

*:*

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### ***3.3 Operand***

***NOM\_UN***

*NOM\_UN = f1*

*One gives here the concept of a function always being worth 1.*

### ***4 Examples***

***A priori, this procedure should never be employed directly by an end-user. It is activated by the automatic mechanism of piloting of the sensitivities.***

#### ***4.1 Function***

***unit***

***One defines F1 as function always being worth 1 and one memorizes it.***

***F1 = DEFI\_CONSTANTE (VALE = 1.) ;***

***MEMO\_NOM\_SENSI (NOM\_UN = F1);***

#### ***4.2 Structures***

***derived***

***A material is defined thanks to a significant parameter. It is necessary to memorize its derived material and how it is obtained.***

***PS = DEFI\_PARA\_SENSI (VALE = 40.)***

***CHECHMATE = DEFI\_MATERIAU (THER\_FO = \_F (LAMBDA = PS));***

***MEMO\_NOM\_SENSI (NAME = \_F (NOM\_SD = "CHECHMATE",***

***PARA\_SENSI***

=

***PS,***

***NOM\_COMPOSE***

=

***“MAT\_PS”,***

***MOT\_CLE***

=

***“LAMBDA”,***

***MOT\_FACT***

=

***“THER\_FO”,***

***VALUE***

=

***“PS”***

)

)

;

***MAT\_PS = DEFI\_MATERIAU (THER\_FO = \_F (LAMBDA = F1));***

***This material is affected with the grid to produce a material field. This field is itself with to derive.***

***CHMAT = AFFE\_MATERIAU (***

***GRID = EMAIL,***

***AFFE = \_F (ALL = “YES”, MATER = CHECHMATE));***

***MEMO\_NOM\_SENSI (NAME = \_F (NOM\_SD = “CHMAT”,***

***PARA\_SENSI***

=

***PS,***

***NOM\_COMPOSE***

=

***“CHMAT\_PS”,***

***MOT\_CLE***

=

***“MATER”,***

***MOT\_FACT***

=

“AFFE”,  
VALUE

=

“CHECHMATE”)

)

;

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*U4.3- booklet: Function HT-66/05/004/A*

---

*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Operator CALC\_FONC\_INTERP*

*Date:*

*31/01/05*

*Author (S):*

*COURTEOUS Mr., J.P. LEFEBVRE, L. VIVAN Key*

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*Organization (S): EDF-R & D /AMA, CS-SI*

*Instruction manual*

*U4.3- booklet: Function*

*Document: U4.32.01*

## ***Operator CALC\_FONC\_INTERP***

### ***1 Goal***

***To build a concept of the function type starting from a function FORMULATES to 1 or 2 variables.  
Can  
to be defined real functions with real and complex variables and tablecloths.***

***One can also produce a new real or complex function, or a tablecloth while interpolating  
another real, complex function or a tablecloth.***

***The use of CALC\_FONC\_INTERP allows a preliminary tabulation of the formula. Its use is  
recommended before any transitory and/or nonlinear analysis for reasons of performances.  
The operator is not any more réentrant: he takes a formula in argument and produces a function or  
one  
tablecloth.***

### ***Instruction manual***

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***Titrate:***

***Operator CALC\_FONC\_INTERP***

***Date:***

***31/01/05***

***Author (S):***

***COURTEOUS Mr., J.P. LEFEBVRE, L. VIVAN Key***

***:***

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## 2 Syntax

***Fr = CALC\_FONC\_INTERP***

(  
***FUNCTION***  
=  
***F***  
/  
***[formula]***  
/  
***[function]***  
/  
***[fonction\_c]***  
/  
***[tablecloth]***

***NOM\_RESU***  
=/"TOUTRESU"  
,  
***[DEFECT]***  
/  
***NR***  
,  
***[K8]***

***NOM\_PARA =***  
***Np,***

/  
*VALE\_PARA*

=  
*lvale*  
, [*l\_R*]

/  
*LIST\_PARA*

=  
*will lpara*

,  
[*listr8*]

*PROL\_DROITE*

=  
/“*CONSTANT*”,  
/“*LINEAR*”,  
/“*EXCLUDED*”

,  
[*DEFECT*]

*PROL\_GAUCHE* = /“*CONSTANT*”,  
/“*LINEAR*”,  
/“*EXCLUDED*”

,  
[*DEFECT*]

*Interpol*  
= /  
“*FLAX*”,  
[*DEFECT*]  
/  
“*LOG*”,  
[*l\_Kn*]  
/  
“*NOT*”,

*NOM\_PARA\_FONC* = *npf*,

*/VALE\_PARA\_FONC = lvalef,*

*[l\_R]*  
*/*  
*LIST\_PARA\_FONC*  
*=*  
*lparaf,*  
*[listr8]*

*PROL\_DROITE\_FONC*  
*=/"CONSTANT",*  
*/"LINEAR",*  
*/"EXCLUDED"*

*,*  
*[DEFECT]*

*PROL\_GAUCHE\_FONC =*  
*/"CONSTANT",*  
*/"LINEAR",*  
*/"EXCLUDED"*

*,*  
*[DEFECT]*

*INTERPOL\_FONC*  
*=*  
*/*  
*"FLAX",*

*[DEFECT]*

/

“LOG”,

*[l\_Kn]*

/

“NOT”,

*INFORMATION*

=

/

1,

*[DEFECT]*

/2,

*TITRATE*

=

*Ti*

,

*[l\_Kn]*

)

*The type of Fr is a function, fonction\_c or tablecloth according to arguments'.*

*Instruction manual*  
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---

**Code\_Aster** ®

Version

7.4

Titrate:

Operator *CALC\_FONC\_INTERP*

Date:

31/01/05

Author (S):

**COURTEOUS Mr., J.P. LEFEBVRE, L. VIVAN** Key

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### **3 Operands**

#### **3.1 Operand**

**FUNCTION**

**FUNCTION = F**

*Name of the FORMULA (interpretable function (FORMULA cf [U4.31.05])).*

*This function can be with one or two variables.*

*One can however create a new function (respectively fonction\_c, tablecloth) to leave of a function (respectively fonction\_c, tablecloth) by interpolating the first on a list parameters different. This probability is primarily used in macro-orders.*

#### **3.2 Operand**

**NOM\_RESU**

**NOM\_RESU = NR**

*Indicate the name of the result, the function thus created is a function whose value is of name NR (8 characters).*

#### **3.3 Operand**

**NOM\_PARA**

***NOM\_PARA = NR***

***Indicate the name of the parameter of the function or tablecloth. By defect, the name of the parameter formula or provided function is employed.***

### ***3.4 Operands***

***VALE\_PARA/LIST\_PARA***

***/VALE\_PARA = lvale,***

***lvale is the list of the values of the parameter.***

***/LIST\_PARA = will lpara,***

***will lpara is the list of the values of the parameter: it is a concept of the listr8 type created previously by order DEF1\_LIST\_REEL [U4.34.01].***

### ***3.5 Operands***

***PROL\_DROITE and PROL\_GAUCHE***

***PROL\_DROITE and PROL\_GAUCHE =***

***Define the type of prolongation on the right (on the left) of the field of definition of parameter of the function or the tablecloth***

***“CONSTANT”***

***for a prolongation with the last (or first) value of function,***

***“LINEAR”***

***for a prolongation along the first definite segment (PROL\_GAUCHE) or of the last definite segment (PROL\_DROITE),***

***“EXCLUDED”***

***the extrapolation of the values apart from the field of definition of parameter is prohibited (in this case if a calculation requires a value function out of the field of definition, the code will stop in fatal error),***

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**31/01/05**

**Author (S):**

**COURTEOUS Mr., J.P. LEFEBVRE, L. VIVAN Key**

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### **3.6 Operand**

#### **Interpol**

#### **Interpol**

=

*Type of interpolation of the function enters the values of the variable or type of interpolation of tablecloth enters the values of the parameter. Behind this key word one awaits a parameter list (two to the maximum).*

*“FLAX”: linear,*

*“LOG”: logarithmic curve,*

*“NOT”: one does not interpolate (and thus the program will stop if for the value is asked function for a value of the parameter where it was not defined).*

*If only one value is given, the interpolation will be identical for the X-coordinates and them ordinates. If two values are given, the first corresponds to the interpolation of X-coordinates and the second with the interpolation of the ordinates.*

### **3.7 Operand**

#### **NOM\_PARA\_FONC**

**NOM\_PARA\_FONC = NR**

*Indicate the name of the variable of the functions defining the tablecloth.*

### **3.8 Operands**

## ***VALE\_PARA\_FONC/LIST\_PARA\_FONC***

***/VALE\_PARA\_FONC = lvale,***

***lvale is the list of the values of the variable of the functions defining the tablecloth.***

***/LIST\_PARA\_FONC = will lpara,***

***will lpara is the list of the values of the variable of the functions defining the tablecloth: it is one concept of the listr8 type created previously by order DEFI\_LIST\_REEL [U4.34.01].***

### ***3.9 Operands***

***PROL\_DROITE\_FONC and PROL\_GAUCHE\_FONC***

***PROL\_DROITE\_FONC and PROL\_GAUCHE\_FONC =***

***Define the type of prolongation on the right (on the left) of the field of definition of variable of the functions of the tablecloth:***

***“CONSTANT”, “LINEAR”, “EXCLUDED” the same direction has as previously.***

### ***3.10 Operand***

***INTERPOL\_FONC***

***INTERPOL\_FONC***

***=***

***Defining type of interpolation of the functions between the values of the variable of the functions tablecloth. Behind this key word one awaits a parameter list (two to the maximum).***

***Operation is identical to Interpol.***

### ***3.11 Operand***

***INFORMATION***

***INFORMATION***

***=***

***Specify the options of impression on the file MESSAGE.***

**1: no the impression (default option)**

**2: impression of the parameters plus the list of the first 10 values in the order crescent of the parameter**

### **3.12 Operand**

**TITRATE**

**TITRATE = Ti**

**Titrate attached to the concept produced by this operator [U4.03.01].**

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**Code\_Aster ®**

**Version**

**7.4**

**Titrate:**

**Operator CALC\_FONC\_INTERP**

**Date:**

**31/01/05**

**Author (S):**

**COURTEOUS Mr., J.P. LEFEBVRE, L. VIVAN Key**

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### **4 Examples**

#### **4.1**

**Case of a function**

**4.1.1 To define the function FORMULATES sin (T)**

**IF = FORMULA (NOM\_PARA = "INST",**

**VALE = sin (INST))**

#### **4.1.2 Tabuler**

**sin (T) starting from a list of realities**

**DEPI**

=  
**2.\*pi**  
**PAS0**  
=  
**DEPI/200.**  
**LII**  
**= DEFI\_LIST\_REEL (BEGINNING = 0, INTERVALLE=\_F (JUSQU\_A=DEPI, PAS=PAS0),)**  
**SII**  
**= CALC\_FONC\_INTERP (FONCTION= IF, LIST\_PARA = LII, NOM\_RESU =**  
**“DEPL”,**  
  
**PROL\_GAUCHE=' EXCLU',**  
**PROL\_DROITE=' CONSTANT',**  
  
**INTERPOL=' LIN', TITRE=' FUNCTION SINUS')**

#### **4.1.3 Tabuler**

*sin (T) starting from a list of values*

**LI2**  
**= ( 0.,0.01,0.03,0.04,0.05,0.06,0.07,0.08,0.09,0.10)**  
  
**SI2**  
**= CALC\_FONC\_INTERP (FUNCTION = IF, VALE\_PARA = LI2,**  
**NOM\_PARA**  
**= ' INST',**  
**PROL\_GAUCHE**  
**=**  
**“EXCLUDED”,**  
**PROL\_DROITE**  
**=**  
**“EXCLUDED”,**  
**Interpol**  
**=**  
**“FLAX”, TITLE = “FUNCTION SINE”)**

#### **4.2**

*Case of a tablecloth*

##### **4.2.1 To define the function FORMULATES sin (T)**

**IF = FORMULA (NOM\_PARA = (“INST”, “FREQ”),**  
**VALE = sin (2\*pi\*FREQ\*INST))**

## **4.2.2 Tabuler**

*sin (T) starting from a list of moments*

*The parameter of the tablecloth is “FREQ”, the variable of the functions defining the tablecloth is “INST”.*

**LI\_FREQ =  
DEFI\_LIST\_REEL  
(BEGINNING = 10, INTERVALLE=\_F (JUSQU\_A=100, PAS=10),)**

**LI\_INST =  
DEFI\_LIST\_REEL  
(BEGINNING = 0, INTERVALLE=\_F (JUSQU\_A=100, PAS=1),)**

**SII  
= CALC\_FONC\_INTERP (FONCTION= IF,**

**NOM\_RESU = “DEPL”,**

**NOM\_PARA\_FONC=' INST',  
LIST\_PARA\_FONC = LI\_INST**

**PROL\_GAUCHE\_FONC=' EXCLU',**

**PROL\_DROITE\_FONC=' CONSTANT',**

**INTERPOL\_FONC=' LIN',**

**NOM\_PARA=' FREQ',  
LIST\_PARA = LI\_FREQ**

**PROL\_GAUCHE=' LINEAIRE',**

**PROL\_DROITE=' LINEAIRE',**

**INTERPOL=' LIN',  
TITRE=' FUNCTION SINUS',)**

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**7.4**

**Titrate:**

**Operator CALC\_FONC\_INTERP**

**Date:**

**31/01/05**

**Author (S):**

**COURTEOUS Mr., J.P. LEFEBVRE, L. VIVAN Key**

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**Code\_Aster** ®

**Version**

**7.4**

**Titrate:**

**Operator LIRE\_FONCTION**

**Date:**

**19/01/05**

**Author (S):**

**C. Key DURAND**

**:**

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**Organization (S): EDF-R & D /AMA**

**Instruction manual**

**U4.3- booklet: Function**

**Document: U4.32.02**

**Operator LIRE\_FONCTION**

## ***1 Goal***

***To see actual values in a data file representing a function and to create a concept of type function [U4.31.02] or tablecloth [U4.31.03].***

### ***Instruction manual***

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***Titrate:***

***Operator LIRE\_FONCTION***

***Date:***

***19/01/05***

***Author (S):***

***C. Key DURAND***

***:***

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## ***2 Syntax***

***F [function] = LIRE\_FONCTION***

***(***

***UNIT = U***

***,***



**[I]**

**FORMAT**

=

**“FREE”**

,

**[DEFECT]**

**NOM\_PARA = cf key word are equivalent of DEFI\_FONCTION [U4.31.02],**

**NOM\_RESU = idem**

**Interpol**

**= idem**

**PROL\_DROITE =**

**idem**

**PROL\_GAUCHE =**

**idem**

**VERIF**

=

**idem**

**TITRATE =**  
*idem*

**INFORMATION =**  
*idem*

**SEPAR**

=

/

**“None”**

,

**[DEFECT]**

/';'

,

/';'

,

/ '/'

,

**INDIC\_PARA**

=

/

[1,1]

, [DEFECT]

**TYPE**

=

/

“FUNCTION”

,

[DEFECT]

/“FONCTION\_C”

,

**/“TABLECLOTH”**

,

**if TYPE=' FONCTION':**

**INDIC\_RESU**

=

/

**[1,2]**

**, [DEFECT]**

**if TYPE=' FONCTION\_C':**

**FORMAT\_C**

=

/

**“REEL\_IMAG”**

**[DEFECT]**

**/“MODULE\_PHASE”**

**,  
if FORMAT\_C=' REEL\_IMAG':**

**INDIC\_REEL**

**=**

**/  
[1,2]  
, [DEFECT]**

**INDIC\_IMAG**

**=**

**/  
[1,3]  
, [DEFECT]  
if FORMAT\_C=' MODULE\_PHASE':**

**INDIC\_MODU**

**=**

**/  
[1,2]  
, [DEFECT]**

**INDIC\_PHAS**

**=**

**/  
[1,3]**

, [DEFECT]

*if TYPE=' NAPPE':*

*NOM\_PARA\_FONC*  
*= cf key word NOM\_PARA*

*INDIC\_ABSCISSE =*  
*[indice1, indice2],*  
*[l\_I]*

*INTERPOL\_FONC*  
*= cf key word ITERPOL*

*PROL\_DROITE\_FONC = cf key word PROL\_DROITE*

*PROL\_GAUCHE\_FONC = cf key word PROL\_GAUCHE*

*DEFI\_FONCTION*  
*=*

*\_F (*

*INDIC\_RESU*  
*=*

*[indice1, indice2],*  
*[l\_I))*

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**Version**

**7.4**

**Titrate:**

**Operator** *LIRE\_FONCTION*

**Date:**

**19/01/05**

**Author (S):**

**C. Key DURAND**

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**3 Operands**

**3.1 Operand**

**UNIT**

**UNIT = U**

**Entirety, logical number of the unit of reading.**

**3.2 Operand**

**FORMAT**

**FORMAT = "FREE",**

**This key word is for the moment useless. It will be able to make it possible in the future to define a format of reading**

**specific, more constraining than the current format.**

**3.3 Operands** *PROL\_DROITE/PROL\_GAUCHE/NOM\_PARA/*

*NOM\_RESU/INTERPOL/VERIF/TITLE/INFORMATION*

***LIRE\_FONCTION* is an macro-order: the numerical values are read in the file indicated by PYTHON then the function is actually created by *DEFI\_FONCTION* [U4.03.01].**

**Thus, these key words are taken again with identical *DEFI\_FONCTION* and make it possible to specify them**

**characteristics of the produced function: interpolation, prolongations, names of the parameters of**

**access.**

### **3.4 Operand SEPAR**

**SEPAR**  
=/"None"/" , "/" ; " /" /"

*Separating character of the columns of figures in the file with reading.  
The default value "None" means one or more white characters. For the others  
separators, of the white characters can also fit between the figures and the separator  
itself.*

### **3.5 Operand INDIC\_PARA**

**INDIC\_PARA** =  
/[indice1, indice2]

*This key word is identical in its principle to other key words INDIC\_\* of the order. It  
allows to choose the column of figures in the file read which will define the X-coordinates of the  
function,  
are the values of the parameter.*

*One awaits obligatorily a list of two entreties: the first indicating the number of "block"  
in the file (cf paragraph [§4] Examples), the second indicating the number of the column. For  
to identify the blocks of the file, one regards as separator of blocks any line which  
would not exclusively contain figures and separators of columns. The columns are  
defined by the presence of separators of columns delimiting them (key word SEPAR).*

*The default value is [1,1]: the first column of the first block is read. That makes it possible to define  
very easily, by informing less possible key words, the reading of a function in one  
file containing two simple columns of figures.*

### **3.6 Operand TYPE**

**TYPE**

=

/

"FUNCTION"



,  
[DEFECT]

/"FONCTION\_C"

,"TABLECLOTH"

Specify the type of function read and created: "FUNCTION", "FONCTION\_C" (call in macro-order with *DEFI\_FONCTION*) or "TABLECLOTH" (call to *DEFI\_NAPPE*).

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**3.7**

***Case of a real function: TYPE=' FONCTION'***

*INDIC\_RESU =*  
*/[indice1, indice2]*

*Of operation identical to INDIC\_PARA, this key word allows to choose the column of figure in the file read defining the ordinates of the function, are the values of the result.*

*The default value is [1,2]: the second column of the first block is read.*

### **3.8**

***Case of a complex function: TYPE=' FONCTION\_C'***

*FORMAT\_C =*  
*“REEL\_IMAG”*  
*INDIC\_REEL =*  
*/[indice1, indice2]*  
*INDIC\_IMAG =*  
*/[indice1, indice2]*

*FORMAT\_C =*  
*“MODULE\_PHASE”*  
*INDIC\_MODU =*  
*/[indice1, indice2]*  
*INDIC\_PHAS =*  
*/[indice1, indice2]*

*In the case of a complex function, two columns of figures (actual values) are to be identified in the file read to define the list of the complex values of the result. One can thus read with the choice real/left part imaginary or modulates/phase.*

*The default values are respectively [1,2] and [1,3]: one reads the second and third columns first block. The first column read by defect having been the value of the parameter (INDIC\_PARA).*

### **3.9**

***Case of a tablecloth: TYPE=' NAPPE'***

*NOM\_PARA\_FONC*  
*= cf key word NOM\_PARA*  
*INDIC\_ABSCISSE =*  
*[indice1, indice2],*

*INTERPOL\_FONC*

= cf key word *ITERPOL*

*PROL\_DROITE\_FONC* = cf key word *PROL\_DROITE*

*PROL\_GAUCHE\_FONC* = cf key word *PROL\_GAUCHE*

*DEFI\_FONCTION*

=

*\_F* (

*INDIC\_RESU*

=

[*indice1*, *indice2*],))

*The principle is the same one as that of DEFI\_NAPPE [U4.31.03]: the list of possible values of parameter (second variable) having been defined by INDIC\_PARA, it remains to identify the functions in the file read by the key word factor DEFI\_FONCTION (similar to the key word factor FUNCTION DEFI\_NAPPE). Attention, the number of identified functions (occurrences of the key word factor) will have to be identical to the cardinal of the values read by INDIC\_PARA.*

*Contrary to the tablecloths in general, one imposes that the functions divide the same list of values of X-coordinates INDIC\_ABSCISSE, this is why only INDIC\_RESU is present under the word key factor DEFI\_FONCTION.*

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## **4 Examples of use**

*That is to say the textual file following containing information to reading. It is composed of columns of figures, here separated by white characters, defining blocks, themselves delimited by free text.*

*Any line understanding of other characters that figures and the preset separator is considered like free text delimiting.*

```

aaa bbb ccc
ddd
eee fff
0. 0. 0.
0.1 1. 10.
0.2 2. 20.
0.3 3. 30.
xxx yyy
www zzz
0.4 4. 40. 400.
0.5 5. 50. 500.
0.6 6. 60. 600.
xxx
70. 700.
80. 800.
90. 900.
PPP qqg
8.8
9.9

```

*Or, with a separator:*

```

...
0.1 ; 1. ; 10. ; 100.
0.2 ; 2. ; 20. ; 200.
...

```

### **4.1 Reading of a simple function**

*By exploiting the default values for the choice of the columns:*

*F=LIRE\_FONCTION (UNIT = 38,*

*NOM\_PARA = "INST",)*

*The function thus created is:*

*X-coordinates =*

*[0., 0.1, 0.2, 0.3]*

*Ordinates = [0. , 1. , 2. , 3. ]*

*While associating for X-coordinates and ordinates of the columns taken in different blocks:*

*F=LIRE\_FONCTION (UNIT = 38,*

*NOM\_PARA = "INST",*

*INDIC\_PARA = [2,4],*

*INDIC\_RESU = [3,1],*

*The function thus created is:*

*X-coordinates =*

*[400., 500., 600.]*

*Ordinates = [70. , 80. , 90.]*

*Attention, the order checks whereas the cardinals of the columns defined by INDIC\_PARA and INDIC\_RESU are quite identical. What would not have been the case here with for example*

*INDIC\_PARA =*

*[1,4].*

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**4.2**

## ***Reading of a complex function***

*By exploiting the default values for the choice of the columns:*

```
F=LIRE_FONCTION (UNIT
= 38,
NOM_PARA =
“INST”,
TYPE =
“FONCTION_C”,
FORMAT_C = “REEL_IMAG”,)
```

*The function thus created is:*

```
X-coordinates =
[0., 0.1, 0.2, 0.3]
Ordinates = [(0. , 0.) , (1. , 10.) , (2. , 20.) , (3. , 30.)]
```

*One could of course have specified other columns for INDIC\_REEL and INDIC\_IMAG that those by defect. Attention however to point on columns in the same way cardinal.*

### **4.3**

#### ***Reading of a tablecloth***

*By exploiting the default values for the choice of the columns:*

```
F=LIRE_FONCTION (UNIT
=
38,
NOM_PARA
=
“INST”,
INDIC_PARA =
[4,1],
NOM_PARA_FONC
=
“FREQ”,
INDIC_ABSCISSE =
[2,2],
DEFI_FONCTION
=
(
F (INDIC_RESU = [3,1],),
F (INDIC_RESU = [2,3],),))
```

*The tablecloth thus created is:*

*For the value of parameter INST=8.8, the function:*

*X-coordinates =*

*[4. , 5. , 6.]*

*Ordinates = [70. , 80. , 90.]*

*For the value of parameter INST=9.9, the function:*

*X-coordinates =*

*[4. , 5. , 6.]*

*Ordinates = [40. , 50. , 60.]*

*The checks of coherence of the cardinals of columns of X-coordinates and ordinates are made by the macro-order.*

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*Operator RECU\_FONCTION*

*Date:*

22/02/06

*Author (S):*

*Key COURTEOUS Mr.*

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*Organization (S): EDF-R & D /AMA*

***Instruction manual***

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***Document: U4.32.03***

***Operator RECU\_FONCTION***

***1 Goal***



*To extract in the form of a function the evolution from a size according to an other.*

*If the extraction is carried out starting from a structure of data result, or a field of size `cham_gd`, or of a `resu_gene`, the produced function corresponds to the temporal evolution of one component in a node or a point of Gauss of the grid.*

*Of a structure of data `tran_gene`, one can also extract the evolution from two parameters in a node of shock.*

*From a table, one can extract the evolution from 2 parameters in the columns of the table or a function contained in a box of the table.*

*From a structure of data `melasflu` one can extract, the evolution of modal parameters in function rate of flow of the fluid.*

*Product a structure of data of the function type.*

*At exit of the order, the function is reordered by increasing X-coordinates.*

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*Titrate:*

*Operator `RECU_FONCTION`*

*Date:*

*22/02/06*

*Author (S):*

*Key `COURTEOUS Mr.`*

*:*

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*2 Syntax*

*Fr [function]*

*= `RECU_FONCTION`*

(

/

**RESULT**

=

**resu,**

/

**[dyna\_harmo]**

/

**[evol\_elas]**

/

**[dyna\_trans]**

/

**[evol\_ther]**

/

**[evol\_noli]**

**# See extraction and localization of the field**

/

**CHAM\_GD**

=

**ch\_gd,**

/

**[cham\_no\_DEPL\_R]**

/

**[cham\_no\_PRES\_R]**

/

**[cham\_no\_TEMP\_R]**

/

**[cham\_elem\_SIEF\_R]**

/

**[cham\_elem\_VARI\_R]**

/

**[cham\_elem\_EPSI\_R]**

/

**[cham\_elem\_FLUX\_R]**

/

**[cham\_elem\_PRES\_R]**

*# See operands of localization of the field*

/  
**RESU\_GENE**  
=  
**obstruct,**

/  
**[tran\_gene]**

*# temporal Evolution of a physical component*

**/NOM\_CHAM = nomsymb,**

**[K16]**

**NOM\_CMP**

=  
**cmp,**  
**[K]**

/  
**NODE**

=  
**No,**  
**[node]**

/  
**GROUP\_NO**

=

***grno,***

***[gr\_noeud]***

***/***  
***MULT\_APPUI = "YES",***

***/***  
***/***  
***CORR\_STAT = "YES",***

***/***  
***ACCE\_MONO\_APPUI =***  
***frap, [function]***

***/***  
***NOEUD\_CHOC =***  
***nd\_choc,***

***[node]***

***/***  
***GROUP\_NO\_CHOC***  
***=***  
***no\_choc,***

***[gr\_noeud]***

***PARA\_X***

=

***nparax,***

***[KN]***

***PARA\_Y***

=

***nparay,***

***[KN]***

***ENTITLE***

=

***name,***

***[KN]***

***LIST\_PARA***

=

***will li\_para,***

***[listr8]***

***SOUS\_STRUC***  
***= nom\_str,***

***[KN]***

***/***  
***RESU\_GENE***  
***=***  
***obstruct,***

***/***  
***[harm\_gene]***

***# frequential Evolution of a generalized component or physics***

***/NOM\_PARA\_RESU = parameter, [K8]***

***/NOM\_CHAM = nomsymb,***

***[K16]***

***/NUME\_CMP\_GENE = numcmp, [K8]***

/  
***NOM\_CMP***  
=  
***cmp,***  
***[K]***

***/NODE = No,***

***[node]***  
/  
***GROUP\_NO***  
=  
***grno,***  
***[gr\_noeud]***

/  
***RESU\_GENE***  
=  
***obstruct,***

/  
***[mode\_gene]***

***# frequential Evolution of a generalized component or physics***

*/NOM\_PARA\_RESU = parameter, [K8]*

*/NOM\_CHAM = nomsymb,*

*[K16]*

*/NUME\_CMP\_GENE = numcmp, [K8]*

*/*  
*NOM\_CMP*  
*=*  
*cmp,*  
*[K]*

*/NODE = No,*

*[node]*  
*/*  
*GROUP\_NO*  
*=*  
*grno,*  
*[gr\_noeud]*



/  
**SKELETON**

=  
*squ,*  
*[skeleton]*

/  
**SOUS\_STRUC =**  
*sstru,*  
**[K]**

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***Key COURTEOUS Mr.***

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/  
**COUNT**  
= *tabl,*

/

[table]

/  
 $PARA\_X = nparax,$

[KN]

$PARA\_Y = nparay,$

[KN]

$/NOM\_PARA\_TABL$   
 $= "FUNCTION",$

$TYPE\_RESU =$   
/  
 $"FUNCTION", [DEFECT]$   
/  
 $"FONCTION\_C",$

$FILTER = _F ($

$NOM\_PARA =$

...

*[KN]*

*CRIT\_COMP =/"EQ",*  
*[DEFECT]*

*/*  
*"LT",*

*/*  
*"WP",*

/  
“”,

/  
“IT”,

/  
“GE”,  
/  
“VACUUM”,  
/  
“NON\_VIDE”,  
/  
“MAXIMUM”,  
/  
“ABS\_MAXI”,  
/  
“MINI”,  
/  
“ABS\_MINI”,

*/VALE = val\_r,*

*[R]*

*/*  
*VALE\_I = val\_n,*

*[I]*

*/*  
*VALE\_C = val\_c,*

*[C]*

*/*  
*VALE\_K = val\_k,*

*[KN]*

/  
*CRITERION* =/"RELATIVE", [*DEFECT*]  
/  
"ABSOLUTE",

/  
*PRECISION* =/prec,  
/  
0.001,

[*DEFECT*]

),

/  
*BASE\_ELAS\_FLUI*  
=  
*flui*,  
[*melasflu*]

/TOUT\_ORDRE = "YES",

*[DEFECT]*

/

*NUME\_ORDRE*

=

*is,*

*[I]*

*NUME\_MODE = im,*

*[I]*

*PARA\_X = "VITE\_FLU",*

*[KN]*

*PARA\_Y =/"FREQ",*

*[KN]*

/

*"AMOR",*

/

*OBSTACLE*

=

*obst,*

*[obstacle]*

*LOCATE*

=

/

*“POLAR”, [DEFECT]*

/

*“TOTAL”, [kN]*

*# Operands of extraction of the field or the parameter*

*/NOM\_CHAM = nomsymb,*

*[K16]*

/

*NOM\_PARA\_RESU*

=

*parameter,*

*/TOUT\_ORDRE = “YES”,*

*[DEFECT]*

/

*TOUT\_INST*

=

*“YES”,*



/  
*NUME\_ORDRE*

=  
*l\_num*,

[*l\_I*]  
/  
*LIST\_ORDRE*

=  
*l\_ord*,

[*listis*]

//*INST = l\_inst*,

[*l\_R*]  
/  
*LIST\_INST*  
=  
*li\_inst*,

[*listr8*]  
/  
*FREQ*

=  
*l\_freq*  
,

[*l\_R*]  
/

*LIST\_FREQ*

=

*li\_freq,*

[*listr8*]

/ *PRECISION* =/*prec,*

[*R*]

/

*1.0D-3,*

[*DEFECT*]

/

*CRITERION* =/"*RELATIVE*", [*DEFECT*]

/

"*ABSOLUTE*",

*INTERP\_NUME* =/"*NOT*",

[*DEFECT*]

/

"*FLAX*",

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*Key COURTEOUS Mr.*

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*# Operands of localization of the field*

*/NODE = No,*

*[node]*

*/*

*GROUP\_NO*

*=*

*grno,*

*[gr\_noeud]*

*/*

*/*

*NET*

*=*

*my,*  
*[mesh]*  
*/*  
*GROUP\_MA*  
*=*  
*grma, [gr\_maille]*

*/NODE = No, [node]*

*/*  
*GROUP\_NO =*  
*grno, [gr\_noeud]*  
*/*  
*NOT*  
*=*  
*nupoint, [I]*

*SOUS\_POINT =*  
*nusp, [I]*

*NOM\_CMP*

=

*cmp,*

*[K]*

*# Overloads attributes of the function created*

*NOM\_PARA*

=

*nom\_pa,*

*[KN]*

*NOM\_RESU*

=

*nom\_res,*

*[KN]*

*Interpol*

= /

*“NOT”,*

*[KN]*

/| “*FLAX*”,

| “*LOG*”,

*PROL\_DROITE*

=

/

“*CONSTANT*”,

/

“*LINEAR*”,

/

“*EXCLUDED*”,

*PROL\_GAUCHE*

=

/

“*CONSTANT*”,

/

“*LINEAR*”,

/

“EXCLUDED”,

*TITRATE*

= *T*,

[*l\_K*]

*INFORMATION*

=

/

1,

[*DEFECT*]

/

2,

)

*If RESULT is one [dyna\_harmo] then Fr is [fonction\_c].*

*If TYPE\_RESU is “FONCTION\_C” then Fr is [fonction\_c].*

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*Date:*

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*Author (S):*

*Key* **COURTEOUS Mr.**

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### **3 Operands**

#### **3.1 Operand**

**RESULT**

*/RESULT = resu*

*Name of the concept of the result type to which the extraction relates.*

*For the operands allowing to extract the field, to refer to [§3.7].*

*For the operands allowing to locate the field, to refer to [§3.8].*

#### **3.2 Operand**

**CHAM\_GD**

*/CHAM\_GD = ch\_gd*

*Name of the concept of the cham\_gd type produces by RECU\_CHAMP [U4.71.01] or CALC\_CHAM\_ELEM [U4.81.03] on which carries the extraction.*

*For the operands allowing to locate the field, to refer to [§3.7].*

#### **3.3 Operand**

**RESU\_GENE**

##### **3.3.1 Temporal evolution of a physical, standard component tran\_gene**

**RESU\_GENE = embarrassment**



*Name of the concept of the `resu_gene` type produces by `DYNA_TRAN_MODAL` [U4.53.21] on which carry the extraction.*

*The recovered function is expressed with the physical variables and not with the variables generalized.*

### **3.3.1.1 Operands**

**`MULT_APPUI` and `ACCE_MONO_APPUI`**

**`MULT_APPUI`**

*If this key word is “YES”, one restores the evolution of the variables in physical space in dealing with the problem moving absolute in the case of an excitation multi-support. In contrary case, the restitution in physical space is done by supposing that the problem is treaty moving relative. This key word is not usable if key word `CORR_STAT` is used.*

**`ACCE_MONO_APPUI`**

*In the case of an acceleration mono-support, one must indicate here the acceleration imposed on all supports in the direction considered in order to calculate the absolute acceleration of the point. If the key word is not indicated, one obtains relative acceleration in result of order.*

**Note:**

*The name of the concept must be same as that well informed under `FONC_MULT` of `DYNA_TRAN_MODAL`.*

### **3.3.1.2 Operands**

**`CORR_STAT`**

**`CORR_STAT`**

*If this key word is “YES”, the evolution of the variables in physical space is obtained in taking account of the correction due to the catch in consideration of static modes (Cf [R4.05.03]). This key word is not usable if key word `MULT_APPUI` is used.*

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### **3.3.1.3 Information concerning the nodes of shock**

**/**

**RESU\_GENE = embarrassment**

**Concept of the tran\_gene type containing for the various nodes of shock**

**:**

**local displacements, normal and tangential speeds and normal forces of shock and tangential.**

**/**

**NOEUD\_CHOC = nd\_choc,**

**GROUP\_NO\_CHOC**

**=**

**no\_choc,**

**Name of the node or the group of nodes (which contains one node) shock where one recover the function.**

**This node of shock is defined in order DYNA\_TRAN\_MODAL [U4.53.21].**

**PARA\_X = nparax**

**Name of the parameter defining the X-coordinates (argument taken among the list: "INST", "FN", "FT1", "FT2", "DXLOC", "DYLOC", "DZLOC", "VN", "VT1", "VT2").**

**PARA\_Y = nparay**

*Name of the parameter defining the ordinates (argument taken among the list: “INST”, “FN”, “FT1”, “FT2”, “DXLOC”, “DYLOC”, “DZLOC”, “VN”, “VT1”, “VT2”).*

*LIST\_PARA = will li\_para*

*List values of the parameter in X-coordinate defining the function.*

*ENTITLE = name*

*This name defines the connection of shock (this name if it is used, is defined in the order DYNA\_TRAN\_MODAL [U4.53.21]).*

*SOUS\_STRUC = nom\_str*

*During a calculation in dynamic under-structuring, name of the substructure which contains it node of shock (cf orders DEFI\_MODELE\_GENE [U4.65.02]). In this case the key word ENTITLE must be also well informed.*

*3.3.2 Frequential evolution of a generalized or physical, standard component  
harm\_gene/mode\_gene*

*RESU\_GENE = embarrassment*

*Name of the concept of the harm\_gene type produces by DYNA\_LINE\_HARM [U4.53.11] or mode\_gene produces by MODE\_ITER\_SIMULT [U4.53.03] or MODE\_ITER\_INV [U4.53.04].*

*The recovered function is expressed with the physical variables if NOM\_CMP is present, with the generalized variables if NUME\_CMP\_GENE is present.*

*NOM\_PARA\_RESU/NOM\_CHAMP*

[See paragraph 3.7.](#)

*NOM\_CMP/NODE/GROUP\_NO*

[See paragraph 3.8.](#)

## ***SKELETON***

***Name of the grid skeleton of the total structure on which the result will be restored: to see operator `DEFI_SQUELETTE` [U4.24.01].***

## ***SOUS\_STRUC***

***See above.***

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***8.2***

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***Operator `RECU_FONCTION`***

***Date:***

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***:***

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## ***3.4 Operand***

***COUNT***

***One can recover:***

- is a function defined starting from two columns of the table,***
- is a function whose name is indicated in a box of the table.***

***/TABLE = tabl***

***Name of the table result in which one carries out an extraction.***

### ***3.4.1 Function defined starting from two columns of the table***

#### ***3.4.1.1 Operands***

***PARA\_X/PARA\_Y***

***PARA\_X = nparax***

*Name of the column of the table defining the X-coordinates.*

***PARA\_Y = nparay***

*Name of the column of the table defining the ordinates.*

### ***3.4.2 Function whose name is indicated in a box of the table***

#### ***3.4.2.1 Operand***

***NOM\_PARA\_TABL***

***NOM\_PARA\_TABL= "FUNCTION"***

*The presence of this key word indicates that one recovers the function whose name is registered in a box of the table.*

#### ***3.4.2.2 Operand***

***TYPE\_RESU***

***TYPE\_RESU =***

*Type of the function to be recovered: function with actual value ("FUNCTION") or with values complexes ("FONCTION\_C").*

### ***3.4.3 Word***

***key***

***FILTER***

*The operands of extraction are different from those used for the preceding cases. To realize the extraction, it is necessary to use the key word FILTERS and operands NOM\_PARA, CRIT\_COMP, VALE\_X, CRITERION, PRECISION.*

*This key word factor makes it possible to filter the information stored in the table. For the use of it key word to see order IMPR\_TABLE [U4.91.03].*

*To recover a function whose name is indicated in a box of the table, It is necessary to use at least twice the key word factor FILTERS to select only the useful box.*

### **3.5 Operand**

#### **BASE\_ELAS\_FLUI**

*One recovers in a structure of data of the melasflu type produced by the operator CALC\_FLUI\_STRU [U4.66.02], evolutions of the frequency or damping, for a mode given, according to various speeds of excitation of the fluid.*

/  
**BASE\_ELAS\_FLUI = flui**

*Concept of the melasflu type produces by order CALC\_FLUI\_STRU.*

#### **3.5.1 Operands**

##### **NUME\_ORDRE/TOUT\_ORDRE**

/NUME\_ORDRE = is,  
/  
**TOUT\_ORDRE**  
=  
"YES",

*The evolution of the frequency or that of damping is given for all speeds fluid (TOUT\_ORDRE) or for some sequence numbers speeds of the fluid (NUME\_ORDRE).*

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### **3.5.2 Operand** **NUME\_MODE**

*/NUME\_MODE = im*

*Number of the mode for which the extraction of the frequency or damping in function speed of the fluid is carried out.*

### **3.5.3 Operands** **PARA\_X/PARA\_Y**

*PARA\_X = "VITE\_FLU"*

*In X-coordinate, the parameter is the speed of excitation of the fluid, of name "VITE\_FLU".*

*PARA\_Y =  
/"FREQ",  
/  
"AMOR",*

*In ordinate, there are the choice between the frequency (name of the parameter: "FREQ") or damping (name of parameter "AMOR").*

### **3.6 Operand** **OBSTACLE**

*One recovers in a structure of data of the obstacle type a function describing the profile of one obstacle in co-ordinates polar or Cartesian.*

*A function having by nature of the monotonous X-coordinates, it is more judicious to recover this profile  
in a table.*

*The key word REFERENCE MARK makes it possible to choose in which frame of reference one recovers the profile.*

### **3.7** **Operands of extraction of the field or the parameter**

#### **3.7.1 Operand** **NOM\_CHAM**

/  
***NOM\_CHAM = nomsymb***

***Reference symbol of the field to which the extraction relates.***

***3.7.2 Operand***  
***NOM\_PARA\_RESU***

/  
***NOM\_PARA\_RESU = parameter***

***Reference symbol of the structural parameter of data which one wants to extract (by example: ETA\_PILOTAGE, MASSE\_EFFE\_DX, MASSE\_GENE...).***  
***See booklets [U5] Structures of data RESULT.***

***The extracted function will then have as a X-coordinate the variable of access (INST, FREQ...) and for ordinate the value of parameter.***

***3.7.3 Operands***  
***TOUT\_ORDRE/NUME\_ORDRE/TOUT\_INST/LIST\_ORDRE***

***/TOUT\_ORDRE = "YES"***  
***(default value)***

***This key word indicates that one wants to extract for all the already calculated sequence numbers.***

***Example: every moment for a result of the evol\_\* type.***

/  
***NUME\_ORDRE = l\_num***

***The extraction will be done for the values of sequence number l\_num provided.***

/  
***TOUT\_INST = "YES"***

***This key word indicates that one wants to extract for every moment.***

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**/**  
**LIST\_ORDRE = l\_ord**

*This key word indicates that one wants to extract with the sequence numbers described in the concept l\_ord of the listis type.*

**3.7.4 Operands**

**INST/LIST\_INST/FREQ/LIST\_FREQ**

**/**  
**INST = l\_inst**

*This key word indicates that one wants to extract at the moments l\_inst.*

**/**  
**LIST\_INST = li\_inst**

*This key word indicates that one wants to extract at the moments described in the concept li\_inst of listr8 type.*

/  
**FREQ = l\_freq**

*This key word indicates that one wants to extract at the frequencies l\_freq.*

/  
**LIST\_FREQ = li\_freq**

*This key word indicates that one wants to extract at the frequencies described in the concept li\_freq of listr8 type.*

### **3.7.5 Operands**

#### **PRECISION/CRITERION**

**PRECISION = prec**

*This operand makes it possible to indicate that one seeks the value of the field of which the moment or frequency is in an interval defined by the absolute or relative position:  
“inst ± prec” (cf CRITERION).*

*By defect prec = 1.0D-3*

**CRITERION =**

*“RELATIVE” the interval of research is  
[inst (1-prec), inst (1+prec)]*

*“ABSOLUTE” the interval of research is  
[inst-prec, inst+prec]*

### **3.7.6 Operand**

#### **INTERP\_NUME**

*This key word defines the type of interpolation between two sequence numbers. It is valid only in case where the user defined a list of moments or frequencies. It is possible to prohibit the interpolation “NOT” or to admit a linear interpolation “FLAX”.*

*The interpolation cannot be used when one extracts the value from a parameter (key word NOM\_PARA\_RESU).*

## **3.8**

## ***Operands of localization of the field***

### ***3.8.1 Operands***

***NODE/GROUP\_NO***

***/NODE = No***

***Name of the node to which the extraction relates.***

***/***

***GROUP\_NO***

***=***

***grno***

***Name of the group of nodes, containing 1 only node, to which the extraction relates.***

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### ***3.8.2 Operands***

***NET/GROUP\_MA/NODE/GROUP\_NO/NOT***

***/MESH = my***

***/GROUP\_MA = grma***

*Name of the mesh (my) or name of a group of meshes (grma), containing only one net, to which the extraction relates. These key words relate to only the cham\_elem.*

**/NODE = No**

*Name of a node of the mesh to which the extraction (case of the cham\_elem relates with the nodes).*

**/  
GROUP\_NO**

**=  
grno**

*Indicate the name of the group of nodes, container only one name of node, on which carries the extraction (case of the cham\_elem to the nodes).*

**/  
NOT**

**=  
nupoint**

*The entirety nupoint specifies the local number with the element of the point of GAUSS which one wishes to obtain the value (case of the cham\_elem at the points of GAUSS).*

**SOUS\_POINT = nusp**

*The entirety nusp specifies the number of the under-point of which one wishes to obtain value (case of the cham\_elem at under-points, used by the elements of structure: beam, pipes, hulls).*

*The number of under-point is the number of the layer in an element of hull, the number of fibre in an element of beam multifibre or them elements pipes. The classification of the layers or fibres is described in documentation of the elements using the concept of under-point (cf [R3.07.03], [R3.07.04], [R3.08.06] and [R3.08.08]).*

**3.8.3 Operand  
NOM\_CMP**

***NOM\_CMP = cmp***

***Name of the component of the size to which the extraction relates.***

### ***3.9***

***Attributes of the concept function created by RECU\_FONCTION***

#### ***3.9.1 Default values***

***By defect the attributes of the concept function created by order RECU\_FONCTION are:***

***Interpolation: "NOT"***

***Left prolongation: "EXCLUDED"***

***Right prolongation: "EXCLUDED"***

***NOM\_PARA: given in entry***

***NOM\_RESU: given in entry***

#### ***3.9.2 Overload attributes***

***The user can overload the attributes given by defect by using the key words following:***

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### **3.9.2.1 Operand**

***NOM\_PARA***

*NOM\_PARA = para*

*He indicates the name of the parameter (variable or X-coordinate) of the function. Values currently authorized for will lpara are:*

/

**“TEMP”**

/

**“INST”**

/

**“EPSI”**

/

**“X”**

/

**“Y”**

/

**“Z”**

/

**“FREQ”**

/

**“PULS”**

/

**“AMOR”**

/

“DX”

/

“DY”

/

“DZ”

/

“DRX”

/

“DRY”

/

“DRZ”

*more those specific to the nodes of shock (cf [§ 3.3.2.2]).*

### **3.9.2.2 Operand**

#### ***NOM\_RESU***

*NOM\_RESU = resu*

*It indicates the name of the result, the function thus created is a function whose value is of name lresu (8 characters).*

### **3.9.2.3 Operand**

#### ***Interpol***

*Interpol*

*Type of interpolation of the function enters the values of the parameter of the field of definition. Behind this key word one awaits a parameter list (two to the maximum) among “NOT”, “FLAX”, “LOG”. If only one value is given the interpolation will be identical for X-coordinates and ordinates. If two values are given, the first corresponds to the interpolation of the X-coordinates and the second with the interpolation of the ordinates.*

### **3.9.2.4 Operands**

#### ***PROL\_DROITE/PROL\_GAUCHE***

*PROL\_DROITE and PROL\_GAUCHE*

*They define the type of prolongation on the right (on the left) of the field of definition of variable:*

.

*“CONSTANT” for a prolongation with the last (or first) value of function,*

*“LINEAR” for a prolongation along the first definite segment (PROL\_GAUCHE) or of the last definite segment (PROL\_DROITE),*

*“EXCLUDED” if extrapolation from the values apart from the field of definition from parameter is prohibited.*

### **3.10 Operand TITRATE**

*TITRATE*

*Titrate attached to the concept produced by this operator [U4.03.01].*

### **3.11 Operand INFORMATION**

*INFORMATION*

*Specify the options of impression on the file MESSAGE.*

*1  
no impression (by defect)*

*2  
impression of the descriptor of the function and the list of the first 10 values of function in the order ascending of the first 10 parameters*

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## **4 Examples**

### **4.1 Extractions**

**of  
function on the dynamic response of a network of  
piping**

**tran\_gen = DYNA\_TRAN\_MODAL (...)**

**l\_inst = DEFI\_LIST\_REEL (BEGINNING = 0. ,  
INTERVAL = \_F (JUSQU\_A = 3. , NOT = 0.005))**

**dyn\_tran = REST\_BASE\_PHYS (RESU\_GENE = tran\_gen, NOM\_CHAM = "DEPL",  
LIST\_INST = l\_inst, Interpol = "FLAX")**

**dyn\_tran = CALC\_ELEM (...,  
OPTION = "SIEF\_ELGA\_DEPL")**

**tab\_rele = POST\_RELEVE\_T (ACTION=\_F (ENTITLES  
= "sixx\_254",  
WAY = line,  
RESULT  
= dyn\_tran,  
NOM\_CHAM  
= "SIEF\_ELGA\_DEPL",  
INST  
=  
2.54,  
TOUT\_CMP  
= "YES",  
OPERATION = "EXTRACTION"))**

**4.1.1 Evolution of the displacement of component node NO01 "DX" with all them  
moments of calculation**

**f1 = RECU\_FONCTION (RESU\_GENE = tran\_gen, NOM\_CHAM = "DEPL",  
NODE = "NO01", NOM\_CMP = "DX")**

#### **4.1.2 Evolution of size “SIXX” on mesh MA01 with node NO01 with all them moments of calculation**

*f2 = RECU\_FONCTION (RESULTAT= dyn\_tran, NOM\_CHAM= “SIEF\_ELGA\_DEPL”,  
NET = “MA01”, NODE = “NO01”, NOM\_CMP=' SIXX')*

#### **4.1.3 Evolution of size “SIXX” along the line of piping at the moment of calculation 2.54 S**

*f3 = RECU\_FONCTION (TABLE = tab\_rele,  
PARA\_X = “ABSC\_CURV”, PARA\_Y = “SIXX”)*

#### **4.1.4 Evolution of size “SIXX” along the line of piping (X-coordinate curvilinear higher than 10) at the moment of calculation 2.54 S**

*f4 = RECU\_FONCTION (TABLE = tab\_rele,  
FILTER = \_F (NOM\_PARA = “ABSC\_CURV”,  
CRIT\_COMP = “GE”,  
VALE = 10. ),  
PARA\_X = “ABSC\_CURV”, PARA\_Y = “SIXX”)*

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#### **4.2 Extraction**

**of  
function in a structure of data melasflu**

```
meles1 = CALC_FLUI_STRU (...)
```

```
f_freq = RECU_FONCTION (BASE_ELAS_FLUI = meles1,  
  PARA_X = "VITE_FLU",  
  PARA_Y = "FREQ",  
  TOUT_ORDRE = "YES",  
  NUME_MODE = 2  
)
```

### 4.3 Extraction

*of  
function whose name is indicated in a box  
of a table of the table\_post\_alea type*

```
reppx_ac = REST_SPEC_PHYS (...)
```

```
statx_ac = POST_DYNA_ALEA (INTE_SPEC = reppx_ac,  
  TOUT_ORDRE = "YES",  
  OPTION = "DIAG")
```

```
f_freq = RECU_FONCTION (TABLE = statx_ac,  
  NOM_PARA_TABL = "FUNCTION",  
  TYPE_RESU = "FONCTION_C",  
  FILTER = (_F (NOM_PARA = "NOEUD_I",  
  VALE_K = "N_TUB_01"),  
  _F (NOM_PARA = "NOEUD_J",  
  VALE_K = "N_TUB_01"),  
  _F (NOM_PARA = "NUME_VITE_FLUI",  
  VALE_I = 3)  
)  
)
```

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

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***Document: U4.32.04***

***Operator CALC\_FONCTION***

***1 Goal***

***To carry out mathematical operations on structures of data of the function type.***

***The following operations are currently available:***

.

***the derivation of a function,***

.

***the integration of a function,***

.

***the reverse of a function,***

.

*the absolute value of a function,*

.

*the research of the envelope of several functions,*

.

*real or complex linear combination several functions,*

.

*the composition of two functions,*

.

*concatenation (put end to end with management of the overlappings) several functions,*

.

*the extraction of a real function starting from a complex function,*

.

*the calculation of the nth power of a function,*

.

*the calculation of direct or opposite FFT of a function,*

.

*correction of a accélérogramme measured for calculation of a seismic answer,*

.

*smoothing wraps one or more rough spectra of oscillator,*

.

*the calculation of the spectrum of oscillator of a accélérogramme (function of the frequency and of damping) in the form of a tablecloth,*

*Product a structure of data function, or tablecloth, according to the key word factor used.*

*At exit of the order, the function is reordered by increasing X-coordinates.*

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Author (S):

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Operator *CALC\_FONCTION*



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## 2 Syntax

**Fr**  
**= CALC\_FONCTION**

(  
**/DRIFT**  
**= \_F (**

**FUNCTION = F, [function]**

**METHOD = “DIFF\_CENTREE”, [DEFECT]**

),  
/  
**JUST**  
**=**

**\_F**  
(  
**FUNCTION = F, [function]**

**METHOD =/“TRAPEZOID”,**  
**[DEFECT]**

/  
“**SIMPSON**”,

**COEF** =/0. ,  
[**DEFECT**]

/R,

[R]

),  
/

**OPPOSITE**

=

**\_F** (  
**FUNCTION** = **F**, [**function**]

),  
/  
**ABS**  
=  
**\_F (**  
**FUNCTION = F, [function]**

),  
/  
**WRAP**  
=  
**\_F (**  
**FUNCTION = F, [l\_fonction]**

**CRITERION =**  
**/"SUP",**  
**[DEFECT]**

/  
**"INF",**

),  
/  
**COMB**  
=  
**F**  
(  
**FUNCTION**  
=  
**F**  
,  
**[function]**

**COEF = R,**

**[R]**

),  
/  
**COMB\_C**  
=  
**F**  
(  
**FUNCTION**  
=  
**f\_c,**

**[fonction\_c]**

**/COEF\_R**

=

**R**

,

**[R]**

/

**COEF\_C**

=

**C**

,

**[C]**

),

**# if COMB or COMB\_C**

**LIST\_PARA**

=

**will lpara,**

**[listr8]**

/

**COMPOSE =**

**\_F (**

**FONC\_RESU**

**= f\_resu**

**, [function]**

**FONC\_PARA**

**= will f\_para**

**, [function]**

)

/

**ADZE**

**=\_F (**

**FUNCTION**

=

**l\_f,**

**[l\_fonction]**

**OVERLOAD**  
=/"**RIGHT**",  
[**DEFECT**]

/  
"**LEFT**",

),  
/  
**EXTRACTION**=\_F (

**FUNCTION**  
=  
**f\_c**,  
[**fonction\_c**]

**PART**  
=/"**REAL**",



/  
“**IMAG**”,

/  
“**MODULE**”,

/  
“**PHASE**”,

),  
/

**POWER = \_F (**

**FUNCTION**

**=**

**F**

**,**  
**[function]**

**EXHIBITOR**

**= /**

**N,**

**[I]**

**/**

**1,**

**[DEFECT]**

**),**

**/**

**FFT**

**=**

**\_F (**

**FUNCTION**

**=**

**F**

**,**

**[function]**

**METHOD =**

**/"PROL\_ZERO",**

**[DEFECT]**

/

**“TRUNCATION”,**

),

/

**CORR\_ACCE**

=

**\_F (**

**FUNCTION**

=

**F**

,

**[function]**

**CORR\_DEPL =/**

**“NOT”,**

**[DEFECT]**

/

**“YES”,**

),  
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*/LISS\_ENVELOP*

= *\_F (*

,  
*TABLECLOTH*

=

*N,*

*[tablecloth]*

*FREQ\_MIN*

=

/

*fmin,*

*[R]*

/

0.2

*[DEFECT]*

*FREQ\_MAX*

=

/

*fmax,*

[R]

/

35.5

[DEFECT]

*ELARG*

=

*/elar,*

[R]

/0.1,

[DEFECT]

*TOLE\_LISS*

=

/

*toleliss,*

[R]

/

0.25,

[DEFECT]

),

/

*SPEC\_OSCI*

=

*\_F (*

*FUNCTION*

=

*F,*

[function]

*METHOD* = "NIGAM",

[*DEFECT*]

*AMOR\_REDUIT*=

*lam*, [*l\_R*]

*/FREQ* = *lfre*,

[*l\_R*]

*/LIST\_FREQ* = *lfreq*,

*[listr8]*

*NATURE* =/"ACCE",

*[DEFECT]*

/

"QUICKLY",

/

"DEPL",

*NATURE\_FONC*=

"ACCE", *[DEFECT]*

*NORMALIZES* =/9.81,

*[DEFECT]*

/R  
,  
[R]

),

*NOM\_PARA*  
=  
*para*  
,  
[KN]

*NOM\_RESU*  
=  
*resu*  
,  
[KN]

*PROL\_DROITE*  
=  
/  
"CONSTANT",  
/  
"LINEAR",  
/



“EXCLUDED”,

*PROL\_GAUCHE*

=

/

“CONSTANT”,

/

“LINEAR”,

/

“EXCLUDED”

*Interpol*

= I “FLAX”,

[l\_Kn]

I “LOG”,

I “NOT”,

*INTERPOL\_FONC*

=

I “FLAX”,

[l\_Kn]

I “LOG”,

*I “NOT”,*

*NOM\_PARA\_FONC*

=

*parf,*  
*[KN]*

*PROL\_DROITE\_FONC*

=/“CONSTANT”,

/

“LINEAR”,

/

“EXCLUDED”,

*PROL\_GAUCHE\_FONC*

=/“CONSTANT”,

/

“LINEAR”,

/

“EXCLUDED”,

*INFORMATION*

=

/

*1,*  
*[DEFECT]*

/

*2,*

)

*If key word factor DERIVES*

*then Fr = [FUNCTION]*

*If JUST key word factor*

*then Fr = [FUNCTION]*

*If OPPOSITE key word factor*

*then Fr = [FUNCTION]*

*If key word factor ABS*

*then Fr = [FUNCTION]*

*If key word factor WRAPS*

*then Fr = [FUNCTION]*

*If key word factor COMB*

*then*

*Fr*

*=*

*[FUNCTION]*

*If key word factor COMB\_C*

*then Fr = [FONCTION\_C]*

*If key word factor COMPOSES*

*then Fr = [FUNCTION]*

*If key word factor ADZE*

*then*

*Fr*

*=*

*[FUNCTION]*

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*If key word factor EXTRACTION*

*then Fr = [FUNCTION]*

*If key word factor FFT*

*then Fr = [FUNCTION]*

*If key word factor CORR\_ACCE*

*then Fr = [FUNCTION]*

*If key word factor POWER*

*then Fr = [FUNCTION]*

*If key word factor SPEC\_OSCI*

*then Fr = [TABLECLOTH]*

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### **3 Operands**

#### **3.1 Word**

*key*

**DERIVES**

**/DRIFT**

=

*The function F (T) is derived.*

**FUNCTION = F**

*Name of the function which one wishes to derive.*

*Do not apply to the concepts of the tablecloth type.*

**METHOD =**

*Name of the METHOD which one wishes to use: the only method available is currently  
DIFF\_CENTREE (by defect).*

*Note:*

*See JUST key word.*

#### **3.2 Word**

**key**  
**JUST**

**/JUST**  
**=**

**The function  $F(T)$  is integrated.**

**FUNCTION = F**

**Name of the function which one wishes to integrate.  
Do not apply to the concepts of the tablecloth type.**

**METHOD =**

**Name of the METHOD which one wishes to use.**

**Two methods are available: method of the "TRAPEZOID" (by defect) and method of "SIMPSON".**

**The method of "SIMPSON" is to be employed with precaution because it can involve oscillations. It is to better discretize  $F(T)$  finely and to integrate with the method of "TRAPEZOID". In particular it is disadvised using method "SIMPSON" for the interpretation of a accélérogramme.**

**COEF = R**

**Constant of integration, by defect 0.**

**Note:**

- For JUST as for DRIFT, the NOM\_PARA of the produced function is unchanged: one does not have for example to expect only NOM\_RESU=' ACCE' NOM\_RESU=' VITE' in the integrated function produces. The user with the faculty of to modify by the key word of the same name in CALC\_FONCTION.**
- Concerning the prolongations, the produced function has by defect of the prolongations EXCLUDED on the left and on the right, some are those of the starting function. Not to thus expect that a linear prolongation becomes constant in the function derived... There still, the user is a Master of his prolongations for the function produced by key words PROL\_DROITE and PROL\_GAUCHE.**

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### **3.3 Word**

*key*

**OPPOSITE**

**/OPPOSITE**

**=**

*The function  $F(T)$  is reversed.*

**FUNCTION = F**

*Name of the function which one wishes to reverse, it is necessary that this one is bijective (strictly increasing or strictly decreasing).*

*Do not apply to the concepts of the tablecloth type.*

**Note:**

- The labels of the parameters are not reversed! The care is left with the user to affect the correct values by the key words **NOM\_PARA** and **NOM\_RESU**. Par defect, the **NOM\_PARA** is unchanged and **NOM\_RESU** is affected with “**TOUTRESU**”.*
- The modes of interpolations are inverted: e.g. (“**FLAX**”, “**LOG**”) becomes (“**LOG**”, “**FLAX**”).*
- The prolongations **EXCLUDED** and **LINEAR** are unchanged. On the other hand, one*

***CONSTANT*** prolongation is changed from of ***EXCLUDED***.

### ***3.4 Word***

***key***

***ABS***

***/ABS***

***=***

***Provides the absolute value of a function or a tablecloth.***

***FUNCTION = F***

***Name of the function which one wishes the absolute value.***

***Note:***

- Parameters (prolongations, interpolations, NOM\_PARA and NOM\_RESU) of produced function are the same ones as those of the starting function.***
- Except for the LINEAR prolongation: systematically changed from of EXCLUDED by precaution. Indeed, linear prolongation on the right of a decreasing function conduit for sufficiently large X-coordinates with negative values: responsibility is thus left with the user affect itself PROL\_DROITE=' LINEAIRE' (and respectively on the left).***

### ***3.5 Word***

***key***

***WRAP***

***/***

***WRAP***

***=***

***Calculation of the envelope of several functions.***

***This operation is available on operands of nature function or tablecloth.***

#### ***3.5.1 Operand***

***FUNCTION***

***FUNCTION = F***

***List functions or tablecloths which one seeks the envelope.***

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**3.5.2 Operand**

**CRITERION**

**CRITERION =**

**/**

**“SUP”**

**The higher envelope is sought.**

**/**

**“INF”**

**The lower envelope is sought.**

**Remarks for the research of the envelope:**

**.**

**the functions all must be of comparable nature (function or tablecloth),**

**.**

**Case of the simple functions: for the prolongations, interpolations, NOM\_PARA and NOM\_RESU, they are the parameters of the first of the functions in the list which are retained. The support of X-coordinates of the function envelope will be the meeting of the lists X-coordinates of all the functions.**

**.**

**Case of the tablecloths: the parameters (prolongations, interpolations, NOM\_PARA, NOM\_RESU,**

***NOM\_PARA\_FONC)*** must imperatively be identical between the provided tablecloths. supports of X-coordinates (values of the parameters and X-coordinates of the functions of the tablecloths) are homogenized to be able to calculate the envelope. The produced tablecloth will have this discretization for X-coordinates.

### **3.6 Word**

**key**

**COMB and operand LIST\_PARA**

**/COMB =**

***Real linear combination several concepts of nature function or tablecloth.***

**FUNCTION = F**

***Name of the function to be combined.***

**COEF= R**

***Value of the coefficient.***

**LIST\_PARA= will lpara**

***List values of the parameters for which the combination of the functions will be discretized. If this key word is not indicated, a list by defect is built by taking the union of the lists of values of the parameters of each function.***

***Caution:***

***It is not a key word of the key word factor COMB.***

***Remarks for the combination:***

***See the remarks for the key word WRAPS***

### **3.7 Word**

**key**

**COMB\_C and operand LIST\_PARA**

**/COMB\_C**

**=**

*Linear combination complexes several concepts of nature fonction\_c.*

**FUNCTION =  
f\_c**

*Name of the function to be combined. It can be with complex or real values.*

**/COEF\_R = R,**

**/COEF\_C = C,**

*Value of the multiplying coefficient, either in real form R, or in form complexes C.*

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**LIST\_PARA = will lpara**

*List values of the parameters for which the combination of functions will be discretized. If it key word is not indicated, a list by defect is built by taking the union of the lists of values of the parameters of each function.*

**Remarks for the combination:**

**See the remarks for the key word WRAPS**

### **3.8 Word**

*key*

**COMPOSE**

*Key word factor allowing to calculate the made up one of two functions  $F (G (T))$ .  
Do not apply to the concepts of the tablecloth type.*

/

**COMPOSE**

=

**FONC\_RESU = f\_resu**

*Function f\_resu (X)*

**FONC\_PARA = will f\_para**

*Function will f\_para (T)*

*It is checked that the NOM\_PARA of f\_resu corresponds to the NOM\_RESU of will f\_para.*

### **3.9 Word**

*key*

**ADZE**

/

**ADZE**

=

*Key word factor allowing to create a real function by concaténant two real functions tabulées.*

*Do not apply to the concepts of the tablecloth type.*

#### **3.9.1 Operand**

**FUNCTION**

***FUNCTION = l\_f***

***Functions with concaténer. Two functions exactly are awaited.***

### ***3.9.2 Operand OVERLOAD***

***OVERLOAD  
=/"RIGHT",***

***/"LEFT",***

***The points of discretization of the function created are those of the whole of the two functions, modulo effects of overload.***

***If the fields of definition of the functions overlap, one of the functions impose its points on the zone of covering and for the prolongations:***

***OVERLOAD =/"RIGHT": it is the function which has large the xmax which is chosen,  
OVERLOAD =/"LEFT": it is the function which has smallest xmin which is selected.***

### ***3.9.3 Checks***

***One checks that all the functions have the same NOM\_PARA, as well as the same interpolations.  
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**3.10 Word**  
**key**  
**EXTRACTION**

/  
**EXTRACTION**  
=

*Key word factor allowing to build starting from a complex function (standard fonct\_c), a real function representative either the real part, or the imaginary part, or the module, that is to say the phase of the complex function.*

**3.10.1 Operand FUNCTION**

**FUNCTION = f\_c**

*Complex function.*

**3.10.2 LEFT operand**

**PART**  
=

**/“REAL”**  
*: extraction of the real part of f\_c,*  
**/“IMAG”**  
*: extraction of the imaginary part of f\_c,*  
**/“MODULE”**: *extraction of the module of f\_c,*  
**/“PHASE”**: *extraction of the phase (in degree) of f\_c.*

**3.11 Word**  
**key**  
**POWER**

*This key word makes it possible to build the nth power of a function or a whole of functions provided in the form of a tablecloth.*

**FUNCTION = F**

*Name of the function F concerned (standard function or tablecloth).*

**EXHIBITOR = N**

*The function result calculated will be  $X F (X) N$ . By defect,  $N = 1$ .*

**3.12 Word**

**key**

**FFT**

**/FFT**

**=**

*One calculates the transform of Fourier direct or opposite of a function (algorithm FFT).*

**FUNCTION = F**

*Name of the function on which the operation is carried out.*

*If the NOM\_PARA of the function is INST, then the direct FFT is calculated.*

*If the NOM\_PARA of the function is FREQ, then the opposite FFT is calculated.*

*Do not apply to the concepts of the tablecloth type.*

**METHOD =**

*Algorithm FFT accepts in entry only one signal of which the number of samples is one power of 2.*

*Method "PROL\_ZERO" (by defect) proposes to prolong the input signal with zeros until having a total number of sample which is the first power of 2 whose value is higher than the initial number of samples.*

*The method "TRUNCATION" will consider only the first samples of which the total number is the greatest power of two whose value is lower than the initial number of sample.*

*For example, on a signal of 601 values, method "PROL\_ZERO" will supplement the signal for to have 1024 samples, whereas the method "TRUNCATION" will consider only them the first 512 moments.*

*If the input signal to a number of sample which is a power of two, two methods are obviously equivalent: one takes into account the signal without modifying it.*

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**3.13 Word**

**key**

**CORR\_ACCE**

**/**

**CORR\_ACCE**

**=**

***Key word factor allowing to correct a accélérogramme measured for calculation of seismic response of a system.***

***One removes the drift of the signal, calculated by linear smoothing within the meaning of least squares***

***on the totality of the signal, in order to make the accélérogramme more realistic. Drift speed relative corresponding is also removed.***

***One turns over at exit the corrected accélérogramme.***

**3.13.1 Operand FUNCTION**

**FUNCTION = F**

***Measured real Accélérogramme.***

***Do not apply to the concepts of the tablecloth type.***

**3.13.2 Operand CORR\_DEPL**

**CORR\_DEPL**

**=**

**/**

**“NOT”**

***One does not correct the drift of relative displacement, it is the default value.***

**/**

**“YES”**



*One removes also the drift of relative displacement. This option is to be used with precaution, because one does not know a priori the value of final displacement after the seism.*

### **3.14 Word**

*key*

**LISS\_ENVELOP**

*The data of origin make up of a tablecloth of spectra SRO gross definite on large a number of points for a level of floor given.*

*The first stage consists, for each spectrum, with widening in frequency (shift on the left and) followed on the right by a reduction in the number of point of definition. These operations carried out, one*

*ensure yourself of the character wraps spectrum smoothed compared to the initial spectrum. This stage, each*

*spectrum has its own base of frequency.*

*The second stage consists in homogenizing the base of frequency of the whole of the spectra of tablecloth while ensuring itself of nonthe covering of the spectra between them.*

**TABLECLOTH = N**

*Name of the tablecloth of entry formed of the rough spectra associated each level of damping.*

**FREQ\_MIN and FREQ\_MAX**

*Beach of definition in frequency of the smoothed spectrum.*

*The frequencies mentioned under FREQ\_MIN and FREQ\_MAX must be selected among frequencies of discretization of the rough spectrum.*

*By defect, one considers the complete spectrum.*

**ELARG**

*Widening relates to the whole of the spectrum,*

*It is given expressed as a percentage and is worth 0.1 (10%) per defect.*

*For each  $F_i$  frequency of the rough spectrum, one defines two new values of frequencies such as:*

*.*  
 $F - = I$   
 $F (1 - G)$  with  $0 < G < 1$ ,  
*.*

**$F + = I$**   
 **$F (1 + D)$  with  $0 < D < 1$ .**  
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**The parameters  $G$  and  $D$  represent the amplitude of widening in frequency.**  
**Values of the offset frequencies**

**-**

**$F$  and +**

**$F$  do not correspond to values  $I$**

**$F$  of**

**the list of definition of the rough spectrum.  $J$  thus is defined**

**$F$  and  $K$**

**$F$  such as:**

**-**

**.**

**$J$**

**$F$ : value belonging to the list, immediately below or equalizes with  $F$ ,**

**.**

**$K$**

**$F$ : value belonging to the list, immediately below or equalizes with +**  
 **$F$ .**

**( $jF$ ,  $I$ )**

**For each frequency  $I$**

**$F$ , two points of co-ordinates**

*and (K  
F, I) are defined  
where I represents acceleration at frequency I  
F. Two new spectra resulting from  
shift of the rough spectrum on the axis of the frequencies are thus built.*

**TOLE\_LISS**

*Bearing expressed as a percentage criterion on the elimination of the points during smoothing. This tolerance is*

*fixed at 0.25 times the default value.*

*Smoothing is carried out on the envelope of the spectra rough, shifted on the right and on the left.*

*An example of application is proposed in the case ZZZZ100e test.*

**3.15 Word**

*key*

**SPEC\_OSCI**

**/SPEC\_OSCI**

=

*Calculate the spectrum of oscillator of a accélérogramme, function of nature function [R4.05.03].*

*The spectrum of oscillator is calculable only on the functions of NOM\_RESU = "ACCE" and of NOM\_PARA = "INST".*

*For any I and any J one considers J  
IQ the solution of the differential equation:*

**&**

**Q J**

**J**

**J**

**I + 2**

**2**

**ji &q + Q = F (T)**

**I**

**I**

**I**

**J**

**J**  
**with Q ()**  
**0 =**  
**()**  
**0 = ()**  
**&q**  
**F**  
**I**  
**I**  
**0 and = 2**  
**I**  
**I**

*The concept produces Fr is a tablecloth (function with two variables) made up of the functions (Fr,..., Fr,)...*

**I**  
**J**  
*with Fr J function defined in items I with:*

**Fr (I) = max Q J**

**(T) and D = {T/F**

**J**  
**I**  
**}**  
**defined**  
**T D**

*By defect for the calculation of the spectrum of oscillator*

**.**  
*one considers for reduced depreciation the values:*

**0.02**  
**0.05**  
**0.10**

**.**  
*one considers for the frequencies, the 150 values following in Hz,*

*first is to 0.2 Hz and one deduces the following ones by the rule;*

*2nd with the 57ème: by step of*

**0.05 Hz**

**58**

**65**  
**0.075**  
**Hz**

**66**

**79**  
**0.10**  
**Hz**

**80**

**103**  
**0.125**  
**Hz**  
**104**

**131**  
**0.25**

**Hz**  
**132**

**137**  
**0.5**

**Hz**  
**138**

**141**  
**1.**

**Hz**  
**142**

**150**  
**1.5**

**Hz**

.

*the spectrum is normalized with G (either with the value 9.81 ms<sup>-2</sup>).*

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**Author (S):**

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### ***3.15.1 Operand FUNCTION***

***FUNCTION =***

***F***

***Name of the function on which the operation is carried out.***

***Do not apply to the concepts of the tablecloth type.***

### ***3.15.2 Operand METHOD***

***METHOD =***

***Name of the METHOD which one wishes to use: the only method usable currently is***

***“NIGAM” (by defect) which is detailed in the document [R5.05.01].***

### ***3.15.3 Operand AMOR\_REDUIT***

***AMOR\_REDUIT = lam***

***lam = (***

***1, ...,***

***, )***

***...***

***I***

***List reduced depreciation: example 0.01, 0.05, ....***

### ***3.15.4 Operands FREQ/LIST\_FREQ***

***/***

***FREQ = lfre***

*lfre = (*

*1,...*

*, )*

*...*

*I*

*. List frequencies.*

*/*

*LIST\_FREQ = lfreq*

*List frequencies provided under a concept listr8.*

### *3.15.5 Operands NATURE/NATURE\_FONC*

*NATURE =*

*Nature of the size of the tablecloth created by order CALC\_FONCTION.*

*2*

*“ACCE”: spectrum the pseudo one - acceleration*

*(  
U T) =*

*(  
U T)*

*&*

*I*

*“QUICKLY”: spectrum of pseudovelocity*

*(  
U T) =*

*(  
U T)*

*&*

*I*

*“DEPL”: spectrum of displacement*

*(  
U T)*



**NATURE\_FONC = "ACCE"**

*Nature of the function which is used to build the spectrum. For the moment only value "ACCE" is available. This key word makes it possible to overload the NOM\_RESU of the function specified under key word FUNCTION when this one is created by RECU\_FONCTION [U4.32.03].*

### **3.15.6 Operand NORMALIZES**

**= R NORMALIZES**

*The spectrum of oscillator will be normalized with the value R (value of pseudo-acceleration), this value is recalled in the file of message.*

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### **3.16 Attributes of the concept function at exit**

#### **3.16.1 Default values**

*By defect the attributes of the concept function at exit of order CALC\_FONCTION are for various options (cf orders DEFI\_FONCTION [U4.31.02] and DEFI\_NAPPE [U4.31.03]).*

.

**Option DERIVES:**

**Interpolation: data by the function in entry**

***Left prolongation: EXCLUDED***

***Right prolongation: EXCLUDED***

***NOM\_PARA = "INST" (example) given by the function in entry***

***NOM\_RESU = "QUICKLY" (example) given by the function in entry***

.

***JUST option:***

***Even rules that for DRIFT***

.

***Options COMB/COMB\_C:***

***Attributes of the first combined function.***

.

***Option SPEC\_OSCI: the result is a tablecloth***

***Attributes of the tablecloth:***

***NOM\_PARA = "AMOR"***

***NOM\_RESU = "DEPL" or "QUICKLY" or "ACCE"***

***Interpolation: "LOG"***

***Left prolongation: "EXCLUDED"***

***Right prolongation: "EXCLUDED"***

***Attributes of each function:***

***NOM\_PARA = "FREQ"***

***Interpolation: "LOG"***

***Left prolongation: "EXCLUDED"***

***Right prolongation: "CONSTANT"***

.

***Option WRAPS:***

*Attributes of the first function given.*

.

*Option FFT:*

*NOM\_PARA = FREQ if NOM\_PARA of the function is INST  
If not it is the reverse*

.

*Option COMPOSES:*

*NOM\_PARA: that of function FONC\_PARA  
NOM\_RESU: that of function FONC\_RESU  
Interpol: that of function FONC\_RESU  
Prolongation: that of function FONC\_RESU*

.

*Option EXTRACTION:*

*Attributes identical to those of the function given in entry*

.

*Option ADZE:*

*NOM\_PARA: that of the functions  
NOM\_RESU: that of the functions  
Interpol: linear  
Prolongation: "EXCLUDED"  
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### **3.16.2 Overload attributes**

*The user can overload the attributes given by defect by using the following key words:*

#### **3.16.2.1 Operand NOM\_PARA**

**NOM\_PARA = para**

*He indicates the name of the parameter (variable or X-coordinate) of the function or the tablecloth. values currently authorized for para are:*

/  
**“TEMP”**  
/  
**“INST”**  
/  
**“EPSI”**  
/  
**“X”**  
/  
**“Y”**  
/  
**“Z”**  
/  
**“FREQ”**  
/  
**“PULS”**  
/  
**“AMOR”**  
/  
**“DX”**  
/  
**“DY”**  
/  
**“DZ”**  
/  
**“DRX”**  
/  
/

**“DRY”**

/

**“DRZ”**

/

**“ABSC”**

### **3.16.2.2 Operand NOM\_RESU**

*NOM\_RESU = resu*

*It makes it possible to document, the function created by giving a name (8 characters) to the function. Except exception (cf [§3.1], [3.2], [§3.5]), this name is not tested.*

### **3.16.2.3 Operand Interpol**

*Interpol*

*Type of interpolation of the function enters the values of the parameter of the field of definition. Behind this key word one awaits a parameter list (two to the maximum) among “NOT”, “FLAX”, “LOG”. If only one value is given the interpolation will be identical for X-coordinates and ordinates. If two values are given, the first corresponds to the interpolation of the X-coordinates and the second with the interpolation of the ordinates.*

### **3.16.2.4 Operands PROL\_DROITE/PROL\_GAUCHE**

*PROL\_DROITE and PROL\_GAUCHE*

*They define the type of prolongation on the right (on the left) of the field of definition of variable:*

.

*“CONSTANT” for a prolongation with the last (or first) value of function,*

.

*“LINEAR” for a prolongation along the first definite segment (PROL\_GAUCHE) or of the last definite segment (PROL\_DROITE),*

.

*“EXCLUDED” if extrapolation from the values apart from the field of definition from parameter is prohibited.*

### **3.16.2.5 Operands NOM\_PARA\_FONC/INTERPOL\_FONC/PROL\_DROITE\_FONC/ PROL\_GAUCHE\_FONC**

*These key words make it possible to modify the attributes of the functions which intervene in the definition of tablecloths. They thus have the same significance as the key words without suffix FONC.*

### **3.17 Operand INFORMATION**

*INFORMATION*

=

*Specify the options of impression on the file MESSAGE.*

*1*

*no impression*

*2*

*impression of the descriptor of the function (default option) and of the list of the 10 first values of each function in the order ascending of the first 10 parameters.*

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Operator *CALC\_FONCTION*

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## **4 Examples**

### **4.1**

#### **Calculation of an envelope**

**The command file which follows:**

**DEPI=2. \* pi**

**PAS0=DEPI/200.**

**LII=DEFI\_LIST\_REEL (DEBUT=0.,**

**INTERVALLE=\_F (JUSQU\_A = DEPI, NOT = PAS0))**

**COa = FORMULA (NOM\_PARA=' INST', VALE=' cos (INST) ')**

**SIa = FORMULA (NOM\_PARA=' INST', VALE=' sin (INST) ')**

**CO = CALC\_FONC\_INTERP (FONCTION=COa, LIST\_PARA=LII,**

**NOM\_PARA=' INST',**

**NOM\_RESU=' DEPL',**

**PROL\_GAUCHE=' EXCLU', PROL\_DROITE=' LINEAIRE',**

**INTERPOL=' LIN',**

**TITRE=' FUNCTION COSINUS')**

**IF = CALC\_FONC\_INTERP (FONCTION=SIa, LIST\_PARA=LII,**

**NOM\_PARA=' INST',**

**NOM\_RESU=' DEPLACEMENT',**

**PROL\_GAUCHE=' EXCLU',**

**PROL\_DROITE=' CONSTANT',**

**INTERPOL=' LIN',**

**TITRE=' FUNCTION SINE '**

**ENV1=**CALC\_FONCTION (ENVELOPPE=\_F (FUNCTION = (IF, CO,),  
CRITERION = "SUP"))

**4.2**  
*Calculation of derived from the function if*

*The orders which follow*

**der1 =** CALC\_FONCTION (DERIVE=\_F (FONCTION= if),)

**inst1 =** 20. \* not

**TEST\_FONCTION (**  
**VALEUR=**  
**\_F (**  
**FUNCTION =** der1, **NOM\_PARA =** "inst",  
**VALE\_PARA=**  
**inst1,**  
**VALE\_REFE=**  
**COa (INST1),)**

)

*produce on the file "RESULT":*

**---- FUNCTION: DER1**

**OK INST RELA -0.016% VALE: 8.0888392298046D-01**  
**6.28319E-01 TOLE 0.100% REFE: 8.0901699437495D-01**

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**4.3**

**Concatenation of two functions**

**DFC1=DEFI\_FONCTION (NOM\_PARA=' X', NOM\_RESU=' Y',  
VALE= (0. , 10. ,**

**4.,  
14.,**

**6.,  
16.),  
PROL\_DROITE=' LINEAIRE',  
PROL\_GAUCHE=' LINEAIRE'**

**)**

**#**

**DFC2=DEFI\_FONCTION (NOM\_PARA=' X', NOM\_RESU=' Y',  
VALE= (5. , 25. ,**

**7.,  
27.,**

**8.,**

28.),  
**PROL\_DROITE=' LINEAIRE',**  
**PROL\_GAUCHE=' LINEAIRE'**  
)

#

**DFC3=CALC\_FONCTION (ASSE=\_F (**  
**FUNCTION = (DFC2, DFC1),**  
**OVERLOAD = "RIGHT")**  
)

**DFC4=CALC\_FONCTION (ASSE=\_F (**  
**FUNCTION = (DFC1, DFC2),**  
**OVERLOAD = "LEFT")**  
)

*The values of the function dfc3 are:*

**X**  
**=**  
**0.**  
**4.**  
**5.**  
**7.**  
**8.**  
**y**  
**=**  
**10.**  
**14.**  
**25.**  
**27.**  
**28.**

*The values of the function dfc4 are:*

**X**  
**=**  
**0.**  
**4.**

6.

7.

8.

y

=

10.

14.

16.

27.

28.

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4.4

*Composition of two functions*

*fonc1 = DEFINI\_FONCTION (NOM\_PARA = "X",*

*NOM\_RESU*

*=*

*"F",*

*VALE*

*=*

*(*

*0.,*

0.,  
2.,  
  
5.,  
3.,  
10.,  
5.,  
15.,  
7.,  
13.,  
8.,  
10.,  
10.,

9.,  
12.,  
  
8.,  
13.,

5.,  
15.,  
  
1.,  
20.,

0.  
)  
)

*fonc2 = DEFI\_FONCTION (NOM\_PARA = "INST",  
NOM\_RESU  
=  
"X",  
VALE  
=  
(  
0.,  
  
0.,  
0.1,  
  
2.,  
0.2*

,  
4.,  
0.3  
,  
6.,  
0.4  
,  
8.,  
0.5  
, 10.,  
0.6  
, 12.,  
0.7  
, 14.,  
0.8  
, 16.,  
0.9  
, 18.,  
1.0  
, 20.  
)  
)

*comp1 = CALC\_FONCTION (COMPOSES = \_F (*  
*FONC\_RESU = fonc1,*  
*FONC\_PARA*  
*=*  
*fonc2*  
*)*

)

*The values of the function comp1 are:*

*inst = 0.*  
*0.1*  
*0.2 0.3 0.4 0.5 0.6*  
*0.7*

**0.8**

**0.9**

**1.0**

**$F = 0.$**

**5.**

**12.5 14.**

**10.**

**9.**

**8.**

**3.**

**0.8**

**0.4**

**0.**

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*Organization (S): EDF-R & D /AMA, DeltaCAD*

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Document: U4.32.05***

***Operator INFO\_FONCTION***

***1 Goal***

***To carry out mathematical operations on structures of data of the function type.***

***The following operations are currently available:***

- .  
the research of the maxima of a function,***
- .  
the calculation of the L2 standard of a function,***
- .  
the standard deviation of a function,***
- .  
value RMS of a function,***
- .  
the value of the indicator of harmfulness of seism.***

***Product a structure of data counts.***

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## **2 Syntax**

**Fr**  
**= INFO\_FONCTION**  
  
**(**  
**/MAX**  
**=**  
**\_F (**  
**FUNCTION = F, [function]**

**),**  
**/STANDARD**  
**=\_F (**  
**FUNCTION**  
**=**  
**F**  
**,**  
**[function]**  
**),**  
**/**  
**ECART\_TYPE**  
**=**  
**(identical to the key word**  
**RMS**  
**)**  
**[function]**  
**/**  
**RMS**  
**=**

***\_F (***

***FUNCTION***

***= F,***

***[function]***

***METHOD =***

***/"TRAPEZOID",***

***[DEFECT]***

***/***

***"SIMPSON",***

***INST\_INIT= tdeb,***

***[R]***

***INST\_FIN***

***= tfin,***

***[R]***

**CRITERION =/“RELATIVE”,**

**[DEFECT]**

/

**“ABSOLUTE”,**

**PRECISION=/0.001,**

**[DEFECT]**

/

**prec,**

**[R]**

),

/

**NOCI\_SEISME**

=

**\_F (**

**/FUNCTION =**

**F**

,

**[function]**

**OPTION**

=

***I “ALL”***  
,  
***[DEFECT]***

***I “MAXIMUM”,***

***COEF =/0, [DEFECT]***  
***/r1***  
,  
***[R]***

***INST\_INIT = tdeb,***  
***[R]***

***INST\_FIN = tfin,***

**[R]**

**CRITERION =/“RELATIVE”, [DEFECT]**

**/**  
**“ABSOLUTE”,**

**PRECISION =/0.001,**

**[DEFECT]**

**/**  
**prec,**  
**[R]**

**I “INTE\_ARIAS”,**

***INST\_INIT = tdeb,***

***[R]***

***INST\_FIN = tfin,***

***[R]***

***CRITERION =/"RELATIVE", [DEFECT]***

***/***  
***"ABSOLUTE",***

***PRECISION =/0.001,***

***[DEFECT]***

/

***prec,***

***[R]***

***I “POUV\_DEST”,***

***COEF =***

/

***0, [DEFECT]***

/

***r1***

,

***[R]***

***INST\_INIT = tdeb,***

***[R]***



***INST\_FIN = tfin,***

***[R]***

***CRITERION =/"RELATIVE", [DEFECT]***

***/***  
***"ABSOLUTE",***

***PRECISION =/0.001,***

***[DEFECT]***

***/***  
***prec,***  
***[R]***

***I "VITE\_ABSO\_CUMU",***

*INST\_INIT = tdeb,*

*[R]*

*INST\_FIN = tfin,*

*[R]*

*CRITERION =/"RELATIVE", [DEFECT]*

*/*  
*"ABSOLUTE",*

***PRECISION =/0.001,***

***[DEFECT]***

***/***  
***prec,***  
***[R]***  
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***I “DUREE\_PHAS\_FORT”,***

***INST\_INIT = tdeb,***

***[R]***

***INST\_FIN = tfin,***

***[R]***

***CRITERION =/"RELATIVE", [DEFECT]***

***/***  
***"ABSOLUTE",***

***PRECISION =/0.001,***

***[DEFECT]***

***/***  
***prec,***  
***[R]***

***BORNE\_INF =/0.05,***

***[DEFECT]***

***/  
binf,  
[R]***

***BORNE\_SUP =/0.95,***

***[DEFECT]***

***/  
bsup,  
[R]***

***I "INTE\_SPEC",***

***AMOR\_REDUIT***

=

***amndt,***

***[R]***

***FREQ\_INIT***

= / 0.4,

***[DEFECT]***

/

***fdeb,***

***[R]***

***FREQ\_FIN***

= / 10.,

***[DEFECT]***

/

***ffin,***

***[R]***

***CRITERION =/“RELATIVE”, [DEFECT]***

***/***  
***“ABSOLUTE”,***

***PRECISION =/0.001,***

***[DEFECT]***

***/***  
***prec,***  
***[R]***

***NORMALIZES***

***=***  
***/***  
***1. , [DEFECT]***

***/***  
***r2***  
***,***  
***[R]***

*I* “ACCE\_SUR\_VITE”,

*COEF* =

/  
*0*,  
[DEFECT]

/  
*r1*,  
[R]  
/  
*SPEC\_OSCI*  
=  
*sro*,  
[function]

*OPTION*

=



*I “INTE\_SPEC”,*  
*[DEFECT]*

*AMOR\_REDUIT*  
=  
*amndt,*  
*[R]*

*NATURE*  
=  
/  
*“ACCE”,*  
*[DEFECT]*

/  
*“QUICKLY”,*

/  
*“DEPL”,*

***NORMALIZES***

=

/

***1. , [DEFECT]***

/

***r2***

,

***[R]***

***FREQ\_INIT***

= / ***0.4,***

***[DEFECT]***

/

***fdeb,***

***[R]***

***FREQ\_FIN***

= / ***10.,***

***[DEFECT]***

/

***ffin,***

***[R]***

***CRITERION*** =/“***RELATIVE***”, [***DEFECT***]

/  
“***ABSOLUTE***”,

***PRECISION*** =/0.001,

[***DEFECT***]

/  
***prec***,  
[***R***]

***FREQ*** =  
***lfre***, [***l\_R***]

***LIST\_FREQ***

=  
*lfreq,*  
*[listr8]*

),

***TITRATE***

= *T,*  
*[l\_Kn]*

***INFORMATION***

=  
/  
*1,*  
*[DEFECT]*

/  
*2,*

)

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***Code\_Aster*** ®

**Version**

**8.2**

**Titrate:**

**Operator INFO\_FONCTION**

**Date:**

**31/01/06**

**Author (S):**

**COURTEOUS Mr., F. LEBOUVIER Key**

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**3 Operands**

**3.1 Word**

**key**

**MAX**

**/MAX**

**=**

**Seek X-coordinates where the maximum and the minimum are reached.**

**This operation is available on functions of nature function or tablecloth.**

**FUNCTION = F**

**Name of the function of which one seeks the maxima.**

**If F is a function, the produced concept is a table whose parameters of access are:**

**FUNCTION, TYPE, the NOM\_PARA of the function, the NOM\_RESU of the function.**

**where one respectively finds the name of the function, MAXIMUM or MINI, the X-coordinate of the maximum/minimum,**

**the value of the minimum maximum/.**

**If F is a tablecloth, the produced concept is a table whose parameters of access are:**

**FUNCTION, TYPE, the NOM\_PARA of the tablecloth, the name of the parameter of the functions (NOM\_PARA\_FONC), the NOM\_RESU of the functions.**

### 3.2 Word

key

**NORMALIZES**

*This key word makes it possible to follow convergence in accordance with the L2 standard of a continuation of function F given*

**NR**

*in the form of a tablecloth. The table result comprises a line by function, the parameters of entry are STANDARD and FUNCTION.*

**FUNCTION = F**

*Name of the tablecloth whose standard must be evaluated.*

### 3.3 Word

key

**ECART\_TYPE**

**/ECART\_TYPE**

=

*One calculates the standard deviation of the function F (T) which is defined by:*

**1**

=

(

**2**

**tfin**

**T**

**F () - F)**

(

*where F is the average on [tdeb, tfin]*

**tfin - tdeb)**

**dt**

**tdeb**

*The key words are identical to those provided under the key word factor RMS.*

*The produced concept is a table whose parameters of access are:*

**FUNCTION, METHOD, AVERAGE, INST\_INIT, INST\_FIN, ECART\_TYPE.**

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**3.4 Word**

**key**

**RMS**

**/RMS**

**=**

**One calculates value RMS of the function  $F(T)$  which is defined by:**

**1**

**$t_{fin}$**

**$RMS =$**

**2**

**(**

**$F$**

**$t_{fin} - t_{deb}$ )**

**$(T) dt$**

**$t_{deb}$**

**FUNCTION = F**

**Name of the function which one calculates value RMS.**

*Do not apply to the concepts of the tablecloth type.*

**METHOD =**

*Name of the METHOD which one uses to calculate the integral.*

*Two methods are available: method of the “TRAPEZOID” (by defect) and method of “SIMPSON”.*

**INST\_INIT = tdeb,**

**INST\_FIN = tfin,**

*Limits lower and higher of the interval of integration.*

*If these values are not indicated, the points of discretization inferior and superior (relation of order being defined compared to the parameter in X-coordinate) are taken as limits the interval of integration.*

**PRECISION =/0.001,**

**/**

**prec,**

**CRITERION =**

**/“ABSOLUTE”,**

**/**

**“RELATIVE”, [DEFECT]**

*One seeks a point of discretization of the function in an interval defined by the position absolute or relative around a value of the parameter of the X-coordinates for which the function must be estimated:*

**.**

**[inst (1-prec), inst (1+prec)] if CRITERION = “RELATIVE”**

**.**

**[inst - prec, inst + prec]**

**if CRITERION = “ABSOLUTE”**



*The produced concept is a table whose parameters of access are:*

*FUNCTION, METHOD, INST\_INIT, INST\_FIN, RMS.*

### *3.5 Word*

*key*

*NOCI\_SEISME*

*/NOCI\_SEISME*

*=*

*/FUNCTION = F,*

*/SPEC\_OSCI = sro,*

*Name of the function or the tablecloth considered which must be defined in DEFI\_FONCTION [U4.31.02] with NOM\_RESU=' ACCE'.*

*If a tablecloth is considered, only the calculation of spectral radiant intensity is available.*

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**COURTEOUS Mr., F. LEBOUVIER** Key

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*/OPTION =*

*Allows to choose one or more of the six following indices of harmfulness:*

/

**“ALL”**

*give all six index of harmfulness,*

/

**“MAXIMUM”**

*give the maximum of acceleration, speed and displacement*

*PGA = max {a(T)}, PGV = max {v (T)} PGD = max {X (T)}*

*T [*

*T,*

*T [*

*T,*

*T [*

*T,*

*I T F]*

*I T F]*

*I T F]*

/

**“INTE\_ARIAS”**

*T*

give the intensity of Arias  $I =$

$2 T$

$() dt$

With

$F$

$T$

$2g I$

/

“POUV\_DEST”

$I$

$3$

$T$

give the destroying capacity  $Pd = A =$

$v T^2$

$() dt$

$C$

$ft$

$2g I$

$0$

/

“VITE\_ABSO\_CUMU”

$T$

give the cumulated absolute value speed  $CAV = F T () dt$

$T_i$

/

Lasted “DUREE\_PHAS\_FORT” of strong phase:

Minimal duration  $T$

-  $T$  such as:

$sup$

$inf$

$T$

$binf \times I$

$sup^2 T$

$() dt B$

$\times I$

With

$sup$

With

$T$   
 $2g \text{ inf}$   
  
/
  
“INTE\_SPEC” spectral radiant intensity  
( , )  
 $I = \text{ffin } S F N$   
 $v$   
 $df$   
 $H$   
 $fdeb$   
 $F 2$   
/
  
“ACCE\_SUR\_VITE”  $A_{\max}/V_{\max}$  report/ratio  
 $\max \{(T)\}$   
 $T [$   
 $T, \text{ it } F]$   
 $ITE$   
 $ACCE\_SUR\_V$   
 $=$   
.  
 $\max \{v (T)\}$   
 $T [$   
 $T, \text{ it } F]$

According to the option, one must inform certain parameters, if one does not indicate an option, by defect, one thus calculate all the indices it is necessary all to inform.

The method of integration is the method of the “TRAPEZOID”

$INST\_INIT = tdeb,$   
 $INST\_FIN = tfin,$

Limits lower and higher of the interval of time.

If these values are not indicated, the points of discretization inferior and superior (relation of order being defined compared to the parameter in X-coordinate) are taken as limits the interval.

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**Code\_Aster** ®

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*Titrate:*

*Operator INFO\_FONCTION*

*Date:*

*31/01/06*

*Author (S):*

***COURTEOUS Mr., F. LEBOUVIER** Key*

*:*

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*PRECISION =/0.001,*

*/*

*prec,*

*CRITERION =*

*/“ABSOLUTE”,*

*/*

*“RELATIVE”, [DEFECT]*

*One seeks a point of discretization of the function in an interval defined by the position absolute or relative around a value of the parameter of the X-coordinates for which the function must to be estimated:*

*.*

*[inst\* (1-prec), inst\* (1+prec)] if CRITERION = “RELATIVE”*

*.*

*[inst - prec, inst + prec]*

*if CRITERION = “ABSOLUTE”*

*.*

*[freq\* (1-prec), freq\* (1+prec)] if CRITERION = “RELATIVE”*

*.*

*[freq - prec, freq + prec]*

*if CRITERION = “ABSOLUTE”*

*COEF = r1*

*Constant of integration, by defect 0. In the “MAXIMUM” option, one calculates speed and it displacement by two successive integrations of damping, it is thus necessary to inform COEF if one does not want to take it by defect.*

*FREQ\_INIT = fdeb,*

$FREQ\_FIN = f_{fin}$ ,

*Frequencies representing the two terminals of integration for the calculation of the spectral radiant intensity.*

*Those must lie between the extrema base of frequencies defining tablecloth SRO, if not poses a problem of interpolation. By defect, these two frequencies 0,4Hz and 10Hz are worth.*

$AMOR\_REDUIT = amndt$

*Reduced damping, for the calculation of the spectral radiant intensity.*

$FREQ = lfre$

$fre = ($

1, ...,

, )

...

I

*. List frequencies.*

$LIST\_FREQ = lfreq$

*List frequencies provided under a concept listr8.*

$= r2 \text{ NORMALIZES}$

*The spectrum of oscillator will be normalized with the value r2 (value of pseudo-acceleration).*

$BORNE\_INF = binf$ ,

$BORNE\_SUP = bsup$ ,

*Terminals limiting the share of intensity Arias defining the moments initial and final of the strong phase (between (binf) % and (bsup) % of (IA) max) of the seism.*

### **3.6 Operand**

#### **TITRATE**

$TITRATE = T$

*Titrate attached to the concept produced by this operator [U4.03.01].*

### **3.7 Operand**

#### **INFORMATION**

## ***INFORMATION***

=

*Specify the options of impression on the file MESSAGE.*

*1*

*no impression*

*2*

*impression of the descriptor of the function (default option) and of the list of the 10 first values of each function in the order ascending of the first 10 parameters.*

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## ***4 Examples***

### ***4.1***

***Seek extrema of a function***

***A5=DEFI\_FONCTION (***

***NOM\_RESU=' SIGM',***

***NOM\_PARA=' EPSI',***

***VALE= (0.002, 400.0,***

***0.003,500.0,***

***0.0045,550.0,***

***0.0065,580.0,***

***0.008,590.0,***

***0.01,600.0,***

0.02,600.0,  
,  
**PROL\_DROITE=' CONSTANT',**  
**PROL\_GAUCHE=' LINEAIRE',**  
)  
**= INFO\_FONCTION (MAX=\_F (FONCTION=A5),)**

**IMPR\_TABLE (TABLE=tab)**

*give on the file "RESULT".*

#  
**#ASTER 8.02.00 CONCEPT CALCULATE the 24/01/2006 A 16:14: 04 OF TYPE**  
**#TABLE\_SDASTER**  
**STANDARD FUNCTION EPSI SIGM**  
**MINI A5 2.00000E-03 4.00000E+02**  
**MAXIMUM A5 1.00000E-02 6.00000E+02**  
**MAXIMUM A5 2.00000E-02 6.00000E+02**

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Key COURTEOUS Mr.*

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*Organization (S): EDF-R & D /AMA*

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*Document: U4.33.01*

*Operator IMPR\_FONCTION*

*1 Goal*

*To print the contents of objects of the function type or list of realities in a file intended for a tracer of curves.*

*Replace, with IMPR\_TABLE, old procedure IMPR\_COURBE.*

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**Key COURTEOUS Mr.**

**:**

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**2 Syntax**

**IMPR\_FONCTION**

**(  
FORMAT =**

**/"TABLE",**

**/  
"XMGRACE",**

**/  
"AGRAF",**

**# Definition of the logical unit to format AGRAF**

**UNIT**

**= /  
links,  
[I]  
/  
25,  
[DEFECT]**

**UNITE\_DIGR**

**=  
/  
unit\_digr, [I]  
/  
26,  
[DEFECT]**

## *# Definition of the logical unit to format XMGRACE and the pilot of impression*

**UNIT**

= /  
*links*,  
[I]  
/  
29,  
[DEFECT]

**PILOT**

= /",  
[DEFECT]  
/  
"POSTSCRIPT",  
[KN]  
/  
"EPS",  
/  
"MIF",  
/  
"SVG",  
/  
"PNM",  
/  
"Png",  
/  
"JPEG",  
/  
"Pdf",  
/  
"INTERACTIVE",

## *# Definition of the logical unit to the format TABLE*

**UNIT**

= /  
*links*,  
[I]

/  
8,  
[DEFECT]

# Put on graphic page common to XMGRACE and AGRAF

$BORNE\_X = (xmin, xmax), [l\_R]$

$BORNE\_Y = (ymin, ymax), [l\_R]$

$ECHELLE\_X$   
=  
/  
"FLAX",  
[DEFECT]

/“LOG”,

*ECHELLE\_Y*

=

/

“FLAX”,  
[DEFECT]

/“LOG”,

*GRILLE\_X*

=

/

0,

*[DEFECT]*

/  
*nx, [R]*

*GRILLE\_Y*

=  
/  
*0,*  
*[DEFECT]*

/  
*ny,*

*[R]*

*LEGENDE\_X*

=

*xlegen*

,

*[KN]*

*LEGENDE\_Y*

=

*ylegen*

,

*[KN]*

*# Put on page of the table*

*SEPARATOR*

=

/

*separ,*

*[DEFECT]*

/

,

,

*[KN]*



*COMMENT*

=

/

*COM,*

*[KN]*

/

*'#,*

*[DEFECT]*

*DEBUT\_LIGNE*

=

/

*deb.,*

*[KN]*

*/"*,

*[DEFECT]*

*FIN\_LIGNE*

=

/

*end,*

*[KN]*

/

*"\,*

*[DEFECT]*

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*Key **COURTEOUS Mr.***

*:*

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*# Definition of the function to be traced*

*CURVE = \_F (*

*# Formatted of the function at formats XMGRACE and AGRAF*

*CAPTION = legend,*

*[KN]*

*STYLE*

*= sty,*

*[I]*

*COLOR*

=

*coul,*

*[1]*

*MARKER*

= *marq,*

*[1]*

*FREQ\_MARQUEUR*

=

*freqmarq,*

*[1]*

*# Recovery of the function to be traced*

/  
*FUNCTION =*  
*Fr,*  
*[function]*

*LIST\_PARA = will lpara,*  
*[listr8]*

/  
*FUNCTION =*  
*FC,*  
*[fonction\_C]*

*PART =/“REAL”,*

/  
"IMAG",

*LIST\_PARA = will lpara,*

*[litr8]*

/  
*FONC\_X = fx, [function]*

*FONC\_Y = fy, [function]*

*LIST\_PARA*

=

*will lpara,*  
*[listr8]*

/

*LIST\_PARA*

=

*will lpara,*  
*[listr8]*

*LIST\_RESU*

=

*lresu,*  
*[listr8]*

/

*X-COORDINATE = labs,*

*[l\_R]*

*ORDINATE = lordo,*

*[l\_R]*

*# Tri possible*

*SORTING =/“*

*,  
[DEFECT]*

*/  
“X”,*

/  
“Y”,

/  
“XY”,

/  
“YX”,

*# Commun runs with all the formats*

*TITRATE*  
=  
*titrate,*  
*[KN]*  
*SOUS\_TITRE =*  
*sous\_titre,*  
*[KN]*  
*INFORMATION =*  
/  
*1,*



/ 2,

),

)

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***Key COURTEOUS Mr.***

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### ***3 Operands***

#### ***3.1***

##### ***Presentation of the curves***

***A whole of operands optional makes it possible to define the presentation of the curve. All have one default value.***

### **3.1.1 Operand FORMAT**

**FORMAT =**

*Format of impression of the function*

**“AGRAF”**

*impression intended for the software agraf, which also makes it possible to adapt them*

*parameters of presentation in interactive,*

**“TABLE”**

*the impression in columns makes it possible to import the data in one easily*

*spreadsheet, if several curves are given, it is the list of the X-coordinates of first function which is used to interpolate the values of the others functions,*

**“XMGRACE”**

*impression intended for the software xmgrace. One can also adapt them parameters of presentation in interactive. The use of the PILOT key word allows to directly produce a file image or postscript.*

### **3.1.2 Operand UNIT**

*UNIT = links*

*UNITE\_DIGR = unit\_digr if FORMAT = “AGRAF”*

*Allow to choose on which logical unit one prints the functions. The value of links must be the same one as in the interface askt.*

*If many curves are plotted, it is more flexible to use the repe type combined with order DEFI\_FICHER, the files will be in the ./REPE\_OUT repertory.*

*With format AGRAF, the data are written in UNIT whereas the directives are written in UNITE\_DIGR (is worth 26 per defect).*

*The default value of links is worth:*

- 8 with the format TABLE (corresponds to the file result),
- 25 with format AGRAF,
- 29 with format XMGRACE (optional if PILOT = “INTERACTIVE”)

### **3.1.3 Operand**

#### **PILOT**

By choosing *FORMAT* = “*XMGRACE*”, one has the pilots of exit used by *xmgrace* in using the *PILOT* key word. This amounts using the functions of export of *xmgrace* via its menu “*File/Print Setup...*”.

The exact list of the pilots available on your waiter is provided by the option “- version” of *xmgrace*.

Possible values of *PILOT*:

- . ”
- : in this case, no pilot is used, the file obtained is the *.agr* or *.dat* of *xmgrace* (file containing them data and directives of the graph),
- . “*POSTSCRIPTP*”, “*EPS*”
- : file postscript full-page or encapsulated,
- . “*PNG*”, “*JPEG*”, “*PNM*”
- : file of the image type,
- . “*PDF*”, “*MIF*”, “*SVG*”
- : formats
- private individuals,
- . “*INTERACTIVE*”
- : no file is turned over if one can open *xmgrace* with the screen.

**NB:** “*JPEG*” and “*pdf*” are not available on the waiter of calculation *EDF* (*clayastr*).

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Author (S):

Key **COURTEOUS Mr.**

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### **3.1.4 Page-setting of the graph common to XMGRACE and AGRAF**

#### **3.1.4.1 Operands**

##### ***BORNE\_X/BORNE\_Y***

*BORNE\_X =*

*Layout of the function in an interval of the X-coordinates given.*

*BORNE\_Y =*

*Layout of the function in an interval of the ordinates given.*

#### **3.1.4.2 Operands**

##### ***ECHELLE\_X/ECHELLE\_Y***

*ECHELLE\_X =*

*Type of scale desired for the X-coordinates, Linear or Logarithmic curve.*

*ECHELLE\_Y =*

*Type of scale desired for the ordinates, Linear or Logarithmic curve.*

#### **3.1.4.3 Operands**

##### ***LEGENDE\_X/LEGENDE\_Y***

*LEGENDE\_X =*

*Caption associated with the x-axis.*

*LEGENDE\_Y =*

*Caption associated with the y-axis.*

#### **3.1.4.4 Operands**

##### ***GRILLE\_X/GRILLE\_Y***

*GRILLE\_X = nx*

*For xmgrace, NOC is the distance between two vertical successive lines of the grid.  
For agraf, nx is the entirety defining the frequency of layout of these lines.*

*GRILLE\_Y = ny*

*Even thing for the horizontal lines of the grid.*

### **3.1.5 Page-setting with the format TABLE**

*One can define here the membership of the printed table: of a traditional table in columns with a format compatible csv or HTML...*

#### **Note:**

*The labels of the columns are suffixées by “\_ + n° of column” (while starting to 0) so to avoid the repetition because the names all of columns must be different.*

*SEPARATOR = separ*

*The separator used between two columns (a space by defect) defines.*

*COMMENT = COM*

*Character inserted at the beginning of line to indicate a line in comment (or titrates, # by defect).*

*DEBUT\_LIGNE = deb.*

*Chain inserted into the beginning of each line (vacuum by defect).*

*FIN\_LIGNE = fine*

*Chain inserted at the end of the line (“\ by defect).*

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*Operator IMPR\_FONCTION*

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*22/02/06*  
*Author (S):*  
*Key COURTEOUS Mr.*  
*:*  
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### ***3.1.6 Key words common to all the formats***

***TITRATE***

***SOUS\_TITRE***

***Allow to define the principal and secondary titles graph or table.***

### ***3.2 Word***

***key***  
***CURVE***

***CURVE***

***Key word factor allowing to print the definite functions or to trace one or more functions in the same graph (a function by occurrence of the key word factor).***

#### ***3.2.1 Complementary attributes for the layout of each function by the software xmgrace or agraf***

***STYLE = sty***

***This key word defines the style of feature of the curve.***

***For xmgrace, the correspondence is as follows:***

***0 step of line 1 continuous feature 2 dotted lines***

***3 short indents 4 long indents***

***5, 6, 7, 8 alternate indents dotted lines***

***For agraf, the styles are:***

***0 line***

***1 dotted lines***

***2 point***

***MARKER = marq***

***This key word defines the type of marker or symbol of the points of the curve.***

***For xmgrace:***

***0 step of marker***

***1 circle***

***2 square***

***3 rhombus***

***4 high triangle***

***5 left triangle***

***6 low triangle 7 right triangle 8 more***

***9 crosses***

***10***

***star***

***For agraf, the markers are:***

***0 circle***

***1 square***

***2 more***

***3 rhombus***

***4 full circle***

***5 full square***

***6 full rhombus 7 cercle+croix 8 losange+croix***

***COLOR = coul***

***This key word defines the color of the curve.***

***For xmgrace, the colors are:***

***0 white***

***1 black***

***2 red***

***3 green***

***4 blue***

**5 yellow**  
**6 brown**  
**7 gray**  
**8 purple**  
**9 cyan**  
**10 magenta**  
**11 orange**  
**12 chestnut**  
**13 indigo**  
**14 turquoise**  
**15**  
**green**  
**dark**

***For agraf, the colors are:***

**0 black**  
**1 red**  
**2 dark green**  
**3 blue**  
**4 magenta**  
**5 cyan**  
**6 green**  
**7 chestnut**  
**8 orange**  
**9 mauve**  
**10 yellow**  
**11 clear chestnut**

***CAPTION = legend***

***Caption given to the function (by defect one recovers the name of the function).***

***FREQ\_MARQUEUR = freqmarq***

***Entirety indicating the frequency of impression of the marker associated with a function. All the im points of discretization of the function, a marker is printed (by defect all points).***

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**Code\_Aster** ®

Version

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Titrate:

Operator *IMPR\_FONCTION*

Date:

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Author (S):

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### **3.2.2 Attributes**

**additional**

**for the layout by the software agraf**

*SORTING = tr*

*This key word makes it possible to sort by order ascending the parameters defining the function:*

.  
*tr = “”, not of sorting,*

.  
*tr = “X”, sorting of the points of the function according to the order ascending of X-coordinates X,*

.  
*tr = “Y”, sorting of the points of the function according to the order ascending of the ordinates y,*

.  
*tr = “XY”, sorting of the points of the function according to the order ascending of X-coordinates X and in*

*case of equality according to the order ascending of the ordinates,*

.  
*tr = “YX”, sorting of the points of the function according to the order ascending of the ordinates y and in*

*case of equality according to the order ascending of the X-coordinates,*

### **3.2.3 Impression or layout of a real function**

/

*FUNCTION = Fr*

*Name of the real function to print or trace.*

*LIST\_PARA = Lr*

*Impression or layout of the function according to the list of the parameters given.*

### ***3.2.4 Impression or layout of a complex function***

*One trace either the real part, or the imaginary part. If one wants to trace the real part and the part imaginary in the same graph, it is necessary to repeat the key word CURVED factor.*

/  
*FUNCTION = FC*

*Name of the function complexes to print or trace.*

*PART =*

*Impression or layout of the Real or Imaginary part.*

*LIST\_PARA = Lr*

*Impression or layout of the function according to the list of the parameters given.  
Without effect during an impression in column (format "EXCEL").*

### ***3.2.5 Impression or layout of a function defined by 2 lists of realities***

/  
*LIST\_PARA = will lpara*

*Name of the list of the X-coordinates.*

*LIST\_RESU = lresu*

*Name of the list of the ordinates.*

*Or:*

/  
*X-COORDINATE = labs*

*List python of the X-coordinates.*

*ORDINATE = lordo*

*List python of the ordinates.*

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### ***3.2.6 Impression or layout of a parametric function***

/  
*FONC\_X = fx*

*Name of the parametric function  $X = F(T)$  to print or trace.*

*FONC\_Y = fy*

*Name of the parametric function  $y = G(T)$  to print or trace.*

*LIST\_PARA = Lr*

*Impression or layout of the function according to the list of the parameters given.*

### **3.2.7 Functionalities which existed in IMPR\_COURBE**

*Working of the graphs starting from table from now on is ensured by IMPR\_TABLE.*

*The layout of a resu\_gene in a node of shock must be made in two times: to recover a function with RECU\_FONCTION, key word RESU\_GENE, then to print the graph with IMPR\_FONCTION.*

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### **4 Examples**

#### **4.1**

**Curve representing a complex function**

**FC = DEFI\_FONCTION (NOM\_PARA=' INST', NOM\_RESU=' DX',  
VALE\_C= (0. , 0. , 0. , 1. , 2. , 3. ,  
2., 3., 4., 3., 4., 5.,  
4., 5., 6., 5., 6., 7. ),)**

**IMPR\_FONCTION (  
UNIT = 24,  
FORMAT = "XMGRACE",  
PILOT = "POSTSCRIPT",  
LEGENDE\_X = "Time (S)",  
LEGENDE\_Y = "DX (mm)",  
CURVE = (**

```
_F (FUNCTION = FC,  
PART = "REAL",  
COLOR = 4,  
STYLE = 2,  
MARKER = 5,  
CAPTION = "left real"),  
_F (FUNCTION = FC,  
PART = "IMAG",  
COLOR = 2,  
STYLE = 5,  
MARKER = 8,  
CAPTION = "left imaginary"),  
)  
TITRATE = "Traced of a complex function",  
)
```

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## **4.2 Curve**

### **parametric**

*lt = DEFI\_LIST\_REEL (BEGINNING = 0. , INTERVALLE=\_F (JUSQU\_A=10., PAS=0.01),)*

*fx = FORMULA (NOM\_PARA='you,*  
*VALE= "" 2.\*cos (T) - cos (2.\*t) "" ,)*

```
cardioX=CALC_FONC_INTERP (  
FUNCTION = fx,  
LIST_PARA = lt,)
```

```
fy = FORMULA (NOM_PARA=' you,  
VALE= "" 2.*sin (T) - sin (2.*t) """)  
cardioY=CALC_FONC_INTERP (  
FUNCTION = fy,  
LIST_PARA = lt,)
```

```
IMPR_FONCTION (  
UNIT = 27,  
FORMAT = "XMGRACE",  
TITRATE = "Ardioid",  
CURVE = (  
_F (FONC_X = cardioX,  
FONC_Y = cardioY),  
)  
)
```

*A file thus is obtained that one can visualize in xmgrace:*

*Additional working in xmgrace: small Stud/Graph appearance, fixed type (grid square), and to remove the legend by stripping the box Display legend.*

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*Organization (S): EDF-R & D /AMA*

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***Operator CREA\_TABLE***

***1 Goal***

***To create a table.***

***This order makes it possible to create a table starting from a function or lists of real numbers. count created has two parameters at least and as many lines as the user wishes it.***

***The lists used to generate the table must have the same number of terms, or it is necessary to indicate the numbers of the lines which one wishes to fill.***

***The function making it possible to fill the cells of the table is tabulée, which means that it is not known that in certain points. It will have to be as a preliminary defined in the command file with assistance of order DEFI\_FONCTION.***

***The concept created by this operator is of type counts or its derived types (tabl\_...).***  
***Instruction manual***



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**2 Syntax**

**Tb [\*] = CREA\_TABLE (**

**/FUNCTION = \_F (**

**FUNCTION**

**=**

**fct**

**[function]**

**PARA = (npx, npy)**

**[l\_K16]**

),

/

**LIST**

=(

**\_F (**

**/LISTE\_I = Li [l\_I]**

**/LISTE\_R = Lr [l\_R]**

**/LISTE\_K = lk [l\_K]**

**TYPE\_K = /K8 `[DEFECT]**

/

**“K16”**

/

**“K24”**

**NUME\_LIGN**

=

/

**lind,**

**[l\_I]**

/

**(1,2,3,...)**

**[DEFECT]**

**PARA = npx [K16]**

)

**TYPE\_TABLE**

=

/

**“TABLE”,**

**[DEFECT]**

/

**“TABL\_\*\*\*\*”,**

**TITRATE**

= *tit*,

[*KN*]

)

[\*] is the type indicated by *TYPE\_TABLE*.

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*3 Word*

*key*

*FUNCTION*

*3.1 Operand*

*FUNCTION*

*The table is created starting from a function. The first column of the table contains the X-coordinates of function and the second values of the function to the corresponding X-coordinates.*

*3.6 Operand*

*PARA*

*Names of the parameters of the table. This key word is optional: the names of the parameters are then*

*identical to the NOM\_PARA and NOM\_RESU of the function. If it is indicated, its cardinal must be equal to*

*2: name of parameter for the column associated with the X-coordinates, name of parameter for the column associated the ordinates.*

**4 Word  
key  
LIST**

*This key word must be provided at least 2 times: each occurrence makes it possible to define a column of count.*

*The lists do not have necessarily the same cardinal, one uses key word NUME\_LIGN to indicate which lines must be filled.*

**4.1 Operand  
LISTE\_R**

*A column is created in the table starting from a list of reality.*

**4.2 Operand  
LISTE\_I**

*A column is created in the table starting from a list of entirities.*

**3.5 Operand  
LISTE\_K**

*A column is created in the table starting from a list of character strings.*

**4.3 Operand  
TYPE\_K**

*Length of the character strings for case LISTE\_K.*

**4.4 Operand  
NUME\_LIGN**

*When the lists do not have all the same cardinal or to build a table with holes, one uses this key word to specify which lines are filled.*

**4.5 Operand**

## **PARA**

*Name of the parameter of the table associated with the provided list.*

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## **5 Examples**

### **5.1**

**Creation of a table starting from a function**

```
FCT=DEFI_FONCTION (NOM_PARA=' X',  
VALE= (0.0, 5.0, 4.0, 17.5)) ;
```

```
T_FCT=CREA_TABLE (FONCTION=_F (FONCTION=FCT));
```

```
IMPR_TABLE (TABLE=T_FCT);
```

**The impression of the table created is as follows:**

```
X TOUTRESU
```

```
0.00000E+00 5.00000E+00
```

```
4.00000E+00 1.75000E+01
```

### **5.2**

**Creation of a table starting from three lists, heterogeneous types**

```

T_LST=CREA_TABLE (LISTE= (
_F (LISTE_R= (0.0, 4.0), PARA=' X'),
_F (LISTE_R = (5.0, 17.5), PARA=' Y'),);
_F (LISTE_I = (6.7), PARA=' K')

```

```

IMPR_TABLE (TABLE=T_LST);

```

*The impression of the table created is as follows:*

```

X Y K
0.00000E+00 5.00000E+00 6
4.00000E+00 1.75000E+01 7

```

### **5.3**

*Creation of a table with holes*

```

TAB=CREA_TABLE (
LISTE= (
_F (
PARA=' NUME_ORDRE',
LISTE_I= (8,15,156,67),
),
_F (
PARA=' VAR',
LISTE_R= (2. , 15. , 18),
NUME_LIGN= (1,3,4),
),
_F (
PARA=' COMMENT',
LISTE_K= ("VALUE"),
TYPE_K=' K24',
NUME_LIGNE=1,
),
),

```

*The impression of the table created is as follows:*

```

NUME_ORDRE

```

```

VAR
HOW
8 2.00000E+00
VALUE
15 -

```

-  
**156 1.50000E+01**

-  
**67 1.80000E+01**

-  
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**Organization (S): EDF-R & D /AMA, DeltaCAD**

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## ***Procedure CALC\_TABLE***

### ***1 Goal***

***To handle the data of the tables to the manner of a spreadsheet.***

***The order makes it possible to carry out operations on the data of the tables. Following operations are currently available:***

.

***Concaténer/To combine two tables,***

.

***To apply a formula,***

.

***To re-elect parameters,***

.

***To filter the lines according to certain criteria,***

.

***To extract certain columns from a table,***

.

***To order the lines,***

***Product a structure of data counts.***

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**2 Syntax**

= *CALC\_TABLE* (

*reuse*

=,

*[tabl\_\*]*

**COUNT**

= *matable*,

*[tabl\_\*]*

**TITRATE**

= *title*

*[l\_Kn]*

**# 1. Concaténer/to combine two tables:**

**COMB =\_F** (

**COUNT**

=

*count,*

*[tabl\_\*]*

*NOM\_PARA*

=

*will l\_para,*

*[l\_Kn]*

),

*# 2. To apply a formula:*

*OPER =\_F (*

*FORMULATE =*

*formulate,*

*[formula]*

*NOM\_PARA*

=

*para, [kN]*

),

**# 3. To re-elect parameters of a table:**

***RE-ELECT =\_F (***  
***NOM\_PARA***

=

***will l\_para,***  
***[l\_Kn]***

),

**# 4. To filter lines:**

***FILTER =\_F (***  
***NOM\_PARA***

=

***para, [kN]***

/

***CRIT\_COMP***

=

**/“EQ”,**  
**[DEFECT]**  
**/“”,**  
**/“LT”,**  
**/“WP”,**  
**/“IT”,**  
**/“GE”,**

**/VALE\_I**

=  
**ival,**  
**[I]**

/  
**VALE\_K**

=  
**kval,**  
**[KN]**

//  
**VALE**

=  
**rval,**  
**[R]**

/  
**VALE\_C**

=  
**cval,**  
**[C]**

/  
**PRECISION =/prec,**  
**[R8]**

/  
**1.0D-3,**  
**[DEFECT]**





**# 6. To order the lines according to values' of a parameter:**

***SORTING =\_F (***  
***NOM\_PARA***  
***=***  
***will lpara,***  
***[l\_Kn]***

***ORDER***  
***=/"GROWING"***  
***,***  
***[DEFECT]***

***/"DECREASING",***

***),***

***INFORMATION***  
***=***  
***/***  
***1,***  
***[DEFECT]***

/  
2,

)  
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**3 Operands**

**3.1 Operand**  
**COUNT**

**COUNT = matable**

**Name of the initial table on which one will carry out handling**

**3.2 Operand**  
**COMB: concaténer/to combine two tables**

/  
**COMB**

**Key word COMB allows concaténer, to combine two tables between them, with seam on one common parameter list.**

### **3.2.1 Operand COUNT**

**COUNT = table**

**Name of the table whose values must come to overload and/or enrich the initial table.**

### **3.2.2 Operand NOM\_PARA**

**NOM\_PARA = will l para**

**Name of the parameters whose values must be identical in the two tables.**

**Remarks for the combination:**

**Ex: tab\_resu=CALC\_TABLE (TABLE=tab1,  
COMB=\_F (TABLE=tab2,  
NOM\_PARA= (“ABSC\_CURV”, “NODE”)))**

**When ABSC\_CURV and NODE are identical between tab1 and tab2, one inserts the values of tab2 on the line of tab1 (for the other parameters common to the 2 tables, it is thus value of tab2 which crushes that of tab1). If not one adds the line of tab2 at the end of tab1.**

**NOM\_PARA acts like a primary key: if one does not find more once couple (ABSC\_CURV, NODE), the line is added.**

**This operator is not répétable because the order of the occurrences of the key word factor could to modify the final result.**

### **3.3 Operand**

**OPER: To apply a formula**

**/  
OPER**

**Allows to apply a formula whose variables are the parameters of the table and to insert it result in a new column.**

**Note:**

**This operator is répétable.**

### **3.3.1 Operand** **FORMULATE**

*FORMULATE = formula*

*Name of the formula to be applied*

### **3.3.2 Operand** **NOM\_PARA**

*NOM\_PARA = para*

*Name of the new parameter.*

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### **3.4 Operand** **RE-ELECT: To re-elect parameters of a table**

/

**RE-ELECT**

*The key word RE-ELECTS makes it possible to re-elect one or more parameters of a table.*

### **3.4.1 Operand** **NOM\_PARA**

*NOM\_PARA = will l\_para*

*Name of the parameters: couples values (old name of the parameter, new name of parameter)*

**Note:**

*This operator is répétable.*

**3.5 Operand FILTERS: To filter the lines according to certain criteria**

/  
**FILTER**

*The key word factor FILTER makes it possible to retain in the table only the lines checking some criteria imposed by the user. The occurrences of the key word are added the ones to the others like successive filters. For each occurrence of this key word, one specifies the name of parameter for which one imposes a condition, the type of condition (equality, not-equality, more small.) as well as the value associated with the condition.*

**Note:**

*This operator is répétable.*

**3.5.1 Operand**

**NOM\_PARA**

*NOM\_PARA = para*

*para is the name of the parameter to which the constraint of filtering relates.*

**3.5.2 Operand**

**CRIT\_COMP**

*CRIT\_COMP = crit*

*crit is the type of the constraint of filtering.*

**EQ**

*“equality” for the entirities, the texts, realities or the complexes.*

*For the floating numbers (real or complex), this equality is evaluated with a certain tolerance given by the key words PRECISION and CRITERION.*

*“not-equality” (cf EQ)*

**LT**

***“smaller than”***

***Relations of order:***

***- natural for the entireties and realities***

***- alphabetical for the texts***

***- invalid for the complexes***

**WP**

***“larger than” (cf LT)***

***“smaller or equal to” (cf LT)***

**GE**

***“larger or equal to” (cf LT)***

**VACUUM**

***blank cell***

**NON\_VIDE**

***nonempty cell***

**MAXIMUM**

***the line selected will be that which will have the maximum value***

**ABS\_MAXI**

***the line selected will be that which will have the maximum absolute value***

**MINIS**

***the line selected will be that which will have the minimal value***

**ABS\_MINI**

***the line selected will be that which will have the minimal absolute value***

***Instruction manual***

***U4.3- booklet: Function HT-62/06/004/A***

---

**Code\_Aster ®**

**Version**

**8.2**

***Titrate:***

***Procedure CALC\_TABLE***

***Date:***

***31/01/06***

***Author (S):***

***COURTEOUS Mr., F. LEBOUVIER Key***

**:**

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***3.5.3 Operands***

**VALE/VALE\_I/VALE\_C/VALE\_K**

*These various key words are used according to the type of the column associated with the parameter on which carries the constraint: entirety, reality, complex or text.*

*One gives in argument the value associated with the constraint; for example 12 if one is interested only in sequence number 12.*

*This operand is useless when the types of constraint are used: “VACUUM”, “NON\_VIDE”, “MAXIMUM”, “MINI”,...*

**3.5.4 Operands****CRITERION/PRECISION**

*When the constrained parameter is of floating type (real or complex) and that the type of constraint is the equality (or not-equality), this equality is evaluated with a certain tolerance.*

**PRECISION = eps,**

*eps is the tolerance*

**“RELATIVE” CRITERE=/,**

**|x-xref| < eps\*|xref|**

**/“ABSOLUTE”**

,

**|x-xref|**

**<**

**eps**

**3.5.5 Example of use of the key word FILTERS**

*If one specifies:*

**FILTRE= (\_F (NOM\_PARA= “NODE”, VALE\_K = “N7”),  
\_F (NOM\_PARA= “INST”, CRIT\_COMP= “WP”, VALE= 3.0),  
\_F (NOM\_PARA= “INST”, CRIT\_COMP= “LT”, VALE= 13.0),  
)**

*One thus selects the lines of the table such as the parameter NODE is worth “N7” and such as parameter INST lies between 3. and 13.*



### **3.6 Operand**

**EXTR: To extract certain columns from a table**

/

**EXTR**

*Key word EXTR makes it possible to extract certain columns from a table.*

#### **3.6.1 Operand**

**NOM\_PARA**

**NOM\_PARA = will l\_para**

*Name of the parameters which one wants to extract.*

**Note:**

*This operator is not répétable.*

### **3.7 Operand**

**SORTING: To order the lines**

/

**SORTING**

*The TRI key word makes it possible to order the lines according to values' of the parameters.*

**Note:**

*This operator is not répétable because the order of the occurrences of the key word factor could to modify the final result.*

**Instruction manual**

**U4.3- booklet: Function HT-62/06/004/A**

---

**Code\_Aster ®**

**Version**

**8.2**

**Titrate:**

**Procedure CALC\_TABLE**

**Date:**

**31/01/06**

**Author (S):**

**COURTEOUS Mr., F. LEBOUVIER Key**

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### **3.7.1 Operand**

**NOM\_PARA**

**NOM\_PARA = will l\_para**

**Names of the parameters to which the sorting relates.**

### **3.7.2 Operand**

**ORDER**

**ORDER =/“GROWING”**

**/**

**“DECREASING”**

**This key word is used to specify if one must use an order ascending or decreasing. By defect, one sort by ascending order.**

**The relations of order used are:**

**.**

**the natural order for the entireties and realities,**

**.**

**the alphabetical order for the texts and the names of concepts.**

**Note:**

**One cannot be useful oneself of a parameter complexes to classify the lines of a table.**

**For the parameters of the NODE type (or NETS), the order is alphabetical because these parameters contain the name of the nodes (or of the meshes).**

**If one specifies:**

**TRI=\_F (NOM\_PARA= (“NODE”, “INST”), ORDRE= “GROWING”),**

**One will sort the lines of the table in the alphabetical order of the nodes. If there are several lines corresponding to a given node, the second sort criterion (INST) will be used for**

*to classify these lines.*

### **3.8 Operand INFORMATION**

**INFORMATION = inf**

**Print in the file “message” of additional information if inf=2. Nothing occurs if inf=1.**

**Instruction manual**

**U4.3- booklet: Function HT-62/06/004/A**

---

**Code\_Aster ®**

**Version**

**8.2**

**Titrate:**

**Procedure CALC\_TABLE**

**Date:**

**31/01/06**

**Author (S):**

**COURTEOUS Mr., F. LEBOUVIER Key**

**:**

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### **4 Examples**

**Count “TB1”**

**NR Y Z**

**NODE**

**0.2.0.4.5 NO1**

**1 4.0**

**17.5 N03**

**2 17.5 9.0 N06**

**Count “TB2”**

**NR X Z**

**NODE**

**1.2.0.2.5 NO1**

**3.4.0.5.5 N031**

4 17.5  
20.5 N062  
6.5.0.8.0 N013

#--- COMBINATION

TB3=CALC\_TABLE (TABLE=TB1,  
COMB =\_F (TABLE = TB2, NOM\_PARA=' NOEUD'))

The contents of table TB3 are:

NR Y Z NODE X  
1 2.00000E+00 2.50000E+00 N01 2.00000E+00  
1 4.00000E+00 1.75000E+01 N03 -  
2 1.75000E+01 9.00000E+00 N06 -  
3 - 5.50000E+00 N031 4.00000E+00  
4 - 2.05000E+01 N062 1.75000E+01  
6 - 8.00000E+00 N013 5.00000E+00

#--- FORMULATE

DNOR=FORMULE (NOM\_PARA = ("X", "Z"),  
VALE = "SQRT (X\*X+Z\*Z)")

TB3=CALC\_TABLE (TABLE = TB3,  
reuse = TB3,  
OPER =\_F (FORMULE=DNOR, NOM\_PARA=' NOR\_COOR'))

The contents of table TB3 are:

NR Y Z NODE X NOR\_COOR  
1 2.00000E+00 2.50000E+00 N01 2.00000E+00 3.20156E+00  
1 4.00000E+00 1.75000E+01 N03 - -  
2 1.75000E+01 9.00000E+00 N06 - -  
3 - 5.50000E+00 N031 4.00000E+00 6.80074E+00  
4 - 2.05000E+01 N062 1.75000E+01 2.69537E+01  
6 - 8.00000E+00 N013 5.00000E+00 9.43398E+00

Instruction manual

U4.3- booklet: Function HT-62/06/004/A

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Code\_Aster ®

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8.2

*Titrate:*

*Procedure CALC\_TABLE*

*Date:*

31/01/06

*Author (S):*

**COURTEOUS Mr., F. LEBOUVIER** *Key*

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*#--- TO RE-ELECT*

*TB3=*CALC\_TABLE (TABLE = TB3,

*reuse = TB3,*

*RENOMME=\_F (NOM\_PARA= ("NOR\_COOR", "NORM\_XZ")))*

*The contents of table TB3 are:*

*NR Y Z NODE X NORM\_XZ*

*1 2.00000E+00 2.50000E+00 N01 2.00000E+00 3.20156E+00*

*1 4.00000E+00 1.75000E+01 N03 - -*

*2 1.75000E+01 9.00000E+00 N06 - -*

*3 - 5.50000E+00 N031 4.00000E+00 6.80074E+00*

*4 - 2.05000E+01 N062 1.75000E+01 2.69537E+01*

*6 - 8.00000E+00 N013 5.00000E+00 9.43398E+00*

*#--- FILTER*

*TB4=*CALC\_TABLE (TABLE = TB3,

*FILTER =\_F (NOM\_PARA=' NORM\_XZ', CRIT\_COMP=' LE', VALE=30.))*

*The contents of table TB4 are:*

*NR Y Z NODE X NORM\_XZ*

*1 2.00000E+00 2.50000E+00 N01 2.00000E+00 3.20156E+00*

*3 - 5.50000E+00 N031 4.00000E+00 6.80074E+00*

*4 - 2.05000E+01 N062 1.75000E+01 2.69537E+01*

*6 - 8.00000E+00 N013 5.00000E+00 9.43398E+00*

*#--- EXTRACTION*

*TB3=*CALC\_TABLE (*TABLE = TB3, reuse=TB3,*  
*EXTR =\_F (NOM\_PARA= ("NODE", "X", "Z", "NORM\_XZ"))*)

*The contents of table TB3 are:*

*NODE X Z NORM\_XZ*

*N01 2.00000E+00 2.50000E+00 3.20156E+00*

*N03 - 1.75000E+01 -*

*N06 - 9.00000E+00 -*

*N031 4.00000E+00 5.50000E+00 6.80074E+00*

*N062 1.75000E+01 2.05000E+01 2.69537E+01*

*N013 5.00000E+00 8.00000E+00 9.43398E+00*

*#--- SORTING*

*TB3=*CALC\_TABLE (*TABLE = TB3, reuse=TB3,*  
*SORTING =\_F (NOM\_PARA=' NORM\_XZ', ORDRE=' DECROISSANT')*)

*The contents of table TB3 are:*

*NODE X Z NORM\_XZ*

*N062 1.75000E+01 2.05000E+01 2.69537E+01*

*N013 5.00000E+00 8.00000E+00 9.43398E+00*

*N031 4.00000E+00 5.50000E+00 6.80074E+00*

*N01 2.00000E+00 2.50000E+00 3.20156E+00*

*N06 - 9.00000E+00 -*

*N03 - 1.75000E+01 -*

*Instruction manual*

*U4.3- booklet: Function HT-62/06/004/A*

---

**Code\_Aster** ®

*Version*

8.2

*Titrate:*

*Procedure CALC\_TABLE*

*Date:*

31/01/06

*Author (S):*

***COURTEOUS Mr., F. LEBOUVIER Key***

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*Instruction manual*

*U4.3- booklet: Function HT-62/06/004/A*

---

***Code\_Aster*** ®

*Version*

7.4

*Titrate:*

*Operator* **DEFI\_LIST\_REEL**

*Date:*

20/12/04

*Author (S):*

**COURTEOUS Mr., J. Key PELLET**

:

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*Organization (S): EDF-R & D /AMA*

***Instruction manual***

***U4.3- booklet: Function***

***Document: U4.34.01***

***Operators*** **DEFI\_LIST\_REEL**

***1 Goal***

***To create a strictly increasing list of realities.***



*The list can be given “in extenso” by the user, or, it can be formed from under lists defined in “constant step”.*

*Product a structure of data of the listr8 type.*

*Instruction manual*

*U4.3- booklet: Function*

*HT-66/04/004/A*

---

*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Operator DEFILISTREEL*

*Date:*

*20/12/04*

*Author (S):*

*COURTEOUS Mr., J. Key PELLET*

*:*

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*2 Syntax*

*Lr*

*[listr8] = DEFILISTREEL*

*( /*

*VALE= lr8*

*,*

*[l\_R]*

*/*

*DEBUT=*

*debu*

,  
**[R]**

**INTERVALLE= (\_F (JUSQU\_A**  
**=**  
**r1,**  
**[R]**

**/A NUMBER**  
**= n1,**  
**[I]**

**/**  
**NOT**  
**=**  
**r2,**  
**[R]**  
**),)**

**INFORMATION**  
**=**  
**/**

1

,

**[DEFECT]**

/ 2 ,

**TITRATE**

= *title*

,

**[l\_Kn]**

)

***Instruction manual***  
***U4.3- booklet: Function***  
***HT-66/04/004/A***

---

**Code\_Aster** ®

Version

7.4

Titrate:

Operator *DEFI\_LIST\_REEL*

Date:

20/12/04

Author (S):

**COURTEOUS Mr., J. Key PELLET**

:

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### **3 Operands**

#### **3.1 Operand**

**VALE**

**VALE = lr8**

*List realities which will form the structure of data *listr8* result.*

*This list can be built starting from a Python list.*

#### **3.2 Operand**

**BEGINNING**

**BEGINNING**

=

*It is the first reality of the list of realities which one wants to build.*

#### **3.3 Operand**

**INTERVAL**

**INTERVAL**

=

**JUSQU\_A**

=

**r1**

*It is the end of the interval which one will cut out with a constant step.*

**/A NUMBER**

**= nI**

*It is the number of steps which one wants in the interval which ends in r1.*

**/**

**NOT**

**=**

**r2**

*It is the step of division interval.*

**3.4 Operand**

**INFORMATION**

**INFORMATION**

**=**

**I**

*Indicate the level of impression of the results of the operator.*

*1: no impression,*

*2: impression of the list of realities created*

**3.5 Operand**

**TITRATE**

**TITRATE**

**= title**

*Titrate that the user wants to give to his list realities.*

**4 Remarks**

.

*when the key word STEP is used it may be that the number of calculated step is not rigorously entirety. One “will then adapt” the last interval to fall down exactly on the end value (JUSQU\_A). If for that, one modifies the step value of more than 1/1000 one emits an alarm,*

.

*caution: this order produces a structure of data listr8 which can only be used in the orders awaiting such structures of data and not in those which wait lists of realities (notation: l\_R).*

***Instruction manual  
U4.3- booklet: Function  
HT-66/04/004/A***

---

***Code\_Aster*** ®

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***7.4***

***Titrate:***

***Operator DEFI\_LIST\_REEL***

***Date:***

***20/12/04***

***Author (S):***

***COURTEOUS Mr., J. Key PELLET***

***:***

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***5 Examples***

***Example 1:***

***Let us imagine that one wants to create the list:***

***1. 3. 5. 10. 15. 20. 25. 26. 27. 28.***

***who is such as the step is: 2.***

***from 1.***

***to 5.***

***5. of 5.***

***to 25.***

**1. of 25.**

**to 28.**

**One can write:**

***Lr = DEFI\_LIST\_REEL (BEGINNING***

***= 1.,***

***INTERVAL***

***= (\_F (JUSQU\_A= 5. , NOMBRE= 2),***

***\_F***

***(JUSQU\_A=***

***25.,***

***NOMBRE=***

***4,***

***),***

***\_F***

***(JUSQU\_A=***

***28.,***

***PAS=***

***1.,),),***

***)***

**Example 2:**

**To create the list: 1.**

- 3.
- 12.
- 13.

**One can write:**

***Lr = DEFI\_LIST\_REEL (VALE = (1. , 3. ,  
12., 13.), )***

**Example 3:**

**One can build a Python list in this manner.**

***Lr = DEFI\_LIST\_REEL (VALE = [sqrt (I) for I in arranges (5)],)***

**Instruction manual**

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**Code\_Aster ®**

**Version**

**7.4**

**Titrate:**

**Operator DEFI\_LIST\_ENTI**

**Date:**

**20/12/04**

**Author (S):**

**COURTEOUS Mr., J. PELLET, L. VIVAN Key**

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**Organization (S): EDF-R & D /AMA, CS IF**



***Instruction manual  
U4.3- booklet: Function  
Document: U4.34.02***

***Procedure DEFI\_LIST\_ENTI***

***1 Goal***

***To create a list of strictly increasing entreties.***

***The list can be given “in extenso” by the user, or, it can be formed from under lists defined in “constant step”.***

***Product a structure of data of the listis type.***

***Instruction manual  
U4.3- booklet: Function  
HT-66/04/004/A***

---

***Code\_Aster ®***

***Version***

***7.4***

***Titrate:***

***Operator DEFI\_LIST\_ENTI***

**Date:**

**20/12/04**

**Author (S):**

**COURTEOUS Mr., J. PELLET, L. VIVAN Key**

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## **2 Syntax**

**Li [listis] = DEFI\_LIST\_ENTI**

**( /**

**VALE = read, [l\_I]**

**/**

**BEGINNING**

**=**

**deb.**

**,**

**[I]**

**INTERVALLE= (\_F (**

**JUSQU\_A =**

**yew**

**,**

**[I]**

**/A NUMBER**

= *in*  
, [*I*]  
/  
**NOT**  
=  
*ipas*  
,  
[*I*]  
,),

**INFORMATION**

=/  
*1*  
,  
[**DEFECT**]

/ 2 ,

**TITRATE**

= *title*  
,  
[*l\_Kn*]

)

**Instruction manual**  
**U4.3- booklet: Function**  
**HT-66/04/004/A**

---

**Code\_Aster** ®

## **Version**

**7.4**

## **Titrate:**

**Operator *DEFI\_LIST\_ENTI***

## **Date:**

**20/12/04**

## **Author (S):**

***COURTEOUS Mr., J. PELLET, L. VIVAN Key***

**:**

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## **3 Operands**

### **3.1 Operand**

***VALE***

***VALE = read***

***List entireties which will form the structure of data listis result, one can provide does not import which list Python.***

### **3.2 Operand**

***BEGINNING***

***BEGINNING***

**=**

***deb.: first entirety of the list to be built.***

### **3.3 Word**

***key***

***INTERVAL***

***INTERVAL***

***Key word factor whose each occurrence makes it possible to define an interval at constant step.***

#### **3.3.1 Operand**

***JUSQU\_A***

***JUSQU\_A = yew***

*yew is the whole end of the interval to be cut out with a constant step.*

### **3.3.2 Operand**

**NOT**

*/NOT*

=

*ipas*

*No interval division.*

### **3.3.3 Operand**

**NUMBERS**

/

*NUMBERS = in*

*Numbers of steps which one wants in the interval.*

### **3.4 Operand**

**INFORMATION**

*INFORMATION = I*

*Indicate the level of impression of the results of the operator:*

*1: no impression,*

*2: impression of the list of entireties created.*

### **3.5 Operand**

**TITRATE**

*TITRATE = title*

*Titrate attached to the concept produced by this operator [U4.03.01].*

*Instruction manual*

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

## ***Operator DEF1\_LIST\_ENTI***

***Date:***

***20/12/04***

***Author (S):***

***COURTEOUS Mr., J. PELLET, L. VIVAN Key***

***:***

***U4.34.02-H Page***

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### ***4 Remarks***

***.***

***it is checked that the list is increasing,***

***.***

***caution: the structure of data of the listis type cannot be used behind a key word awaiting a l\_I (continuation of entireties written between brackets).***

### ***5 Examples***

***To build the list of entireties to constant step:***

***1***

***4***

***7***

***10***

***13***

***16***

***listi = DEF1\_LIST\_ENTI***

***(BEGINNING = 1,***

***INTERVAL***

***=***

***(\_F***

***(JUSQU\_A***

***=***

***16,***

***NOT***

***=***

***3***

***),),***

)

*To build the list of entreties with two values different from the step:*

*1  
2  
3  
4  
5  
10  
15*

*listi = DEFI\_LIST\_ENTI*

*(BEGINNING =*

*1,*

*INTERVAL*

*=*

*(\_F*

*(JUSQU\_A*

*=*

*5,*

*NOT*

*=*

*1,*

*),*

*\_F*

**(JUSQU\_A**

=

**15,**

**NOT**

=

**5,**

**),)**

)

**or**

**listi = DEFI\_LIST\_ENTI**

**(BEGINNING =**

**1,**

**INTERVAL**

=

**(\_F**

**(JUSQU\_A**

=

**5,**

**NUMBERS**

=

**4,**

**),**

**\_F**

**(JUSQU\_A**



=  
15,  
**NUMBERS**  
=  
2,  
,),

)

*or, from object does not import lists Python:*

*listi = DEFI\_LIST\_ENTI (VALE = arranges (10),)*  
*Instruction manual*  
*U4.3- booklet: Function*  
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*7.4*

*Titrate:*

*Operator DEFI\_FONC\_FLUI*

*Date:*

*31/01/05*

*Author (S):*

*A. Key ADOBES*

*:*

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*Organization (S): EDF-R & D /MFTT*

***Instruction manual  
U4.3- booklet: Function  
Document: U4.35.01***

***Operator DEFI\_FONC\_FLUI***

## ***1 Goal***

***To define a profile rate of flow fluid along a beam. Profiles corresponding to “standard” profiles resulting from results experimental and used within the framework of a dynamic calculation with taking into account of forces fluid-rubber bands.***

***Speeds are calculated with the nodes for which one seeks in the concept grid value of the associated curvilinear X-coordinate.***

***Currently, it is possible to apply a profile speed defined by DEFI\_FONC\_FLUI only to one structure whose meshes are of type “SEG2”. The produced concept is of type function (parameter “ABSC”, curvilinear X-coordinate)***

***Instruction manual  
U4.3- booklet: Function HT-66/05/004/A***

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***Code\_Aster ®***

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***Titrate:***

***Operator DEFI\_FONC\_FLUI***

***Date:***

***31/01/05***

**Author (S):**

**A. Key ADOBES**

**:**

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**2 Syntax**

**F**

**[function] = DEFI\_FONC\_FLUI (**

**GRID**

**=**

**my**

**, [grid]**

**NOEUD\_INIT**

**=**

**nor**

**, [node]**

**NOEUD\_FIN**

**=**

**nf**

**, [node]**

**QUICKLY = \_F**

**(**

**/PROFILE**

**="/UNIFORM"**

**,**

**VALE =/1.**

**[DEFECT]**

/  
**vale,**

**[R]**

/  
**PROFILE**  
**=/"LEONARD",**

**NB\_BAV**  
**=**  
**/**  
**0**  
**[DEFECT]**

/  
**2**

/

3,

),

***Interpol***

=

/

***“FLAX”***

***[DEFECT]***

/

***“LOG”***

/

***“NOT”,***

***PROL\_GAUCHE =/“EXCLUDED” [DEFECT]***

/

***“LINEAR”***

/

***“CONSTANT”***

,

***PROL\_DROITE*** =/"EXCLUDED" [DEFECT]

/

**"LINEAR"**

/

**"CONSTANT"**

,

***INFORMATION*** =/1 [DEFECT]

/

2,

***TITRATE***

=

***titrate***

**, [TXM]**

);

***Instruction manual***

***U4.3- booklet: Function HT-66/05/004/A***

---

***Code\_Aster*** ®

***Version***

**7.4**

***Titrate:***

## ***Operator DEFI\_FONC\_FLUI***

***Date:***

***31/01/05***

***Author (S):***

***A. Key ADOBES***

***:***

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### ***3 Operands***

#### ***3.1 Operand***

***GRID***

***GRID***

***=***

***my***

***Name of the grid for which the curvilinear X-coordinate is defined.***

#### ***3.2 Operands***

***NOEUD\_INIT and NOEUD\_FIN***

***NOEUD\_INIT = nor/NOEUD\_FIN = nf***

***The function is defined on the whole of the grid. The nodes “INIT” and “END” allow to define the zone of application of the profile speed. Apart from this zone, the value of the function is null.***

#### ***3.3 Key word***

***QUICKLY***

***QUICKLY***

***Key word factor, it makes it possible to define the profile speed.***

***PROFILE***

***This operand, associated operands VALE and NB\_BAV, makes it possible to define a “standard” profile:***

***“UNIFORM” or “LEONARD”.***

***/***

**VALE = vale**

*Allows to define the level of the function, if the standard profile is “UNIFORM”.*

/  
**NB\_BAV**

*If the profile is of type “LEONARD”, NB\_BAV defines a “standard” profile stored in one catalogue.*

**Note:**

*BAV (Vibratory Anti Bar) is a terminology related to the tubes of generator of vapor. NB\_BAV corresponds to the number of anti-vibratory bars being in the zone of obtaining the profile.*

**3.4 Operand**  
**Interpol**

**Interpol**

*Type of interpolation of the function enters the values of parameter of the field of definition.*

· “FLAX”:

*linear,*

· “LOG”:

*logarithmic curve,*

· “NOT”:

*one does not interpolate (and thus the program will stop if one asks value of the function for a value of the parameter for which it was not defined).*

*Instruction manual*

*U4.3- booklet: Function HT-66/05/004/A*

---

**Code\_Aster** ®

*Version*

**7.4**

*Titrate:*

*Operator **DEFI\_FONC\_FLUI***

*Date:*

**31/01/05**

*Author (S):*



## **A. Key ADOBES**

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### **3.5 Operands**

#### **PROL\_GAUCHE and PROL\_DROITE**

##### *PROL\_GAUCHE/PROL\_DROITE*

*Define the type of prolongation on the left (respectively on the right) of the field of definition parameter.*

· *“LINEAR”:*

*the function is prolonged on the left (on the right) by a segment of the same line slope than on the lower terminal (higher) field of definition of the parameter,*

· *“EXCLUDED”:*

*the extrapolation of the function apart from the field of definition of the parameter is prohibited,*

· *“CONSTANT”:*

*the function is prolonged on the left (on the right) by the value that it takes on the lower terminal (higher) field of definition of the parameter.*

### **3.6 Operand**

#### **INFORMATION**

##### *INFORMATION*

*Level of impression.*

· *INFORMATION = 1:*

*no impression,*

· *INFORMATION = 2:*

*one prints in the file MESSAGE the name of the function, it a number of points of definition, the name of the parameter, the name result, options of prolongation and interpolation and the first 10 values of the function, in the ascending order parameter.*

### **3.7 Operand**

***TITRATE***

*TITRATE*

=

*titrate*

*Argument of the text type defining the title attached to the concept function at exit.*

*Instruction manual*

*U4.3- booklet: Function HT-66/05/004/A*

---

**Code\_Aster** ®

Version

7.4

Titrate:

Operator **DEFI\_FONC\_FLUI**

Date:

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Author (S):

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**4**

### ***Presentation of the standard profiles speed***

*They are defined in a form discretized in (varying angle in degrees of 0. to 180.) - [Figure 4-a], [Figure 4-b] and [Figure 4-c].*

*Thus, it is possible starting from the equation [éq 4-1] to apply these profiles to a field defined in curvilinear X-coordinate.*

. +  
v (S  
I  
I  
I  
I) =

**éq 4-1**

*vmoy*

$v_{k+1} - v_k$

$I =$

$k+1-k$

$I$

$S - N$

$S I$

*with*

180

$I =$

*nf*

$S - nor$

$S$

$v_k \quad k+1 - v_{k+1} \quad K$

$I =$

$k+1-k$

$S, S, S$

$I$

*nor*

*nf is respectively the curvilinear X-coordinate of the point running, the NOEUD\_INIT and of NOEUD\_FIN which define the zone of application.*

*K: index in the table of the discretized function.*

$NR$

$(I.$

$I + I)$

$I$

v  
=1  
moy =

NR

NR: a number of points of discretization of the zone of application.

Instruction manual

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Titrate:

Operator **DEFI\_FONC\_FLUI**

Date:

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**Leonard profile without BAV**

1,8

1,6

1,4

1,2

**tess**

1

0,8

**L**

**from VI**

0,6

**Profi**

0,4

0,2

0 0

5

5

30  
75  
90  
48,  
105  
150  
180  
131,  
**Angle (°)**

**Appear 4-a: Profile speed - NB\_BAV = 0**

**Leonard profile 2 BAV**

1  
0,9  
0,8  
0,7  
0,6  
**tess**  
0,5  
**L**  
**from VI 0,4**  
**Profi 0,3**  
0,2  
0,1  
0 0  
4  
4  
6  
6  
29  
51  
99  
90  
01  
49  
151  
180  
33,  
47,  
70,  
75,

104,  
109,  
132,  
146,  
**Angle (°)**

**Appear 4-b: Profile speed - NB\_BAV = 2**

*Instruction manual*

*U4.3- booklet: Function HT-66/05/004/A*

---

**Code\_Aster ®**

*Version*

7.4

*Titrate:*

*Operator DEF1\_FONC\_FLUI*

*Date:*

31/01/05

*Author (S):*

**A. Key ADOBES**

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**Leonard profile 3 BAV**

1,4

1,2

1

0,8

0,6

**Profile Speed 0,4**

0,2

0 0 7 7

2

8

3

3

48

44

15

90  
85  
56  
25,  
30,  
132  
180  
51,  
75,  
77,  
102,  
104,  
128,  
149,  
154,  
**Angle (°)**

***Appear 4-c: Profile speed - NB\_BAV = 3***

*Instruction manual*

*U4.3- booklet: Function HT-66/05/004/A*

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***Code\_Aster*** ®

*Version*

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*Titrate:*

*Operator* ***DEFI\_FONC\_FLUI***

*Date:*

31/01/05

*Author (S):*

***A. Key ADOBES***

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## ***5 Bibliography***

[1]

***NR. GAY: Flustru Version 2.0 - general Presentation. Note of use - source FORTRAN of software. Note technical EDF/DER HT-32/93.05A.***



*Instruction manual*

*U4.3- booklet: Function HT-66/05/004/A*

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***Code\_Aster*** ®

*Version*

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*Titrate:*

*Operator FONC\_FLUI\_STRU*

*Date:*

*27/01/05*

*Author (S):*

***A. Key ADOBES***

*:*

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*Organization (S): EDF-R & D /MFTT*

***Instruction manual***

***U4.3- booklet: Function***

***Document: U4.35.02***

***Operator FONC\_FLUI\_STRU***

***1 Goal***

*To create a constant function parameterized by the curvilinear X-coordinate. This function gives the value of coefficient of mass added for a configuration of the type “beam of tubes under flow transverse”.*

*This function is used downstream by operator DEFI\_MATERIAU [U4.43.01], key word factor ELAS\_FLUI. Product a concept of the function type.*

*Instruction manual*

*U4.3- booklet: Function HT-66/05/004/A*

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*Code\_Aster* ®

*Version*

*7.4*

*Titrate:*

*Operator FONC\_FLUI\_STRU*

*Date:*

*27/01/05*

*Author (S):*

*A. Key ADOBES*

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*2 Syntax*

*fonc\_cm*

*[function] = FONC\_FLUI\_STRU*

*(*

*TYPE\_FLUI\_STRU = typeflui*

*,*

*[type\_flui\_stru]*

);

**Instruction manual**

**U4.3- booklet: Function HT-66/05/004/A**

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**Titrant:**

**Operator FONC\_FLUI\_STRU**

**Date:**

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**Author (S):**

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**3 Operands**

**3.1 Key word**

**TYPE\_FLUI\_STRU**

**TYPE\_FLUI\_STRU = typeflui**

**Concept of the type [type\_flui\_stru] produced by operator DEFI\_FLUI\_STRU [U4.25.01], providing the value of the coefficient of added mass  $C_m$ .**

**Note:**

**The  $C_m$  value can be imposed via key word COEF\_MASS\_AJOU appearing in order DEFI\_FLUI\_STRU. If the coupling fluidelastic is taken in count, the coefficient of added mass can be calculated by the operator according to other characteristics of the beam.**

***Operator FONC\_FLUI\_STRU creates a concept of the type [function] which is then directly usable by DEFI\_MATERIAU [U4.43.01], key word ELAS\_FLUI.***

***The function constant, is parameterized by the curvilinear X-coordinate, and gives the Cm value.***

***The combined use of operators FONC\_FLUI\_STRU then DEFI\_MATERIAU option ELAS\_FLUI is necessary when one studies a configuration of the type “beam of tubes under transverse flow”, and it is allowed only for this type of configurations.***

*Instruction manual*

*U4.3- booklet: Function HT-66/05/004/A*

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***Code\_Aster*** ®

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*Titrate:*

*Operator FONC\_FLUI\_STRU*

*Date:*

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*Author (S):*

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***Code\_Aster*** ®

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*Titrate:*

*Operator LIRE\_INTE\_SPEC*

*Date:*

04/02/05

*Author (S):*

***S. CAMBIER. G. JACQUART*** Key

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*Organization (S): EDF-R & D /AMA, Industrie/CNPE EDF-Pole of Tricastin*

***Instruction manual***

***U4.3- booklet: Function***

***U4.36.01 document***

## ***Operator LIRE\_INTE\_SPEC***

### ***1 Goal***

***To see on an external file of the complex functions to create a matrix interspectrale.***

***The file user is coded in ASCII.***

***The functions read are of fonction\_C type.***

***The produced concept is of tabl\_intsp type.***

### ***Instruction manual***

***U4.3- booklet: Function***

***HT-66/05/004/A***

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### ***Code\_Aster*** ®

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***7.4***

***Titrate:***

***Operator LIRE\_INTE\_SPEC***

***Date:***

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***Author (S):***

***S. CAMBIER. G. JACQUART Key***

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### ***2 Syntax***

***int***

***[tabl\_intsp] = LIRE\_INTE\_SPEC***

(  
**UNIT**  
=  
/  
**U**  
**[I]**

**FORMAT**  
=  
/  
**“REEL\_IMAG”**

/  
**“MODULE\_PHASE”**  
**[DEFECT]**

**TITRATE**  
=  
/

**NOM\_PARA**  
=  
/  
**“DX”**  
/  
**“DY”**

/

**“DZ”**

/

**“DRX”**

/

**“DRY”**

/

**“DRZ”**

/

**“TEMP”**

/

**“INST”**

**/“X”**

**/“Y”**



**/“Z”**

**/**

**“EPSI”**

**/**

**“FREQ”**

**/**

**“PULS”**

**/**

**“AMOR”**

**/**

**“ABSC”**

**NOM\_RESU**

**=**

**nomren**

**[KN]**

**PROL\_DROITE**

**=**

**/**

**“CONSTANT” [DEFECT]**

**/**

**“LINEAR”**

/  
“**EXCLUDED**”

**PROL\_GAUCHE**  
=  
/  
“**CONSTANT**”

/  
“**LINEAR**”

/  
“**EXCLUDED**” [DEFECT]

**Interpol**  
=  
**I** “**NOT**”

***I “LOG”***

***I “FLAX”  
[DEFECT]***

***INFORMATION =/1 [DEFECT]***

***/ 2***

***);***

***Instruction manual  
U4.3- booklet: Function  
HT-66/05/004/A***

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**Code\_Aster** ®

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7.4

Titrate:

Operator LIRE\_INTE\_SPEC

Date:

04/02/05

Author (S):

**S. CAMBIER. G. JACQUART** Key

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### **3 Operands**

#### **3.1 Operand**

**UNIT**

**UNIT = U**

***Logical number of unit of the external file on which the reading is made.***

#### **3.2 Operand**

**FORMAT**

***The format of reading of the complex function defines:***

.

***“MODULE\_PHASE” by defect,***

.

***Real left “REEL\_IMAG” and imaginary part.***

#### **3.3 Operand**

**NOM\_PARA**

***The name of the parameter of the function (X-coordinate) defines “FREQ” DEFECT***

#### **3.4 Operand**

**NOM\_RESU**

***The name of the result of the function defines (ordered)***

### **3.5 Operands**

#### ***PROL\_DROITE/PROL\_GAUCHE***

##### ***PROL\_DROITE***

=

*The prolongation of the function on the right field of definition of the variable defines.*

##### ***PROL\_GAUCHE***

=

*The prolongation of the function on the left field of definition of the variable defines:*

.

***“CONSTANT”***

.

***“LINEAR”***

*for a prolongation along the first definite segment (PROL\_GAUCHE) or of the last definite segment (PROL\_DROITE).*

.

***“EXCLUDED”***

*if the extrapolation of the values apart from the field of definition of parameter is prohibited.*

### **3.6 Operand**

#### ***Interpol***

##### ***Interpol***

=

.

***“LOG” interpolation logarithmic curve between two values of the field of definition.***

.

***“FLAX” linear interpolation between two values of the field of definition.***

### **3.7 Operand**

#### ***INFORMATION***

##### ***INFORMATION***

=

***Specify the options of impression on the file MESSAGE.***

1

*impression of the attributes of the functions: a number of points of definition, names of parameter and of the result, as well as options of prolongation and checking*

2

*like 1 plus the list of the first 10 values of each function in the order crescent of the parameter*

*Instruction manual*

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*Code\_Aster* ®

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*Operator LIRE\_INTE\_SPEC*

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*:*

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*For example:*

*.*

*PROL\_DROITE = "CONSTANT", PROL\_GAUCHE = "CONSTANT"*

*y*

*x1*

*x2*

*xn-1*

*xn*

*X*

*.*

*PROL\_DROITE = "LINEAR", PROL\_GAUCHE = "EXCLUDED"*

*y*  
*x1*  
*x2*  
*xn-1*  
*xn*  
*X*

#### *4* *Phase of checking*

*Checking of the number of values read by functions.*

*Checking of the number of functions read.*

*Instruction manual*  
*U4.3- booklet: Function*  
*HT-66/05/004/A*

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*Code\_Aster* ®  
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*Titrate:*  
*Operator LIRE\_INTE\_SPEC*

*Date:*  
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*Author (S):*  
*S. CAMBIER. G. JACQUART Key*  
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#### *5 Remarks* *of use*

*In addition to the produced concept of `tabl_intsp` type, the operator creates concepts of the `fonction_C` type associated the defined functions, of the matrix interspectrale. These functions are accessible to*

*the user using order **RECU\_FONCTION** [U4.32.03] or by printing them with **IMPR\_TABL** [U4.91.03]. They will be printed with format **MODULE\_PHASE**.*

*The names of the parameter and result of the functions have as a default value “**FREQ**” and “**DSP**”.*

## **5.1**

### *Syntax of the file*

*The information read on the file is made up of three parts:*

•  
*a key word of head of imposed chapter: **INTERSPECTRE**.*

•  
*the key word **DIM**, dimension of the matrix.*

•  
*“subfiles defining “complex functions. Each subfile starts with key word **FONCTION\_C** and ends in **FINSF**.*

•  
*the file ends obligatorily in **END**.*

## **5.2 Descriptor**

### **5.2.1 Key word describing caractérisques matrix**

***DIM = dim***

*Entirety makes it possible to define the dimension of the matrix.*

***Note:***

*The sign “=” is obligatory.*

### **5.2.2 Key word describing a fonction\_C**

***Notice preliminary:***

*“, the number of functions to be defined is equal to:  
 $N = (dim * (dim + 1)) / 2$ , since the matrix considered is “**SQUARE**”.*

*N functions are defined by their indices **I** and **J** in the matrix. Only the triangular part higher of the matrix is defined, (indices (1,1); (1,2); (2,2); (1,3); ... (N, N)).*

***FONCTION\_C***

***I = whole***



*index line of the function in the matrix.*

*J = whole*

*index column of the function in the matrix.*

*NB\_POIN = whole number of points of the FUNCTION*

*VALUE =*

*3\*NB\_POIN real must be present. The reading of the values is carried out  
line  
with  
line.*

*On each line are defined in the following order:*

*.  
the value of the parameter, the real part of the result, the imaginary part of the result  
(FORMAT = "REEL\_IMAG"),  
or*

*.  
the value of the parameter, the module of the result, the phase of the result  
(FORMAT = "MODULE\_PHASE"),*

*Note:*

*For format MODULE\_PHASE, the phase is given in degree.*

*Instruction manual*

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*Date:*

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### **6 Example**

*Example of syntax of file user:*

**INTERSPECTRE**

**DIM = 2**

**FONCTION\_C**

**I = 1**

**J = 1**

**NB\_POIN = 4**

**VALUE =**

0. 10.

0.1

10. 10. 0.1

10.01 0.

0.

100. 0.

0.

**FINSF**

**FONCTION\_C**

**I = 1**

**J = 2**

**NB\_POIN = 4**

**VALUE =**

0. 2. 0.5

10. 2. 0.5

10.01 0.

0.

100. 0.

0.

**FINSF**

**FONCTION\_C**

**I = 2**

**J = 2**

**NB\_POIN =4**

**VALUE =**

0. 20.

0.1  
10. 20. 0.1  
10.01 0.  
0.  
100. 0.  
0.

**FINSF**  
**END**

*Example of syntax of the order:*

**AUTOSPC=LIRE\_INTE\_SPEC (**  
**UNITE=19,**  
**FORMAT=' MODULE\_PHASE',**  
**PROL\_DROITE=' EXCLU',**  
**PROL\_GAUCHE=' EXCLU',**  
**INTERPOL=' LIN'**  
**)**

*Instruction manual*  
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**Code\_Aster** ®  
**Version**  
**7.4**

**Titrate:**  
**Operator DEFI\_INTE\_SPEC**

**Date:**  
**10/02/05**  
**Author (S):**  
**S. CAMBIER, G. JACQUART Key**  
**:**  
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**Organization (S): EDF-R & D /AMA, Industrie/CNPE EDF-Pole of Tricastin**

***Instruction manual  
U4.3- booklet: Function  
Document: U4.36.02***

***Operator DEF1\_INTE\_SPEC***

***1 Goal***

***To define a matrix interspectrale.  
The terms of the matrix are defined by:***

***.  
constants (white vibration),  
.  
existing complex functions,  
.  
the analytical formula of KANAI-TAJIMI.***

***Product a structure of data of the tabl\_intsp type.***

***Instruction manual  
U4.3- booklet: Function  
HT-66/05/004/A***

**Code\_Aster** ®

**Version**

**7.4**

**Titrate:**

**Operator** *DEFI\_INTE\_SPEC*

**Date:**

**10/02/05**

**Author (S):**

**S. CAMBIER, G. JACQUART** *Key*

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**2 Syntax**

*int*

*[tabl\_intsp] = DEFI\_INTE\_SPEC*

(  
**DIMENSION**

=

/

1

**[DEFECT]**

**/N**

**[I]**

/  
**PAR\_FONCTION =\_F (**

**NUME\_ORDRE\_I**  
**= I [I]**

**NUME\_ORDRE\_J**  
**= J [I]**

**FUNCTION**  
**=fonct**  
**[fonction\_C]**

)  
  
/  
**KANAI\_TAJIMI =\_F (**

**NUME\_ORDRE\_I**  
**= I [I]**

**NUME\_ORDRE\_J**  
**= J [I]**

**FREQ\_MIN =/0. [DEFECT]**  
/  
**fmin**  
**[R]**

*FREQ\_MAX =/100. [DEFECT]*

/

*fmax*

*[R]*

*NOT*

=

/

*1.*

*[DEFECT]*

/

*not*

*[R]*

*/VALE\_R*

*= valr [R]*

/

*VALE\_C*

=



*valc*  
[C]

*AMOR\_REDUIT=*  
*/0.60 [DEFECT]*  
*/*  
*amor*  
[R]

*FREQ\_MOY =/5. [DEFECT]*  
*/*  
*fmoy*  
[R]

*INTERPOL = I "FLAX"*  
[DEFECT]

*I “LOG”*

*I “NOT”*

*PROL\_GAUCHE=*  
*/“EXCLUDED” [DEFECT]*  
*/*  
*“CONSTANT”*  
*/*  
*“LINEAR”*

*PROL\_DROITE=*  
*/“EXCLUDED” [DEFECT]*  
*/*  
*“CONSTANT”*  
*/*  
*“LINEAR”*

)  
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*/*  
*CONSTANT:*  
*(*

*NUME\_ORDRE\_I*  
=/I [I]

*NUME\_ORDRE\_J*  
=/J [I]

*FREQ\_MIN*  
=  
/  
0.  
[DEFECT]  
/  
*fmin*  
[R]

*FREQ\_MAX* =/100. [DEFECT]

/  
*fmax*  
[R]

*NOT*

=  
/  
1.  
[DEFECT]  
/  
*not*

[R]

*VALE\_R*  
= / 1.  
[DEFECT]  
/  
*valr*  
[R]  
/  
*VALE\_C*  
=  
*valc*  
[C]

*INTERPOL = I “FLAX”*  
*[DEFECT]*

*I “LOG”*

*I “NOT”*

*PROL\_GAUCHE* =/"EXCLUDED" [DEFECT]

/

"CONSTANT"

/

"LINEAR"

*PROL\_DROITE* =/"EXCLUDED" [DEFECT]

/

"CONSTANT"

/

"LINEAR"

)

*TITRATE*

=

*titrate*

[*l\_Kn*]

*INFORMATION* =/1 [DEFECT]

/ 2

)

;

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*Titrate:*

*Operator* **DEFI\_INTE\_SPEC**

*Date:*

10/02/05

*Author (S):*

**S. CAMBIER, G. JACQUART** *Key*

:

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### **3 Operands**

#### **3.1 Operand**

**DIMENSION**

**DIMENSION**

= **N**

*Dimension of the matrix interspectrale, stored in a table of interspectres (tabl\_intsp).*

#### **3.2 Word**

*key*

**PAR\_FONCTION**

**/PAR\_FONCTION**

=

*Key word factor, makes it possible to define a term (I, J) of the matrix interspectrale from already definite concepts of the fonction\_C type.*

**NUME\_ORDRE\_I**



**= I**

**NUME\_ORDRE\_J**

**= J**

***Couples indices (line, column) of the matrix on which one will affect a function.***

**FUNCTION: fonct**

***fonct is a concept of the fonction\_C type.***

### **3.3 Word**

**key**

**KANAI\_KAJIMI**

**/KANAI\_TAJIMI**

**=**

***Key word factor, makes it possible to define a function of the matrix interspectrale like a noise white filtered by an oscillator [bib2].***

***One gives the three parameters of the filter of KANAI\_TAJIMI: damping, frequency and level.***

#### **3.3.1 Operands**

**AMOR\_REDUIT/FREQ\_MOY/VALE\_R/VALE\_C**

***AMOR\_REDUIT = amor***

***FREQ\_MOY = fmoy***

**/VALE\_R**

**= valr**

**/**

**VALE\_C**

**=**

**valc**

***fmoy and amor are the Eigen frequency and the reduced damping of the filter. The level can***

*to be given in the complex or real form.*

### **3.3.2 Operands**

***INTERPOL/PROL\_GAUCHE/PROL\_DROITE***

*One gives for each function the traditional parameters which condition the interpolation and the extrapolation of the produced function. The possibilities as well as the default values are pointed out on page 2. For more details to see them [§3.4] and [§3.5].*

***Interpol***

***PROL\_GAUCHE***

***PROL\_DROITE***

### **3.3.3 Operands**

***FREQ\_MIN/FREQ\_MAX/PAS***

*One gives the parameters of the frequential discretization.*

*FREQ\_MIN = fmin*

*FREQ\_MAX = fmax*

*NOT*

*=*

*not*

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### **3.4 Operands**

#### ***PROL\_DROITE and PROL\_GAUCHE***

*PROL\_DROITE and PROL\_GAUCHE =*

*Define the type of prolongation on the right (on the left) of the field of definition of the variable:*

*.*

*“CONSTANT” for a prolongation with the last (or first) value of function,*

*.*

*“LINEAR” for a prolongation along the first definite segment (PROL\_GAUCHE) or of the last definite segment (PROL\_DROITE),*

*.*

*“EXCLUDED” if the extrapolation of the values apart from the field of definition of parameter is prohibited (in this case if a calculation requires a value function out of the field of definition, the code will stop in fatal error).*

*For example:*

*.*

*PROL\_DROITE = “CONSTANT”, PROL\_GAUCHE = “CONSTANT”*

*y*

*X*

*X*

*X*

*X*

*X*

*1*

*2*

*n-1*

*N*

.

*PROL\_DROITE = "LINEAR", PROL\_GAUCHE = "EXCLUDED"*

*y*

*X*

*X*

*X*

*X*

*1*

*x2*

*n-1*

*N*

**Note:**

*The type of prolongation and interpolation are independent one of the other.*

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**3.5 Operand**

## ***Interpol***

*Interpol*

=

*Type of interpolation of the function enters the values of the field of definition of the function: one type for the interpolation of the parameter and for the interpolation of the function. This is obtained in providing a list of texts among:*

*Interpol*

=

*(“FLAX”,  
“LOG”)*

*“FLAX”: linear,*

*“LOG”: logarithmic curve,*

*“NOT”: one does not interpolate (and thus the program will stop if for the value is asked function for a value of the parameter where it was not defined).*

### ***Note:***

*If only one value is specified, it is taken into account at the same time by the interpolation of parameter and of the function. Interpol = “LOG” is equivalent to (“LOG”, “LOG”).*

## **3.6 Word**

***key***

***CONSTANT***

***/CONSTANT***

=

*Key word factor which makes it possible to define a function of the matrix interspectrale like a noise white (constant).*

*All the key words under this key word factor have the same direction as for the key word factor KANAI\_TAJIMI except AMOR and FREQ\_MOY which do not have a direction here.*

## **3.7 Operand**

***TITRATE***

*TITRATE = title*

*title is the title of calculation to print results at the head. See [U4.03.01].*

## **3.8 Operand**

## ***INFORMATION***

### ***INFORMATION***

=

*1 :*

*no impression.*

*2 :*

*impression of the characteristics of the definite matrix interspectrale.*

**4**

### ***Phase of Checking***

.

*Checking of coherence enters the number of functions and the dimension of the matrix (square) - (see remark of use).*

.

*Checking of the coherence of the indices.*

### **5 Remark**

#### ***of use***

.

*If N is the dimension of the matrix, this one being square*

*- N is needed \* (N +)*

*1/2 fonction\_C, corresponding to the higher triangular part of stamp, only stored.*

.

*To print the contents of the matrix, it is necessary to use operator IMPR\_TABLE [U4.91.03].*

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Author (S):

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## **6 Example**

*To define a interspectre (matrix 1 X 1) in constant value*

1.

**100**

**0**

**Hz**

**INTEREXC**

=

**DEFI\_INTE\_SPEC**

(

**DIMENSION=1,**

**INFO=2,**

**CONSTANT=\_F (**

**NUME\_ORDRE\_I=1,**

**NUME\_ORDRE\_J=1,**

**FREQ\_MIN=0.,**

**FREQ\_MAX=100.,**

**PAS=1.,**

**PROL\_GAUCHE=' CONSTANT',**

**PROL\_DROITE=' CONSTANT',**

**INTERPOL=' LIN',**

**VALE\_C= ("IH", 1. , 0.),**

),

);

*To define the interspectre of a white vibration filtered by an oscillator represented by the filter of KANAI-TAJIMI:*

***INTKTJ1***

=

***DEFI\_INTE\_SPEC***

(

***DIMENSION=1,***

***INFO=2,***

***KANAI\_TAJIMI=\_F (***

***NUME\_ORDRE\_I=1,***

***NUME\_ORDRE\_J=1,***

***FREQ\_MOY=15.,***

***AMOR=0.05,***

***VALE\_R=1.,***

***INTERPOL=' LIN',***

***PROL\_GAUCHE=' CONSTANT',***

***PROL\_DROITE=' CONSTANT',***

***FREQ\_MIN=0.,***

***FREQ\_MAX=30.,***

***PAS=5.,***



),

);

*The 3 parameters of the filter were given:*

*damping = 0.05*

*frequency = 15. Hz*

*level = 1.*

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*Author (S):*

*S. CAMBIER, G. JACQUART Key*

*:*

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*7 Bibliography*

*[1]*

***J.S. BENDAT, J. WILEGSON: "Spectral Engineering application of correlation and analysis".***

***[2]***

***C. DUVAL "Dynamic response under random excitations in Code\_Aster: principles theoretical and examples of use ". Note DER HP-61/92-148***

***Instruction manual***

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***S. CAMBIER, G. JACQUART Key***

***:***

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***Organization (S): EDF-R & D /AMA, Industrie/CNPE EDF-Pole of Tricastin***

***Instruction manual***

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***Document: U4.36.03***

## ***Operator CALC\_INTE\_SPEC***

### ***1 Goal***

***To calculate a matrix interspectrale starting from a function of time. The matrix is the average arithmetic of a certain number of matrices interspectrales calculated on various temporal blocks of a function of the time which one wants to know the interspectre.***

***Product a concept of the tabl\_intsp type.***

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***S. CAMBIER, G. JACQUART Key***

***:***

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### ***2 Syntax***

***int***

***[tabl\_intsp] = CALC\_INTE\_SPEC***

***(***

***INST\_INIT***

=

/

***II***

***[R]***

/

0

***[DEFECT]***

***INST\_FIN***

= *yew*

***[R]***

***DUREE\_ANALYSE***

=

*da*

***[R]***

***DUREE\_DECALAGE***

=

*dd*

***[R]***

***NB\_POIN =***

*Np*

***[I]***

**FUNCTION**

=  
*fo*  
[*function,*  
*formulate*]

**TITRATE**

=  
*titrate*  
[*l\_Kn*]

**INFORMATION =/1 [DEFECT]**

/ 2

);  
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### ***3 Operands***

#### ***3.1 Operands***

***INST\_INIT/INST\_FIN***

***INST\_INIT = II***

***First value of the parameter for which the signals will be used for the calculation of the matrix interspectrale (urgent initial).***

***INST\_FIN = yew***

***Last value of the parameter for which the signals will be used for the calculation of the matrix interspectrale (urgent final).***

***Note:***

***The functions will be calculated with the mode of interpolation which was associated to them. It is advised not to have a problem of discretization which the functions have one authorized linear interpolation.***

***F (T)***

***INST\_INIT***

***INST\_FIN***

***T***

***DUREE\_DECALAGE***

***fenestrate 1***

***DUREE\_ANALYSE***

***fenestrate 2***

***fenestrate 3***

***T***

***T***

***T3***

***1***

***2***

***Appear 3.1-a: Analyze and calculation of interspectre on 3 windows with covering***

#### ***3.2 Operands***

***DUREE\_ANALYSE/DUREE\_DECALAGE***

**DUREE\_ANALYSE = da**

*The functions will be cut out in several windows of duration of analysis da. For each one of these windows a matrix interspectrale is calculated. The matrix interspectrale result of the operator will be the arithmetic mean of the calculated matrices.*

**DUREE\_DECALAGE = dd**

*Allows during the function division according to the duration of analysis in windows, to shift each window one compared to the other one dd duration. If tk is the initial moment the kth one fenestrate, the initial moment of K + lième window will be tk +dd*

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**If X [**

**K] and y [K] are two discrete temporal signals.**

**Are X [**

**K] and Y [K] their transforms of FOURIER discrete, then [bib1] the matrix interspectrale**

**S**

**[K] S [K]**

**[**

**xx**

**xy**

***S K] is worth***

***S\* [K] S [K]***

***xy***

***yy***

***where***

***p***

***l***

***S***

***[K] =***

***X [K***

***]***

***X***

***.***

***\* [K]***

***xx***

***p.n T***

***I = 1***

***p***

***l***

***S***

***[K] =***

***X [K***

***]***

***Y***

***\* [***

***. K]***

***xy***

***p.n T***

***I = 1***

***where N is the number of points per block,***

***p is the number of blocks.***

***Caution:***

***This average adapted perfectly to the “real” signals, results of a measurement is not appropriate not without precaution for functions close to a sine (the frequency of the average must***



*to be much higher than the frequency of the signal.*

**Note:**

*If the treated signals come from operator GENE\_FONC\_ALEA via possibly it calculation of a dynamic response (operator DYNA\_TRAN\_MODAL for example), then it is advised to treat each pulling of GENE\_FONC\_ALEA independently. In this case, it is necessary to choose durations of analysis and shift equal to the duration of each pulling GENE\_FONC\_ALEA (cf GENE\_FONC\_ALEA [U4.36.05]).*

### **3.3 Operand**

**NB\_POIN**

$NB\_POIN = N_p$

*A number of points of the parameter for one duration of analysis. For each point the functions will be calculated according to the type of definite interpolation and prolongation. The number of points must be a power of 2 (calculation of the fast transform of Fourier).*

**Note:**

*If the signals consist of a number (power of two) sufficient of points with one not constant, it is preferable to choose this number to avoid interpolations which can generate artifacts. In particular, if the treated signals come from the operator GENE\_FONC\_ALEA via possibly the calculation of a dynamic response (operator DYNA\_TRAN\_MODAL for example), this number will correspond to the double of the number of points informed in GENE\_FONC\_ALEA key word NB\_POIN or obtained by INFO=2 in GENE\_FONC\_ALEA (cf GENE\_FONC\_ALEA [U4.36.05]).*

### **3.4 Operand**

**FUNCTION**

**FUNCTION**

=

*List names of the functions of concept of the function type, which one wishes to calculate the matrix interspectrale.*

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**3.5 Operand**

**TITRATE**

**TITRATE**

**=**

*title is the title of the concept tabl\_intsp to print at the head results [U4.03.01].*

**3.6 Operand**

**INFORMATION**

**INFORMATION**

**=**

*Specify the options of impression on the file MESSAGE.*

**1**

*print the initial frequency, the final frequency and the step in frequency.*

**2**

*like 1 more for each autospectre and interspectre, a criterion of convergence in function of the number of random pullings. (a random pulling corresponds to a window of analysis).*

**4**

**Phase of checking**

*It is checked if the number of points  $N_p$  is a power of 2.*

## **5 Remarks of use**

*In addition to the concept of the `tabl_intsp` type produced, the operator creates the concepts of the `fonction_C` type which constitute the matrix interspectrale. This square matrix being, definite positive, functions complexes defining the higher triangular part of the matrix are enough.*

*These functions can be printed using operator `IMPR_TABLE` [U4.91.03].*

## **6 Example**

```
FONC1=RECU_FONCTION (RESU_GENE=DYNAMODE, NOM_CHAM=' DEPL',  
NOEUD=' N51', NOM_CMP=' DY',  
INTERPOL=' LIN')
```

```
FONC2=RECU_FONCTION (RESU_GENE=DYNAMODE, NOM_CHAM=' DEPL',  
NOEUD=' N52', NOM_CMP=' DY',  
INTERPOL=' LIN')
```

```
INTERS=CALC_INTE_SPEC (INST_INIT=0.,  
INST_FIN=10.24,  
DUREE_ANALYSE=1.024,  
DUREE_DECALAGE=1.024,  
NB_POIN=1024,  
FONCTION= (FONCT1, FONCT2,  
)
```

## **7 Bibliography**

[1]  
*Note DER HP-61/93-067 - Generation of random signals of spectral concentration given -  
G. JACQUART  
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***Titrate:***  
***Operator GENE\_FONC\_ALEA***

***Date:***  
***08/02/05***  
***Author (S):***  
***S. CAMBIER, A. DUMOND, G. JACQUART Key***  
***:***  
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***Organization (S): EDF-R & D /AMA, EDF-GDF/DIT-BEX, Industrie/CNPE EDF-Pole of Tricastin***

***Instruction manual***  
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***Document: U4.36.05***

***Operator GENE\_FONC\_ALEA***

***1 Goal***

***To generate a trajectory of a monodimensional multivariate stochastic process (i.e with several***

*components and indexed on only one variable) stationary of null average starting from its density spectral of power. The first use of this operator is the generation of temporal functions known by their matrix interspectrale with an aim of carrying out a transitory dynamic calculation then.*

*The trajectories obtained have a matrix interspectrale which converges on average towards the matrix interspectrale target and is the achievements of a process asymptotically Gaussian (i.e when it a many pullings tend towards the infinite one). The algorithm used is an algorithm of simulation per series trigonometrical with random and transformed phase of opposite fast Fourier.*

*Product a concept of the type counts.*

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*Author (S):*

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*2 Syntax*

*vf [table] = GENE\_FONC\_ALEA*

*(  
INTE\_SPEC*

=

*intf*  
*[tabl\_intsp]*

*NUME\_VITE\_FLUI = nk*  
*[I]*

#

*Case*  
*with*  
*interpolation*  
*authorized*  
:

*/INTERPOL = "YES", [DEFECT]*

*DUREE\_TIRAGE*

=

*duration*  
*[R]*

*FREQ\_INIT*

=

*fi*  
*[R]*

*FREQ\_FIN*  
=  
*FF*  
*[R]*

#  
*Case*  
*with*  
*interpolation*  
*not*  
*authorized*  
:

*/INTERPOL = "NOT",*

*NB\_POIN = nb\_poin [I]*

*NB\_TIRAGE*  
=  
/  
*NT*  
*[I]*



/

1

**[DEFECT]**

**INIT\_ALEA**

=

**nor**

**[I]**

**INFORMATION =/1 [DEFECT]**

/ 2

**TITRATE**

=

**titrate**

**[l\_Kn]**

)

;

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Titrate:

Operator *GENE\_FONC\_ALEA*

Date:

08/02/05

Author (S):

*S. CAMBIER, A. DUMOND, G. JACQUART* Key

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### **3 Operands**

#### **3.1 Operand**

***INTE\_SPEC***

***INTE\_SPEC = intf [tabl\_intsp]***

***Name of the matrix interspectrale of the tabl\_intsp type towards which the matrix interspectrale of generated signal must tend.***

***The matrix interspectrale is a complex matrix, whose each term is written***

***+***

***S***

***2***

***XY (F) = [***

***E X T***

***(Y***

***) T***

***(-)] - I F***

***E***

***D where E [] is the expectation, and where X and Y are***

***-***

***two stationary random processes (for example two components of a loading in two points distinct from a grid).***

**Note:**

***To be physical, the matrix interspectrale must be a definite square matrix positive.***

**3.2 Operand**

***NUME\_VITE\_FLUI***

***NUME\_VITE\_FLUI***

***=***

***nk***

***[I]***

***Sequence number when the table of interspectres contains several tables.***

***This sequence number corresponds at a rate of flow if the interspectres model, via operators CALC\_FLUI\_STRU and DEFI\_SPEC\_TURB, a turbulent excitation induced by one fluid flow.***

**3.3 Operand**

***Interpol***

***Interpol =***

***/***

***“YES”***

***[DEFECT]***

***One authorizes to interpolate the functions in frequency constituting the terms of the matrix interspectrale. In particular, the new discretization will depend on the duration of the signal to generate***

***(key word DUREE\_TIRAGE) and of the number of point of the FFT (key word NB\_POIN).***

***/“NOT”***

***The values of the interspectre used are only the existing values (not interpolation used).***

**Caution:**

***If INTERPOL='NON', it is necessary that:***

***· the various terms of the matrix interspectrale have the same one exactly discretization and with a constant step in frequency. If the number of points of***

*discretization of the interspectre is not a power of 2, and/or is not compatible with the interspectre one or alarms are emitted and a power of 2 ad hoc is chosen,*  
*· the interspectres are sufficiently finely discretized to allow one generation of temporal with sufficient moments.*

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*3.4 Operand*

*DUREE\_TIRAGE*

*DUREE\_TIRAGE*

*=*

*duration*

*[R]*

*Lasted of the signal to generate, for each pulling (the total duration will be thus NT X duration).*

*If key word DUREE\_TIRAGE is not present, the duration of the signal to be generated is calculated by*

***duration = 1 / F***

***where F***  
***is the step in frequency of the interspectre (not minimum of origin of***  
***the interspectre, or not calculated starting from key words `FREQ_INIT`, `FREQ_FIN` and `NB_POIN`).***

***Note:***

***The generated signals start at moment 0. with a zero value.***

***Note:***

***To obtain the desired duration, the algorithm of generation adjusts the number of points used in the FFT (cf [§3.6](#) Operand `NB_POIN`) and the interspectre prolongs if need be with beyond frequencies min and max by zero values.***

### ***3.5 Operands***

***`FREQ_INIT`/`FREQ_FIN`***

***`FREQ_INIT`***

***=***

***$f_i$***

***[R]***

***`FREQ_FIN` = `FF`***

***[R]***

***First and last values of frequency for which the interspectre will be taken into account.***

***The presence of these key words causes to truncate the interspectre. If the key words are not present, in fact the values of minimal and maximum frequency of the interspectre are used.***

### ***3.6 Operand***

***NB\_POIN***

***NB\_POIN***

***=***

***nb\_poin [I]***

***A number of points of discretization of the interspectre to be used in the algorithm of generation.***

***This number must be a power of 2 but it corresponds to the number of points of the transform of fast Fourier reverses used by the algorithm of generation. If such is not the case, it is power of 2 immediately above than nb\_poin which is retained.***

***If key word NB\_POIN is not present, the number of points is calculated so that the theorem of Shannon is respected, i.e. that  $1/T$***

***> 2 fmax, where  $T$***

***is the step in time of the signal with***

***to generate (which depends on NB\_POIN and DUREE\_TIRAGE) and where fmax is the maximum frequency***

***reserve of the interspectre.***

***Suggestion:***

***It is advised not to specify the number of points, the coded algorithm choosing in this case automatically the optimal value. In particular, if key words DUREE\_TIRAGE and NB\_POIN are not present, then one is assured that the generated signal is coherent with time with the step of discretization of the interspectre and with the maximum frequency. However, if the user wants to specify NB\_POIN, the two remarks which follow must help there.***

***Note:***

***If key words***

***duration***

***DUREE\_TIRAGE and NB\_POIN are present then one a:  $T$***

***=***

***·  
2×nb\_poin***

***In this case, if nb\_poin too small by report/ratio is lasted so that the theorem of Shannon is respected; then an alarm is emitted and it is the minimum number of points allowing the respect of the theorem of Shannon who is retained. The value specified by NB\_POIN is thus taken into account only when it is higher than the value minimum. In imposing a number of points raised, one can force the signal to have a step of discretization in time smaller than that by defect. It is necessary then to be conscious that the discretization of temporal is finer than the maximum frequency of the interspectre allows it theoretically.***

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**Titrate:**

**Operator** *GENE\_FONC\_ALEA*

**Date:**

**08/02/05**

**Author (S):**

**S. CAMBIER, A. DUMOND, G. JACQUART** *Key*

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**Note:**

*If INTERPOL='NON' and if nb\_poin is not compatible with the interspectre, an alarm is emitted and a power of 2 ad hoc is selected.*

**Note:**

*The number of points constituting the generated signals is equal to twice the number of points of discretization of the interspectre, and thus with twice nb\_poin when the key word is informed. This number of points is useful to know for a posterior use in [CALC\\_INTE\\_SPEC \[U4.36.03\]](#) (cf [\[§3.9\]](#) “Operand INFORMATION” and [\[§5\]](#) “Examples”).*

### **3.7 Operand**

**NB\_TIRAGE**

**NB\_TIRAGE**

**=**

**NT**

**[I]**

*A number of pullings which must contain the generated temporal signals. The signals results will contain NT end to end put statistically independent pullings.*

*One can then post-treat the results obtained starting from these signals generated with the operator [CALC\\_INTE\\_SPEC \[U4.36.03\]](#), cf [\[§5\]](#) “Examples”.*



**Caution:**

*If key word DUREE\_TIRAGE is present, the total duration of signal will be NT X duration. However, it is not of course equivalent to generate 1 pulling of duration NT X durée\_tirage and NT pullings of end to end put durée\_tirage duration. In particular,*

*in the second case, there is statistical independence between the various sections of duration D, however not in the first case.*

**3.8 Operand****INIT\_ALEA****INIT\_ALEA****=****nor****[I]**

*Cause initialization in its nor-ième term of the continuation of pseudo-random numbers employed for the generation of the signals.*

*If key word INIT\_ALEA misses, the terms used of the continuation are those immediately consecutive with those already used. If no term were still used, the continuation is initialized with sound first term.*

**Suggestion:**

*With less than one particular use, it is advised not to inform key word INIT\_ALEA in the operators according to: GENE\_FONC\_ALEA, GENE\_VARI\_ALEA and GENE\_MATR\_ALEA.*

*In this case, with the first call to the one of these operators, the continuation of pseudo numbers random is initialized in its first term. The omission of key word INIT\_ALEA to each one calls of these operators in the command file guarantees independence statistics of the pseudo-random numbers used.*

**Note:**

*The germ of the continuation remains identical of one execution to the other of Code\_Aster; results thus remain rigorously identical (one can thus test nonthe regression of results statistics not converged). If one wishes to generate results statistically independent from one execution to another, then it is necessary to use key word INIT\_ALEA with values raising the number of terms used in the former executions.*

**Caution:**

*The generator of random variable used is that of the module “random” of Python. It depends on the version of Python exploited by Code\_Aster. Not converged results statistically can thus vary from one version to another of Code\_Aster or a punt form with the other, if the version of Python is not the same one and that between the two versions it modulate random evolved/moved (case between Python 2.1 and 2.3).*

**Note:**

*In version Python 2.3, the period of the generator is 2 \*\* 19937-1 [bib1].*

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**3.9 Operand**

**INFORMATION**

**INFORMATION**

**=**

**/ 1**

**:**

**no impression.**

**/ 2**

**:**

**impression of the step of time, initial time, the final time of the generated signals, and number of points used in the transform of fast Fourier opposite.**

**Note:**

***INFO=2 makes it possible to know the number of points constituting the generated signals (it is twice the number of points used in the fast transform of Fourier reverse.) It is worth to better use this number of points then in operator CALC\_INTE\_SPEC key word NB\_POIN (cf [§5] “Examples”).***

**3.10 Operand**

**TITRATE**

***TITRATE = title***

***title is the title of calculation to print at the head results [U4.03.01].***

**4**

***Phase of checking***

***Various checks are carried out in FORTRAN to ensure that the data are coherent (nb\_poin sufficiently large compared to the maximum frequency and the duration to be generated, lasted sufficient large compared to the discretization interspectre, etc...). Alarms are emitted if necessary.***

***If key word NB\_POIN is present, then it is checked that the value given is a power of 2. In the contrary case, an alarm is emitted and the value is modified.***

***If INTERPOL='NON', one checks that the various terms of the matrix interspectrale have the same one discretization with a constant step in frequency.***

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## **5 Examples**

*The purpose of # This example is only to give an idea of syntax and # of the operators associated useful (for recovery with the functions # generated and their possible checking).*

*# the interspectre used does not have significance. There is not # of use of the functions generated (with a dyna\_tran\_modal by # example).*

*# the cases test zzzz180a and sdll107a provide more complete examples*

*# Definition of the interspectre  
spect11 = DEFI\_FONCTION (*

*NOM\_PARA = "FREQ",*

*VALE\_C*

*=*

*(*

*0.*

*,*

*10.*

*, 0.,*

*50.0*

*,*

*10.*

*, 0.,*

*150.*

*,*

*0.1*

*, 0.,*

)

)

*spect12 = DEFI\_FONCTION (*

*NOM\_PARA = "FREQ",*  
*VALE\_C*

*=*

*(*

*0.*

*,*

*0.5*

*, 0.8,*

*150.*

*,*

*0.5*

*, 0.8,*

)

)

*spect22 = DEFIN\_FONCTION (*

*NOM\_PARA = "FREQ"*

*VALE\_C*

*=*

*(*

*0.*

*, 1., 0.,*

*150.*

*,*

*1..*

*, 0.,*

)

)

*mat\_int = DEFI\_INTE\_SPEC (*

*DIMENSION = 2,*  
*PAR\_FONCTION*  
*=*  
*(*  
*\_F (*  
*NUME\_ORDRE\_I = 1,*  
*NUME\_ORDRE\_J*  
*=*  
*1,*  
*FUNCTION*  
*=*  
*sp11),*  
*\_F (*  
*NUME\_ORDRE\_I = 1,*  
*NUME\_ORDRE\_J*  
*=*  
*2,*  
*FUNCTION*  
*=*  
*sp12),*  
*\_F (*  
*NUME\_ORDRE\_I = 2,*  
*NUME\_ORDRE\_J*  
*=*

2,  
**FUNCTION**  
=  
sp22)

)

)

*# Generation of the two temporal functions*

*vect = GENE\_FONC\_ALEA (*  
*INTE\_SPEC =*  
*mat\_int,*  
*DUREE\_TIRAGE = 5. ,*  
*NB\_TIRAGE = 10,*  
*)*

*# Recovery of the two functions for example for a IMPR\_COURBE*

*FONC1 = RECU\_FONCTION (TABLE=vect,*  
*FILTRE=\_F (NOM\_PARA = "NUME\_ORDRE",*  
*VALE\_I = 1),*  
*NOM\_PARA\_TABL=' FONCTION',)*

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***Titrate:***

***Operator GENE\_FONC\_ALEA***

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***FONC2 = RECU\_FONCTION (TABLE=VECT1,  
FILTRE=\_F (NOM\_PARA = "NUME\_ORDRE",  
VALE\_I = 2),  
NOM\_PARA\_TABL=' FONCTION',)***

***# Checking: Calculation of the interspectre of the generated functions***

***# Attention: the value given to NB\_POIN is important. It is***

***# desirable to take it equalizes with the constituent number of points***

***# the functions (2\*nb\_fft if coming from GENE\_FONC\_ALEA).***

***INTERS=CALC\_INTE\_SPEC (INST\_INIT=0.,***

***INST\_FIN=50.,***

***DUREE\_ANALYSE=5.,***

***DUREE\_DECALAGE=5.,***

***NB\_POIN=2048,***

***FONCTION= (FONC1, FONC2,))***

***# Recovery of the car-spectrum of FONC1 for comparison with spetc11***

***F11 =RECU\_FONCTION (TABLE=INTERS, TYPE\_RESU=' FONCTION\_C',***

***FILTRE= (***

***\_F (NOM\_PARA=' NUME\_ORDRE\_I', VALE\_I=1),***

***\_F (NOM\_PARA=' NUME\_ORDRE\_J', VALE\_I=1),),***

***NOM\_PARA\_TABL=' FONCTION',***

***)***

## ***6 Bibliography***

***[1]***

***Mr. Matsumoto and T. Nishimura, Mersenne Twister: With 623-dimensionally equidistributed uniform pseudorandom number generator, ACM Transactions on Modeling and Computer***

***Simulation vol. 8, No 1, January pp.3-30 1998.***

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***Titrate:***

***Operator GENE\_MATR\_ALEA***

***Date:***

***22/02/06***

***Author (S):***

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***Document: U4.36.06***

***Operator GENE\_MATR\_ALEA***

## **1 Goal**

**To generate achievements of generalized matrices considered as random for structures or of the substructures. The law of probability of the matrices is built according to the principle of the maximum of entropy by considering information available (average and coefficient of variation) and theirs algebraic properties (definite symmetry positivity) [R4.03.05].**

**Product a structure of data *matr\_asse\_gene\_R* or *macr\_elem\_dyna* according to the type of data input.**

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## **2 Syntax**

**[*macr\_elem\_dyna*]**

**= *GENE\_MATR\_ALEA***

**(**

***/MATR\_MOYEN***

**=**

***average [matr\_asse\_gene\_R]***

**COEF\_VAR**

**= /**

**[R]**

**/ 0.1**

**[DEFECT]**

**/**

**MATR\_MOYEN**

**=**

**average [macr\_elem\_dyna]**

**COEF\_VAR\_RIGI =/R**

**[R]**

**/ 0.1**

**[DEFECT]**

**COEF\_VAR\_MASS =/M**

**[R]**

**/**

**0.**

**[DEFECT]**

***COEF\_VAR\_AMOR =/C***

***[R]***

***/***

***0.***

***[DEFECT]***

***INIT\_ALEA***

***=***

***nor***

***[I]***

***);***

***So average = [matr\_asse\_gene\_R]***

***then Fr = [matr\_asse\_gene\_R]***

***So average = [macr\_elem\_dyna]***

***then Fr = [macr\_elem\_dyna]***

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### **3 Operands**

*With or without under-structuring, this operator consists in in fine generating achievements of one or several noted random matrices in a generic way [A]. [A] is a random variable with value in the whole of the positive definite real matrices of dimension (N, N) whose law is parameterized by its average value []*

*With and its scatter coefficient [R4.03.05].*

#### **3.1 Word**

*key*

**MATR\_MOYEN**

**MATR\_MOYEN = average**

*average indicates the average matrix []*

*With random matrix [A].*

*So average is of type [matr\_asse\_gene\_R], then []*

*A is obtained by projection of one*

*stamp average assembly of the average model to the finite elements on a given number of modes clean of the dynamic system (operator MACRO\_PROJ\_BASE for example). []*

*With and them*

*achievements of [A] generated by GENE\_MATR\_ALEA can thus be matrices of masses, generalized stiffness or damping.*

**Caution:**

*The average matrix ([])*

*With) must be stored in mode of full storage (operator*

*NUME\_DDL\_GENE, key word STOCKAGE=' PLEIN' or operator MACRO\_PROJ\_BASE, key word PROFIL=' PLEIN').*

*So average is of type [macr\_elem\_dyna] (under-structuring), then []*

*A is a concept*

*containing the matrices of rigidity, mass and possibly of damping projected on base modal substructure supplemented by the matrices of connection of the interfaces, the model means.*

#### **3.2 Word**

*key*

**COEF\_VAR**

**COEF\_VAR =**  
/  
/  
**0.1**  
**[DEFECT]**

*This key word informs the parameter of control of the dispersion of the generalized matrix random [A] which can be of mass, stiffness or dissipation. This coefficient of variation is defined by:*

**2**  
**(N +)**  
**1 \* A F**  
**E [**  
**{A} - [ ] 2**  
**WITH F} 1 2**

**=**

**\***

**2**

**2**

**tr (**

**With**

**+ tr (A)**

**[ ] 2**

**WITH F**

**with:**

**1 2**

**.**

**[ ]**

**With**

**= (tr [ {**

**WITH [ ] T**

**With})**

**]**

**F**

**.**

**N**

**[**

**of**

**dimension**

]
With
E [
{A} - [] 2
WITH F} 1/2
.

[A
[]
the scatter coefficient of the matrix

]
2
WITH F
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can also be written:

2
E {[G] - [
With
G WITH F}
=

2
[G



**WITH F**

*with [L A] the lower triangular matrix resulting from the factorization of Cholesky*

$$[A] = [L] T$$

*With*

*[GA] [IT] of the average matrix {*

*E [A]*

*] = [ ]*

*A.*

*One must have (cf [R4.03.05]):*

*N + 1*

*0*

*0*

*< <*

*With*

*,*

*N + 5*

*0*

*where N NR is a constant of the probabilistic model selected so that  $N < N$*

*0*

*0*

*.*

**COEF\_VAR\_RIGI =/R**

**[R]**

**/ 0.1**

**[DEFECT]**

*This key word informs the parameter R of control of the dispersion of the random matrix of rigidity of a substructure. This coefficient of variation is defined in a way identical to definition given for key word COEF\_VAR.*

**COEF\_VAR\_MASS =/R**

**[R]**

**/**

**0.**  
**[DEFECT]**

*This key word informs the parameter **R** of control of the dispersion of the random matrix of mass of a substructure. This coefficient of variation is defined in a way identical to definition given for key word **COEF\_VAR**.*

**COEF\_VAR\_AMOR =/R**

**[R]**

**/**

**0.**  
**[DEFECT]**

*This key word informs the parameter **R** of control of the dispersion of the random matrix of dissipation of a substructure. This coefficient of variation is defined in a way identical to definition given for key word **COEF\_VAR**.*

**3.3 Operand**  
**INIT\_ALEA**

**INIT\_ALEA**

**=**

**nor**

**[I]**

*Cause initialization in its **nor**-ième term of the continuation of pseudo-random numbers used for the generation of the matrices.*

*If key word **INIT\_ALEA** misses, the terms used of the continuation are those immediately consecutive with those already used. If no term were still used, the continuation is initialized with sound first term.*

**Recommendation:**

*With less than one particular use, it is advised not to inform key word **INIT\_ALEA** in the operators according to: **GENE\_FONC\_ALEA**, **GENE\_VARI\_ALEA** and **GENE\_MATR\_ALEA**.*

*In this case, with the first call to the one of these operators, the continuation of pseudo numbers random is initialized in its first term. The omission of key word **INIT\_ALEA** to each one calls of these operators in the command file guarantees independence statistics of the pseudo-random numbers used.*

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**Note:**

*The germ of the continuation remains identical of one execution to the other of Code\_Aster; results thus remain rigorously identical (one can thus test nonthe regression of results statistics not converged). If one wishes to generate results statistically independent from one execution to another, then it is necessary to use key word INIT\_ALEA with values raising the number of terms used in the former executions.*

**Caution:**

*The generator of random variable used is that of the module “random” of Python. It depends on the version of Python exploited by Code\_Aster. Not converged results statistically can thus vary from one version to another of Code\_Aster or a punt form with the other, if the version of Python is not the same one and that between the two versions it modulate random evolved/moved (case between Python 2.1 and 2.3).*

**Note:**

*In version Python 2.3, the period of the generator is  $2^{19937-1}$  [bib1].*

**4 Example**

***By call, the order generates only one realization of the random matrix to simulate. For to generate several achievements of the same random matrix, it is necessary to repeat the order without to change its parameters or to place the order in a loop of the process control language of Code\_Aster - the language python.***

*In the following example, one generates NS achievements of a random matrix of average value MATR\_MOYEN with one = 0.1. These achievements are then used as values of matrix of mass.*

*ns=100*

*for K in arranges (1, ns+1):*

*# Generation*

*MAT\_ALEA=GENE\_MATR\_ALEA (  
MATR\_MOYEN=MAT\_MOY,  
COEF\_VAR=0.1,  
)*

*DYN=DYNA\_TRAN\_MODAL (*

*... MASS\_GENE=  
MAT\_ALEA,  
)*

*# Here for example, statistical processing of DYN*

*TO DESTROY (CONCEPT=\_F (NOM= (DYN, MAT\_ALEA)))*

*# End of the loop (indentation)*

*For more complete examples, to consult the cases test SDNS01 [V5.06.001], SDNL105d [V5.02.105] and SHLS200a [V2.06.200], like [U2.08.05].*

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**Operator GENE\_VARI\_ALEA**

**Date:**  
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**Author (S):**  
**S. CAMBIER, C. DESCELIERS Key**  
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**Organization (S): EDF-R & D /AMA**

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***Document: U4.36.07***

***Operator GENE\_VARI\_ALEA***

***1 Goal***

***To generate a realization of a real random variable of law of probability given (laws gamma or exponential exits of the application of the maximum of entropy, [R4.03.05]).***

***Product a structure of data counts.***

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***2 Syntax***

**[table]**  
**= GENE\_VARI\_ALEA**  
**(**

**/STANDARD = "GAMMA" [DEFECT]**

**VALE\_MOY**

**=**  
**/**  
**vale\_moy**  
**[R]**  
**/**  
**1.0**  
**[DEFECT]**

**BORNE\_INF**

**=**  
**/**  
**has**  
**[R]**  
**/**  
**0.**  
**[DEFECT]**

**COEF\_VAR**

**=**  
**/**  
**delta**  
**[R]**  
**/ 0.1**  
**[DEFECT]**

**/**  
**TYPE**  
**=**  
**"EXPONENTIAL"**



**VALE\_MOY**

=

/

**vale\_moy**

**[R]**

/

0.

**[DEFECT]**

**BORNE\_INF**

=

/

**has**

**[R]**

/

-1.0

**[DEFECT]**

/

**TYPE**

=

**“EXP\_TRONQUEE”**

**VALE\_MOY**

=

/

**vale\_moy**

**[R]**

/

0.

**[DEFECT]**

**BORNE\_INF**

=

/

**has**

**[R]**

/

-1.0

**[DEFECT]**

**BORNE\_SUP**

=

/

**B**

**[R]**

/ 1.0

**[DEFECT]**

**INIT\_ALEA**

=

**nor**

**[I]**

);

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**Version**

**7.4**

**Titrate:**

**Operator GENE\_VARI\_ALEA**

**Date:**

**08/02/05**

**Author (S):**

**S. CAMBIER, C. DESCELIERS Key**

**:**

**U4.36.07-B Page****: 3/6****3 Operands****3.1 Word****keys****TYPE**

*According to information usable on the random variable to simulate, three types of law of probability are*

*available. If information available is a support not limited [has,*

*[*  
*+, an average W, and one*

*scatter coefficient, the law is gamma. If information available is a support not limited*  
*[has,*

*[*  
*+ and an average W, the law is exponential. If information available is a support*  
*compact [has, B] and an average W, the law is exponential truncated.*

**/STANDARD = "GAMMA" [DEFECT]**

*The random variable follows a law of probability of the type "gamma" of which distribution of probability PW (dw) is defined by:*

(2

-

**W - has) 1**

2

2

-

-

-

-

-

-

-

**PW (dw)**

2

1

**W has****= I [has, +] (W)****(W - has) 2 exp-****dw**

1

*(W - has)*

,  
2

2

*with (Z) = + z-1 -*

*T*

*E T dt.*

*0*

*/STANDARD = "EXPONENTIAL"*

*The random variable follows a law of "exponential" probability of the type of which distribution of probability PW (dw) is defined by:*

-

*PW (dw)*

*1*

*W has*

*= I [has, +] (W)*

*exp-*

,

*dw*

*W - has*

*W - has*

*with I [has, +] (W) = 1 if W [has, +]*

*and I [has, +] (W) = 0 if W [has, +]*

*+ .*

*/STANDARD = "EXP\_TRONQUEE"*

*The random variable follows a law of exponential probability of the type "truncated" of which probability distribution PW (dw) is defined by:*

*P*

-

**W (dw)**

**K**

**= I [has,] (W)**

**kw**

**B**

**(K) E**

**dw**

**with I [B has,] (W) = 1 if W [has, B] and I [B has,] (W) = 0 if W [has, B] and where K is such as**

**(K**

**W -)**

**I (K) - K (K) = 0, with (K)**

**- ak**

**B K**

**= E**

**- E and (K)**

**- ak**

**B K**

**= E has**

**- B E.**

### **3.2 Word**

**key**

**VALE\_MOY**

**VALE\_MOY =/**

**W**

**[R]**

**/**

**0.**

**or**

**1.0**

**[DEFECT]**

**Indicate the average value of the random variable to simulate.**

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*Author (S):*

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### **3.3 Word**

*key*

**COEF\_VAR**

*COEF\_VAR*<sup>2</sup> =/

/

0.1

[DEFECT]

*This key word informs the scatter coefficient (standard deviation report/ratio about absolute value of average). The value taken by defect is 0.1.*

### **3.4 Words**

*key*

**BORNE\_INF AND BORNE\_SUP**

*BORNE\_INF*

=

/

*has*

[R]

/  
1.0  
or  
0.  
[DEFECT]  
BORNE\_SUP  
=  
/  
B  
[R]

*/-1.0 or 0.*

*[DEFECT]*

*These key words inform the lower limit and the upper limit (when they exist) support [has, B] or [has, + [ laws.*

### **3.5 Operand INIT\_ALEA**

*INIT\_ALEA*  
=  
*nor*  
[I]

*Cause initialization in its nor-ième term of the continuation of pseudo-random numbers used for the generation of the variables.*

*If key word INIT\_ALEA misses, the terms used of the continuation are those immediately consecutive with those already used. If no term were still used, the continuation is initialized with sound first term.*

**Suggestion:**

*With less than one particular use, it is advised not to inform key word INIT\_ALEA in the operators according to: GENE\_FONC\_ALEA, GENE\_VARI\_ALEA and GENE\_MATR\_ALEA. In this case, with the first call to the one of these operators, the continuation of pseudo numbers random is initialized in its first term. The omission of key word INIT\_ALEA to each one calls of these operators in the command file guarantees independence statistics of the pseudo-random numbers used.*

**Note:**

*The germ of the continuation remains identical of one execution to the other of Code\_Aster; results thus remain rigorously identical (one can thus test nonthe regression of results statistics not converged). If one wishes to generate results statistically independent from one execution to another, then it is necessary to use key word INIT\_ALEA with values raising the number of terms used in the former executions.*

**Caution:**

*The generator of random variable used is that of the module “random” of Python. It depends on the version of Python exploited by Code\_Aster. Not converged results statistically can thus vary from one version to another of Code\_Aster or a punt form with the other, if the version of Python is not the same one and that between the two versions it modulate random evolved/moved (case between Python 2.1 and 2.3).*

**Note:**

*In version Python 2.3, the period of the generator is  $2^{**} 19937-1$  [bib1].*

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#### 4 Example

*By call, the order generates only one realization of the random variable to simulate. For to generate several achievements of the same random variable, it is necessary to repeat the order without to change its parameters or to place the order in a loop of the process control language of Code\_Aster - the language Python. Each realization is statistically independent of the others achievements.*

*In the following example, one generates NS achievements of a random variable gamma of average value 25000, of support and scatter coefficient 0.1 positive realities. These achievements are then used as values of stiffness of shock.*

*ns=100*

*for K in arranges (1, ns+1):*

*# Generation*

*KN = GENE\_VARI\_ALEA (TYPE=' GAMMA',*

*BORNE\_INF =0.,*

*VALE\_MOY =25000.,*

*COEF\_VAR =0.1,*

*)*

*# Extraction of the value in the produced table*

*VKN = KN ["NO.", 1]*

*DYN=DYNA\_TRAN\_MODAL (*

*...*

*CHOC=\_F (*

*...*

*RIGI\_NOR = VKN,*

...  
)  
)

*# Here for example, statistical processing of DYN*

*TO DESTROY (CONCEPT=\_F (NOM= (DYN, KN)))*

*# End of the loop (indentation)*

*For more complete examples, to consult [U2.08.05] or the case test SDNS01 [V5.06.001].*

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## **5 Bibliography**

[1]

**Mr. Matsumoto and T. Nishimura, Mersenne Twister: With 623-dimensionally equidistributed uniform pseudorandom number generator, ACM Transactions on Modeling and Computer Simulation vol. 8, No 1, January pp.3-30 1998.**

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**Date:**

**31/01/06**

**Author (S):**

**J. Key PELLET, J.M. PROIX**

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**Organization (S): EDF-R & D /AMA**

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**Document: U4.41.01**

**Operator AFFE\_MODELE**

## ***1 Goal***

***To define the modelled physical phenomenon (mechanical, thermal or acoustic) and the type of elements finished.***

***This operator allows to affect modelings on whole or part of the grid, which defines:***

***.  
degrees of freedom on the nodes (and the equation or the conservation equations associated),***

***.  
types of finite elements on the meshes,***

***.  
possibly:***

***-  
functions of interpolation on the meshes,***

***-  
points of integration of GAUSS on these meshes.***

***The possibilities of the easily affected finite elements are described in the booklets [U3].***

***The types of meshes are described in the document [U1.03.02].***

***Product a structure of data of the model type.***

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**2 Syntax**

**Mo [model] = AFFE\_MODELE**

(

**GRID**

= *my*

,

/

**[grid]**

/

**[skeleton]**

**INFORMATION**

=

/

1

**[DEFECT]**

/

2

,

**VERIF =**

**/ "MESH"**

/

**"NODE"**

,

*/AFFE = \_F (*

*/ALL = "YES",*

*/  
NET  
=  
email,  
[l\_maille]*

*/  
NODE  
=  
noeu,  
[l\_noeud]*

/  
**GROUP\_MA**  
=  
*g\_mail, [l\_gr\_maille]*

/  
**GROUP\_NO**  
=  
*g\_noeu, [l\_gr\_noeud]*

**/PHENOMENON =**  
**“MECHANICAL”,**

**MODELING =... (see [§3.2.1])**

**/PHENOMENON**  
**= “THERMAL”**

**MODELING =... (see [§3.2.1])**

**/**  
**PHENOMENON:**  
**“ACOUSTIC”,**

**MODELING =... (see [§3.2.1])**

**),**



/  
*AFFE\_SOUS\_STRUC = \_F (*

*/ALL = "YES",*

/  
*NET*  
=  
*l\_mail, [l\_maille]*

)

)  
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### **3 Operands**

#### **3.1 Operand**

##### **GRID**

**GRID = my**

*Name of the associated grid on which one affects the elements.*

**Note:**

*For axisymmetric modelings, the axis of revolution is the axis Y of the grid. All the structure must be with a grid in X 0.*

#### **3.2 Word**

**key**

**AFFE**

**/AFFE**

*Defines the entities of the grid and the types of elements which will be affected for them. For each occurrence, one can introduce a list of modelings. The rule of overload applies between various modelings, from left to right.*

**For example:**

**AFFE=\_F (**

**TOUT=' OUI', PHENOMENE=' MECANIQUE', MODELISATION= ("AXIS", "AXIS\_SI"),**

**Various modelings “overload” the ones the others: AXIS\_SI overloads**

*AXIS on the meshes where AXIS\_SI exists.*

*Note:*

*The code stops in <F> error if modelings of the list are not very of even "dimension" (for example MODELISATION= ("3D", "D\_PLAN")). Moreover, for an occurrence of AFFE, the specified meshes whose dimension is that of the dimension of modeling must be all affected. If not the code emits a <A>larme. This alarm protects the user who uses modelings "with holes ". If for example, it uses only modeling AXIS\_SI on a grid containing only TRIA6.*

*The entities of the grid are specified by the operands:*

*Operands*

*Contents/significance*

*ALL*

*Assignment with the totality of the meshes (but not nodes!!)*

*GROUP\_MA*

*Assignment with a list of groups of meshes*

*GROUP\_NO*

*Assignment with a list of groups of nodes (see remark)*

*NET*

*Assignment with a list of meshes*

*NODE*

*Assignment with a list of nodes (see remark)*

*Note:*

*The use of elements being based only on nodes does not allow to affect materials via AFFE\_MATERIAU. So these elements are not usable neither in STAT\_NON\_LINE [U4.51.03] nor in DYNA\_NON\_LINE [U4.53.01]. In this case, it is necessary to create meshes as a preliminary. POI1 using key word CREA\_POI1 of CREA\_MAILLAGE [U4.23.02].*

*The use of such elements is thus reserved for linear calculations, on discrete elements, of which all the characteristics are affected by AFFE\_CARA\_ELEM.*

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***The type of element is specified by the operands:***

***Operands***

***Contents/significance***

***PHENOMENON***

***Physical phenomenon modelled (conservation equation associated)***

***MODELING***

***Type of interpolation or discretization***

***3.2.1 Operands***

***PHENOMENON and MODELING***

***/***

***PHENOMENON***

***MODELING***

***Are obligatory for each occurrence of the key word factor AFFE. This couple of key words defines in a bijective way the type of affected element in a type of mesh. possible modelings are indicated below by listing them by “packages”:***

***ACCOUSTICS***

***ACCOUSTICS 2D continuous mediums***

***U3.33.01 PLAN***

***ACCOUSTICS 3D continuous mediums***

### **3D U3.33.01**

#### ***THERMICS***

***THERMICS 2D hull***

***COQUE\_AXIS U3.22.01***

***COQUE\_PLAN U3.22.01***

***THERMICS 2D continuous mediums***

***AXIS\_DIAG U3.23.01***

***AXIS\_FOURIER U3.23.02***

***U3.23.01 AXIS***

***PLAN\_DIAG U3.23.01***

***U3.23.01 PLAN***

***THERMICS 3D hull***

***U3.22.01 HULL***

***THERMICS 3D continuous mediums***

***3D\_DIAG U3.24.01***

***3D U3.24.01***

#### ***MECHANICS 2D***

***MECHANICS 2D discrete elements***

***2D\_DIS\_TR***

***2D\_DIS\_T***

***MECHANICS 2D elements joined for the propagation of crack***

***AXIS\_GRAD\_VARI***

***PLAN\_FISSURE***

***MECHANICS 2D fluid-structure***

***2D\_FLUIDE U3.13.03***

***2D\_FLUI\_ABSO U3.13.13***

***2D\_FLUI\_PESA U3.14.02***

***2D\_FLUI\_STRU U3.13.03***

***AXIS\_FLUIDE U3.13.03***

***AXIS\_FLUI\_STRU U3.13.03***

***D\_PLAN\_ABSO U3.13.12***

***MECHANICS 2D continuous mediums***

***AXIS\_FOURIER U3.13.02***

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**AXIS\_INCO U3.13.07**

**AXIS\_SI U3.13.05**

**U3.13.01 AXIS**

**C\_PLAN\_SI U3.13.05**

**C\_PLAN U3.13.01**

**D\_PLAN\_INCO U3.13.07**

**D\_PLAN\_SI U3.13.05**

**D\_PLAN U3.13.01**

**MECHANICS nonlocal 2D**

**C\_PLAN\_GRAD\_EPSI U3.13.06**

**C\_PLAN\_GRAD\_VARI**

**D\_PLAN\_GRAD\_EPSI U3.13.06**

**D\_PLAN\_GRAD\_VARI**

**MECHANICS 2D plates and hulls**

**COQUE\_AXIS U3.12.02**

**COQUE\_C\_PLAN U3.12.02**

**COQUE\_D\_PLAN U3.12.02**

**Mechanics 2D elements joined for the propagation of crack**

**PLAN\_JOINT U3.13.14**

**AXIS\_JOINT U3.13.14**

**Mechanics 2D elements with discontinuities intern for starting and propagation of crack**

**PLAN\_ELDI U3.13.14**

**AXIS\_ELDI U3.13.14**

***Thermohydromecanic MECHANICS 2D***

***AXIS\_HH2MD***

***AXIS\_HHMD***

***AXIS\_HHM U3.13.08***

***AXIS\_HMD***

***AXIS\_HM***

***AXIS\_THH2D***

***AXIS\_THH2MD***

***AXIS\_THHD***

***AXIS\_THHMD***

***AXIS\_THHM U3.13.08***

***AXIS\_THH U3.13.08***

***AXIS\_THMD***

***AXIS\_THM U3.13.08***

***D\_PLAN\_HH2MD***

***D\_PLAN\_HHMD***

***D\_PLAN\_HHM U3.13.08***

***D\_PLAN\_HMD***

***D\_PLAN\_HM U3.13.08***

***D\_PLAN\_THH2D***

***D\_PLAN\_THH2MD***

***D\_PLAN\_THHD***

***D\_PLAN\_THHMD***

***D\_PLAN\_THHM U3.13.08***

***D\_PLAN\_THH U3.13.08***

***D\_PLAN\_THMD***

***D\_PLAN\_THM U3.13.08***

***MECHANICS 3D***

***MECHANICS 3D bars and cables***

***2D\_BARRE***

***BAR U3.11.01***

***CABLE\_POULIE U3.11.03***

***U3.11.03 CABLE***

***Instruction manual***

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***MECHANICS 3D discrete elements***  
***DIS\_TR U3.11.02***  
***DIS\_T U3.11.02***

***MECHANICS 3D fluid-structure***  
***3D\_FAISCEAU***  
***3D\_FLUIDE U3.14.02***

***MECHANICS 3D absorbing border***  
***3D\_ABSO U3.14.09***  
***3D\_FLUI\_ABSO U3.14.10***

***MECHANICS 3D grids of concrete reinforcements***  
***GRILLE\_MEMBRANE***  
***ROAST U3.12.04***

***MECHANICS 3D continuous mediums***  
***3D\_SI U3.14.01***  
***3D U3.14.01***

***MECHANICS nonlocal 3D***  
***3D\_GRAD\_EPSI U3.14.11***  
***3D\_GRAD\_VARI***

***MECHANICS 3D plates and hulls***  
***COQUE\_3D U3.12.03***  
***DKT U3.12.01***  
***DST U3.12.01***  
***Q4G U3.12.01***

***MECHANICS 3D beams***  
***FLUI\_STRU U3.14.02***



***POU\_C\_T U3.11.01***  
***POU\_D\_EM U3.11.07***  
***POU\_D\_E U3.11.01***  
***POU\_D\_TGM U3.11.04***  
***POU\_D\_TG U3.11.04***  
***POU\_D\_T\_GD U3.11.05***  
***POU\_D\_T U3.11.01***

***Quasi incompressible MECHANICS 3D***  
***3D\_INCO U3.14.06***

***Thermohydromecanic MECHANICS 3D***  
***3D\_HHMD***  
***3D\_HHM U3.14.07***  
***3D\_HMD***  
***3D\_HM U3.14.07***  
***3D\_JOINT\_CT***  
***3D\_THHD***  
***3D\_THHMD***  
***3D\_THHM U3.14.07***  
***3D\_THH U3.14.07***  
***3D\_THMD***  
***3D\_THM U3.14.07***  
***3D\_THVD***

***MECHANICS 3D pipes***  
***TUYAU\_3M U3.11.06***  
***TUYAU\_6M U3.11.06***

***MECHANICS 3D massive element of hull***  
***SHB8 U3.12.05***  
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### **3.3 Word**

**key**

**AFFE\_SOUS\_STRUC**

**/AFFE\_SOUS\_STRUC**

**Is usable only for one using model of the static substructures [U1.01.04].**

**/**

**NET = l\_mail**

***l\_mail is the list of the super-meshs which one wants to affect in the model. As for the finite elements, it is not obligatory to affect all the meshs of the grid. It is AFFE\_MODELE which confirms which are the substructures which will be used in model. The difference with the traditional finite elements is that on the super-meshs, one chooses neither MODELING nor the PHENOMENON because the macronutrient (built by the operator MACR\_ELEM\_STAT [U4.62.01]) who will be affected on the super-mesh has its own modeling and its own phenomenon (those which were used to calculate it).***

**/**

**ALL**

**=**

**“YES”**

**All them (super) meshs are affected.**

### **3.4 Operand**

**VERIF**

**VERIF:**

**Value**

**Contents/significance**

**“MESH”**

*check the assignment with all the meshes requested if not error*

**“NODE”**

*check the assignment with all the nodes requested if not error*

*By defect: no checking is carried out.*

#### **4 Phase of execution**

*From the key words PHENOMENON and MODELING, one creates a structure of data specifying it type of element attached to each mesh. There are possibly creations of meshes additional of type POI1 when assignments are made on nodes or groups of nodes. These meshes are not accessible to the user. This is why it is strongly advised to use CREA\_MAILLAGE [U4.23.02] to create meshes POI1 usable in the file of order (for STAT\_NON\_LINE for example).*

*A brief recall of the assignments is systematically printed (INFO=1) in the file message.*

*For example:*

**ON THE 612 MESHES OF GRID MA  
A the ASSIGNMENT OF 612 IS ASKED FOR  
ONE A PU TO AFFECT 612 OF THEM**

**MODELING FINITE ELEMENT STANDARD MESH NUMBERS**

**3D MECA\_TETRA4 TETRA4 52**

**3D MECA\_PENTA6 PENTA6 16**

**...**

**3D MECA\_FACE3 TRIA3 60**

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## **5 Example**

**Mo**

**=**

**AFFE\_MODELE**

**(GRID = my,**

**VERIF**

**= (**

**“MESH”,**

**“NODE”),**

**AFFE**

**=**

**(\_F**

**(**

**GROUP\_MA**

**=**

**gma,**

**PHENOMENON**

**=**

**“MECHANICAL”,**

**MODELING**

**=**

**“3D”**

**),**

**\_F (GROUP\_NO = gno,**

***PHENOMENON***

=

***“MECHANICAL”,  
MODELING***

=

***“DIS\_T”***),

))

***For a modeling of the “MECHANICAL” phenomenon, one affects:***

.

***on the group of meshes gma of the isoparametric elements 3D,***

.

***on the group of nodes gno of the discrete elements with 3 ddl of translation.***

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***Version***

***8.2***

***Titrate:***

***Operator MODI\_MODELE\_XFEM***

***Date:***

***02/03/06***

***Author (S):***

***P. MASSIN, Key S. GENIAUT***

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***Organization (S): EDF-R & D /AMA***

***Instruction manual  
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Document: U4.41.11***

***Operator MODI\_MODELE\_XFEM***

### ***1 Goal***

***To modify a model by the introduction of specific finite elements which can be crossed by one fissure.***

***This operator allows to modify certain traditional finite elements in finite elements nouveau riches; elements to be modified were as a preliminary given by operator DEFI\_FISS\_XFEM [U4.82.08]. The new model thus defined could be useful in the continuation of calculations like datum input of operator STAT\_NON\_LINE [U4.51.03] for example.***

***The operator produces concept of a model type.***

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### ***2 Syntax***

***[model] = MODI\_MODELE\_XFEM (***

***MODELE\_IN***

***= Mo,***

***[model]***

***FISSURE = fiss,***

***[fiss\_xfem]***

***CRITERION = 1.1E-4,***

***[DEFECT]***

*crit,*  
*[R]*

*INFORMATION*  
*= / 1,*

*[DEFECT]*

*/ 2,*

)  
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### **3 Operands**

#### **3.1 Operand**

**MODELE\_IN**

**MODELE\_IN**

=

**Mo**

***Mo: name of the initial model on which one defined the crack as a preliminary by the operator DEF1\_FISS\_XFEM [U4.82.08].***

***This initial model is used as a basis for creation of the new model. It is advised to choose a name different for the new model.***

#### **3.2 Operand**

**FISSURE**

**FISSURE = fiss**

***fiss: name of the crack defined as a preliminary by operator DEF1\_FISS\_XFEM [U4.82.08].***

#### **3.3 Operand**

**CRITERION**

**CRITERION = crit**

***crit: actual value of the criterion allowing to the cancellation of the degrees of freedom (ddls) nouveau riches when the crack passes close to a node. When the crack cuts an element 3D in two volumes, it relationship between smallest volume and greatest volume should not exceed this criterion, if not, that can cause problems of conditioning in the matrix of rigidity, and lead to null pivots. Thus, if the criterion is exceeded, the ddls being able to lead to null pivots are eliminated automatically. The default value of the criterion is based on simple tests [R7.02.12].***

#### **3.4 Operand**

**INFORMATION**

*/1: impression on the file “MESSAGE”*

- Of the stages of calculation*
- Of the number of finite elements of the model*

*/2: even impression + impression for each mesh of the type of mesh enriched and by its number of the type of finite element.*

#### *4 Example*

*FISS\_ELLIPT = DEFI\_FISS\_XFEM (MODEL  
= MOD\_INITIAL,*

*.....*

*)*

*MOD\_ENRICH =  
MODI\_MODELE\_XFEM  
(MODELE\_IN  
= MOD\_INITIAL,  
FISSURE =  
FISS\_ELLIPT,  
INFORMATION  
=  
2,)*

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*Organization (S): EDF-R & D /AMA*

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***Document: U4.42.01***

***Operator AFFE\_CARA\_ELEM***

***1 Goal***

***To assign to elements of structure of the geometrical and material characteristics. Data***

*geometrical affected are complementary to the data of grid.*

*Among the treated characteristics let us quote:*

- for the elements of the hull type: the thickness, a direction of reference in the tangent plan,*
- for the elements of the beam type: characteristics of the cross section and orientation of the principal axes of inertia around neutral fibre, curve of the elements curves,*
- for the elements of the discrete type (arises, mass/inertia, shock absorber): values of matrices of rigidity, mass or damping to be affected directly or after orientation,*
- for the elements of the type bars or of type cables: the surface of the cross section,*
- for the elements of mediums continuous 3D and 2D: local axes by report/ratio to which the user will be able to define directions of anisotropy.*

*The order must be exhaustive for all the elements of structure of the model.*

*This operator produces a structure of the cara\_elem type.*

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*2 Syntax*

*general*

*will cara [cara\_elem] = AFFE\_CARA\_ELEM (*

**MODEL**

=

**Mo**

,  
[*model*]  
**INFORMATION** = /1,  
[**DEFECT**]

/ 2,  
**VERIF** = / “**MESH**”,  
/ “**NODE**”,

**/BAR**

=

(*see key word BARS*  
[§6])

**/CABLE**

=

(*see key word CABLE*  
[§7])

**/HULL**

=

(*see key word HULL*  
[§8])

**/BEAM**

=

(*see key word BEAM*  
[§9])

**ORIENTATION**

=

(*see key word ORIENTATION* [§10])

**DEFI\_ARC**

=

(*see key word DEFI\_ARC* [§11])

**/AFFE\_SECT**

=

(*see key word AFFE\_SECT*  
[§12])

**/AFFE\_FIBRE** = (*see key word AFFE\_FIBRE* [§12])

**/ DISCRETE =**  
*(see DISCRETE key word [§13])*  
**ORIENTATION**  
**=**  
*(see key word ORIENTATION [§10])*

**/ DISCRET\_2D =**  
*(see key word DISCRET\_2D [§13])*  
**ORIENTATION**  
**=**  
*(see key word ORIENTATION [§10])*

**/ SOLID MASS**  
**=**  
*(see MASSIVE key word [§14])*

**/ ASSE\_GRIL**  
**=**  
*(see key word ASSE\_GRIL [§15])*

**/ POUTRE\_FLUI**  
**=**  
*(see key word POUTRE\_FLUI [§16])*

**/ ROAST**  
**=**  
*(see key word ROASTS [§17])*

**/ RIGI\_PARASOL**  
**=**  
*(see key word RIGI\_PARASOL [§18])*

**/ RIGI\_MISS\_3D**  
**=**  
*(see key word RIGI\_MISS\_3D [§19])*

)

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**3 Operands**

**Generals**

**MODEL and VERIF**

**3.1 Operand**

**MODEL**

**MODEL = Mo**

**Concept of the model type, produced by the operator AFFE\_MODELE [U4.41.01] on whom are affected characteristics of the elements. Let us note that the model must contain explicitly with less one of the elements of structure, on which will carry the assignment (if not calculation stops).**

**3.2 Operand**

**VERIF**

**VERIF**

**=/"MESH"**

**/**

**"NODE"**

**Argument Significance**



*Check that the type of element supported by the meshes, to which one wants to affect a characteristic, is compatible with this "MESH" characteristic (including the orientations). In the contrary case, stop with error message.*

*Check that the nodes to which one wants to affect a characteristic "NODE" nodal support a type of element compatible with this (only with characteristic. In the contrary case, stop with error message. DISCRETE)*

### **3.3 Operand INFORMATION**

#### **INFORMATION**

=

/ 2

*Print on the file "MESSAGE", for all the elements, the list of values assigned to the elements:*

- angles of orientation in degrees (beams and discrete),*
- characteristics of the cross sections of beams and of bars,*
- impressions of the elementary matrices (discrete).*

/

*1  
do not print anything*

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**4**

### **Definition of the field of assignment**

**The choice of the elements of the model  $M_0$  to which the assignment relates makes in two stages:**

**1) the choice of the type of element concerned with the assignment (BEAM, DISCRETE,...),**

**2) meshes (of the type of definite element) to affect.**

**The choice of the key word factor defining the type of elements (BEAM, DISCRETE,...) imply that it exist in the model the types of adapted elements (checking carried out systematically).**

**The types of elements concerned depend on modeling:**

**· MECHANICAL phenomenon**

**Key word**

**Modeling**

**BAR BARS**

**CABLE CABLE,**

**CABLE\_POULIE**

**HULL**

**HULL AXIS, HULL C PLANE, HULL D PLANE, DKT, DST,**

**DKQ, DSQ, Q4G, COQUE\_3D**

**DISCRETE**

**DIS\_T, DIS\_TR, 2D\_DIS\_T, 2D\_DIS\_TR**

**BEAM**

**LOUSE D E, LOUSE D T, LOUSE C T, LOUSE D TG, LOUSE D T GD,**

**FLUI\_STRU, TUYAU\_3M, TUYAU\_6M, POU\_D\_TGM, POU\_D\_EM**

**SOLID MASS**

**3D, AXIS, FOURIER AXIS, C PLANE, D PLANE, 3M PIPE,**

**TUYAU\_6M**

**ROAST GRID,**

**GRILLE\_MEMBRANE**

**ASSE\_GRIL ASSE\_GRIL**

**POUTRE\_FLUI 3D\_FAISCEAU**

**AFFE\_SECT POU\_D\_EM,**

**POU\_D\_TGM**

**AFFE\_FIBRE POU\_D\_EM,**

**POU\_D\_TGM**

**RIGI\_PARASOL DIS\_TR**

**RIGI\_MISS\_3D DIS\_T**

· ***THERMAL phenomenon***

***Key word***

***Modeling***

***HULL***

***COQUE\_AXIS, COQUE\_PLAN, HULL***

***SOLID MASS***

***3D, AXIS, PLAN***

***The assignment of the characteristics to the finite elements is done using the key words: “MESH”, “NODE”, “GROUP\_MA”, “GROUP\_NO”, according to the cases.***

· ***If VERIF is not present: In a group or a list of meshes (or nodes), one affects indeed characteristics with the only elements for which they have a direction. For other elements, the characteristics are not affected.***

· ***If VERIF is present: One checks moreover than all the elements of the group or of the list are good type, if not an error message is transmitted.***

***4.1 Operands***

***NET/GROUP\_MA/NODE/GROUP\_NO***

***Operands Significance***

***GROUP\_MA = l<sub>gma</sub>***

***Assignment with all the elements of the groups of meshes specified.***

***NET = l<sub>ma</sub>***

***Assignment with all the elements of the specified meshes.***

***GROUP\_NO = l<sub>gno</sub>***

***Assignment with all the nodes of the groups of specified nodes (DISCRETE only)***

***NODE = l<sub>no</sub>***

***Assignment with all the specified nodes (DISCRETE only)***

***As in the other orders, the rule of overload applies [U1.03.00].***

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**Assignment of values**

**Two methods are usable to affect values of characteristics:**

**· traditional method: operand whose name evokes the treated characteristic followed by a value or of a list of values. Examples:**

**HULL = \_F (THICK = 1.E-2,**

**GROUP\_MA = "G1"),**

**HULL = \_F (ANGL\_REP = (0. , 90.), GROUP\_MA = "G2"),**

**· for the assignments relating to BAR, BEAM and DISCRETE, like ORIENTATION for elements of beam and discrete elements, the great number of characteristics which can be affected led to a better adapted syntax:**

**CARA = (...) # lists names of characteristics**

**VALE = (...) # lists values corresponding to the characteristics**

**One gives an illustrative example below this case.**

**0,4**

**0,05**

**0,02**

**0,02**

**0,01**

**M1**

**M2**

**M3**

**M4**

**M5**

**M6**

**0,2**

**0,018**

**N1**

**N2**

**N3**

**N4**

**N5**  
**N6**  
**N7**

**Description of the meshes:**

**SEG2**

**M1**

**N1**

**N2**

**M2**

**N2**

**N3**

**M3**

**N3**

**N4**

**M4**

**N5**

**N4**

**M5**

**N5**

**N6**

**M6**

**N6**

**N7**

**FINSF**

**Command file:**

**= AFFE\_CARA\_ELEM will cara (**

**POUTRE=**

**(\_F (SECTION=' CERCLE', CARA= ("R", "EP"), VALE= (0.1, 0.02), MAILLE= ("M1", "M5")),**

**\_F (SECTION=' CERCLE', CARA= ("R", "EP"), VALE= (0.2, 0.05), MAILLE= "m3"),**

**\_F (SECTION=' CERCLE', CARA= ("R", "EP"), VALE= (0.09, 0.01), MAILLE= "M6"),**

**\_F (SECTION=' CERCLE', CARA= ("R1", "R2"), VALE= (0.1, 0.2), MAILLE= ("m2", "M4")),**

**\_F (SECTION=' CERCLE', CARA= ("EP1", "EP2"), VALE= (0.02, 0.05), MAILLE= ("m2",  
"M4")),**

**),**

**)**

**It is also possible to use the functionalities of the language python. The example below**

*recover sizes calculated by order MACR\_CARA\_POUTRE, for then affecting them.  
The use of python requires to put PAR\_LOT='NON' in the order BEGINNING.*

*PRE\_GIBI ()*

*SECTION = MACR\_CARA\_POUTRE (NOEUD= "NI", GROUP\_MA\_BORD= "EDGE")*

*II = 2*

*alpha0 = SECTION ["ALPHA", II]*

*cdgx0 = SECTION ["CDG\_X", II]*

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*cdgy0 = SECTION ["CDG\_Y", II]*

*AIRE0 = SECTION ["SURFACE", II]*

*IY0 = SECTION ["IY\_PRIN\_G", II]*

*IZ0 = SECTION ["IZ\_PRIN\_G", II]*

*EY0 = SECTION ["EY", II]*

*EZ0 = SECTION ["EZ", II]*

*JX0 = SECTION ["CT", II]*

*JG0 = SECTION ["JG", II]*

*AY0 = SECTION ["AY", II]*

*AZ0 = SECTION ["AZ", II]*

*IYR20 = SECTION ["IYR2\_PRIN\_G", II]*

*IZR20 = SECTION ["IZR2\_PRIN\_G", II]*

*carelem=AFFE\_CARA\_ELEM (MODELE=mod,*

*BEAM = (*

```
_F (GROUP_MA= ("POUT1", "POUT2"), SECTION=' GENERALE',  
CARA= ("A", "IY", "IZ", "AY", "AZ", "EY", "EZ", "JX", "JG", "IYR2", "IZR2"),  
VALE= (AIRE0, IY0, IZ0, AY0, AZ0, EY0, EZ0, JX0, JG0, IYR20,  
IZR20),),  
)  
)
```

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*6 Word*

*key*

*BAR*

*6.1 Characteristics*

*easily affected*

*Allows to affect the characteristics of the cross sections of elements of the type BARS. One can to treat three types of cross sections defined by the operand SECTION.*

*With each type of section, it is possible to affect various characteristics identified by one or several names (operand CARA) to which as many values (operand VALE) are associated.*

*6.2 Syntax*

*BARRE= (*

*\_F (*

```
/
NET
=
lma,
[l_maille]
/
GROUP_MA
=
lgma,
[l_gr_maille]

/SECTION = "GENERAL",
# constant section
CARA =
"A",

VALE
=
goes
,
[l_R]

/
SECTION = "RIGHT-ANGLED",
# constant section
CARA=/(| "H" | "EP"),
/
(| "HY" | "HZ" | "EPY" | "EPZ"),
VALE
=
goes,
[l_R]

/
SECTION = "CIRCLE",
# constant section
CARA=
(| "R" | "EP"),
VALE= goes,
[l_R]
FCX
=
fv,
[FUNCTION]
```



),  
)

**Regulate use:**

*one cannot overload a type of section (CIRCLE, RECTANGLE, GENERAL) by another.*

**6.3 Operands**

**6.3.1 Operand**

**SECTION = "GENERAL"**

*The only characteristic required in this case is the surface of the cross section of bar "A".*

**6.3.2 Operand**

**SECTION = "CIRCLE"**

**CARA**

**Significance**

**Default value**

**R**

**Ray external of the tube**

**Obligatory**

**EP**

**Thickness in the case of a hollow tube**

**Full tube (EP=R)**

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**Y**  
**G**  
**Z**  
**R**  
**EP**

*These values are used to calculate surface “A” of the section.*

### **6.3.3 Operand**

**SECTION = “RIGHT-ANGLED”**

**CARA**

*Significance*

*Default value*

**/HY**

*Dimension of the rectangle following GY Obligatoire*

**HZ**

*Dimension of the rectangle following GZ Obligatoire*

**/H**

*Length of the edge (if the rectangle is square)*

**Obligatory**

**/EPY**

*Thickness according to GY in the case of a hollow tube*

**HY/2**

**EPZ**

*Thickness according to GZ in the case of a hollow tube*

**HZ/2**

**/EP**

*Thickness along the two axes in the case of a hollow tube*

**Full tube**

**Y**

**EPY**

**HY**

**G**

**Z**

**EPZ**

**HZ**

*Rules of use: for a given mesh*

· “H” is incompatible with “HZ” and “HY”

• “EP” is incompatible with “EPY” and “EPZ”.

## **6.4 Operand**

**`FCX`**

**FCX**

**=**

**fv**

*Assignment of a function describing the dependence of the force distributed with respect to the speed of wind relative (see for example [V6.02.118]).*

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**7 Word**

**key**

**CABLE**

**7.1 Characteristics**

*easily affected*

*Allows to assign a constant section to the elements of the type cables or cable-pulley.*

**7.2 Syntax**

```

CABLE = (
  _F (
  /
  NET
  =
  lma,
  [l_maille]
  /
  GROUP_MA
  =
  lgma,
  [l_gr_maille]

  SECTION
  =
  surface,
  [R]
  FCX
  =
  fv,
  [FUNCTION]
  N_INIT
  =/No,
  [R]
  /
  5000,
  [DEFECT]
  ),
  )

```

### 7.3 Operand

**`SECTION`**

**SECTION:** *surface*

*Allows to define the surface of the cross section of the cable.*

### 7.4 Operand

**`FCX`**

**FCX**

:

*fv*

*Assignment of a function describing the dependence of the force distributed with respect to the speed of wind relative (HM-77/01/046) to see for example test SDNL102 [V5.02.102].*

## **7.5 Operand**

### ***N\_INIT***

*Defines the initial tension in the cable, 5000 NR by defect for cables whose dimensions are defined in meters.*

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## **8 Word**

*key*

***HULL***

### **8.1 Characteristics**

*easily affected*

*The characteristics which one can affect on the elements of plate or hull are:*

- for all the elements of this type, a constant thickness on each mesh, since it grid represents only the average layer (or of diagram for offset),*
- for certain models of hull, the particular characteristics: coefficient of shearing, metric, offsetting,...*
- for the analysis of the generalized efforts, the state of constraint or the deformations, one*

*direction of reference for groups of meshes.*

## **8.2 Syntax**

**COQUE= (**  
**\_F (**  
**/**  
**NET**  
**=**  
**lma,**  
**[l\_maille]**  
**/**  
**GROUP\_MA**  
**=**  
**lgma,**  
**[l\_gr\_maille]**  
  
**THICK**  
**=**  
**ep,**

**[R]**  
  
**ANGL\_REP**  
**=**  
**/**  
**(0.,**  
**0.),**  
**[DEFECT]**  
**/(,**  
**),**  
**[l\_R]**

**MODI\_METRIQUE**  
**=/"NOT",**  
**[DEFECT]**

/

**“YES”,**

**COEF\_RIGI\_DRZ**  
**=/KRZ**

,

**[R]**

/

**1.E-5,**  
**[DEFECT]**

**OFFSETTING**

**=**

**E,**

**[R]**

**0.,**  
**[DEFECT]**

**INER\_ROTA**  
**= “YES”,**

**COQUE\_NCOU =/**  
**n1,**

**[I]**

**/ 1**

,

**[DEFECT]**

)

)

### **8.3 Operands**

#### **8.3.1 Operand** **THICK**

**THICK = ep**

#### **Note:**

**The thickness must be expressed with the same units as the co-ordinates of the nodes of grid.**

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### **8.3.2 Operands *MODI\_METRIQUE/COEF\_RIGI\_DRZ/OFFSETTING/INER\_ROTA***

***/MODI\_METRIQUE***

=

**“NOT”**,

***Fact the assumption that the thickness of the element is low. There is no integration in the thickness but only according to the surface of the average layer (default option for all hulls).***

***/MODI\_METRIQUE***

=

**“YES”**,

***For modelings of thick hulls***

***: COQUE\_AXIS, COQUE\_C\_PLAN,***

***COQUE\_D\_PLAN, COQUE\_3D, integrations are done by taking of account the variations in function thickness.***

***OFFSETTING***

***=/E,***

***/0.***



*The distance between surface with a grid and average surface defines, in the direction of the normal (modelings DKT, DST, GRID).*

**INER\_ROTA**  
= "YES"

*Taking into account of the inertia of rotation for modeling DKT, DST and Q4G. It is obligatory in the event of offsetting. One can omit this key word for thin hulls, where terms of inertia of rotation are negligible compared to different in the matrix of mass [R3.07.03].*

**COEF\_RIGI\_DRZ = KRZ,**

*KRZ is a coefficient of fictitious rigidity (necessarily small) on the degree of freedom of rotation around the normal with the hull. It is necessary to prevent that the matrix of rigidity is singular, but must be selected smallest possible. The default value (1.E-5) is appropriate for majority of the situations (it is a relative value: rigidity around the normal is equal to KRZ time the diagonal minor term of the matrix of rigidity of the element).*

**Note:**

*Attention, in STAT/DYNA\_NON\_LINE, this coefficient can involve iterations of Newton additional (more than one iteration for a linear problem for example).*

**8.3.3 Operand**  
**ANGL\_REP**

**ANGL\_REP = (,)**,

*This key word is used for the definition of a local reference mark in the tangent plan in any point of a hull.*

*The construction of the local reference mark is done using the two "nautical" angles and (provided in degrees) which define a vector  $v$  whose projection on the tangent level with the hull fixes direction  $xl$ .*

*The vector  $V$  is defined in the total reference mark (O, X, Y, Z) by two rotations and:*

**Y**  
**Z**  
**YI**

**X**

**I**  
**V**

**O**  
**X**

**O**  
**XI**  
*Appear 8.3.3-a*  
*Appear 8.3.3-b*  
*Rotation around OZ transforms (OXYZ) into*  
*Rotation - around OY1 OX1 transforms into V*  
*(OX1 Y1 Z)*  
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***In three-dimensional representation [Figure 8.3.3-c].***

**Z**  
**V**  
**Y1**  
**Y**  
**X**

***Appear 8.3.3-c***

*One can define a single vector  $V$  for all the structure, or one by zone (key words  $GROUP\_MA/MESH$ ).*

*The construction of the local reference mark in a point of an element of hull is carried out starting from  $V$ , of following way:*

- the projection of  $V$  on the tangent level provides the axis  $x_l$ ,*
- the normal in tangent plan  $N$  is known for each element.*

*The local reference mark is thus:  $(P, x_l, y_l, z_l)$  with:  $x_l = XR$ ,  $z_l = N$  and  $y_l$  supplements the trihedron.*

*$z_l = N$   
 $V$   
 $y_l$   
 $P$   
 $x_l$   
 tangent plan*

*Important remark:*

*The definition of this reference axis is useful:*

- on the level it postprocessing, to define the local trihedron in which the efforts are expressed generalized or constraints. The user will have to take care that the selected reference axis does not find itself parallel with the normal of certain meshes of the grid: (Example: In case or  $ANGL\_REP = (0. , 0.)$  by defect for a parallel plate in plan  $(Y, Z)$  of the reference mark  $TOTAL$  an error message is transmitted during the calculation of option “ $EFGE\_ELNO\_DEPL$ ” of  $CALC\_ELEM [U4.81.01]$ ). The possibility of defining a posteriori a group of meshes of which normal is in a given solid angle is possible by order  $DEFI\_GROUP [U4.22.01]$ ,*
- to lay down the orientation of fibres of a multi-layer hull (cf operator  $DEFI\_COQU\_MULT [U4.42.03]$ ).*

### **8.3.4 Operand** **$COQUE\_NCOU$**

*A number of layers used for integration in the thickness of the hull, the operators  $STAT\_NON\_LINE$  and  $DYNA\_NON\_LINE$  (modelings  $DKT$ ,  $COQUE\_3D$ ,  $COQUE\_AXIS$ ,  $COQUE\_C\_PLAN$ ,  $COQUE\_D\_PLAN$ ).*

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***This key word makes it possible to affect the characteristics of the cross sections of elements of the beam type***

***(modelings POU\_D\_E, POU\_D\_EM, POU\_D\_T, POU\_C\_T, POU\_D\_TG, POU\_D\_TGM, POU\_D\_TGD,***

***TUYAU\_3M, TUYAU\_6M). One can treat three types of cross sections defined by the operand SECTION.***

***With each type of section, it is possible to affect various characteristics identified by one or several names (operand CARA) to which as many values (operand VALE) are associated.***

***It is possible to treat beams of constant section (name of characteristic without suffix) or of variable section (name of characteristic with suffix 1 or 2). The mode of variation of the section is defined by key word VARI\_SECT (cf [§9.4.1]). One then gives the characteristics of the section to initial node (name with suffix 1) and with the final node (name with suffix 2) (“initial” and “final” relative with***

***the classification of the mesh support). One must also use this key word to define the constant of torsion for modeling (POU\_D\_EM).***

**9.2 Syntax****POUTRE= (**

```

_F (
/
NET
= lma,

[l_maille]
/
GROUP_MA
=
lgma,
[l_gr_maille]

/SECTION = "GENERAL",

VARI_SECT
=
"CONSTANT" [DEFECT]

"HOMOTHETIC"
# constant section
/
CARA =
|"A" | "IY" | "IZ",
|"AY" | "AZ" | "EY" | "EZ",
|"JX" | "AI" | "RY" | "RZ" | "RT",
|"JG" | ' IYR2' | ' IZR2' |,
VALE
=
goes,
[l_R]
# section homothetic
/
CARA = | "A1" | "A2" | "IY1" | "IY2",
| "IZ1" | "IZ2" | "JX1" | "JX2",
| "AY1" | "AY2" | "AZ1" | "AZ2",
| "JG1" | "JG2" | "EY1" | "EY2",
| "EZ1" | "EZ2" | "AI1" | "AI2",
| "RY1" | "RY2" | "RZ1" | "RZ2",
| "RT1" | "RT2",
| "IYR21" | ' IZR21' | "IYR22" | "IZR22",
VALE = goes,
[l_R]

```

/  
**SECTION = "RIGHT-ANGLED",**  
**VARI\_SECT**  
**=**  
/  
**"CONSTANT",**

**[DEFECT]**

/  
**"HOMOTHETIC",**  
**/"REFINES",**  
**# constant section**

/  
**CARA =/| "H" | "EP",**  
/  
**| "HY" | "HZ" | "EPY" | "EPZ",**  
**VALE = goes,**

**[L\_R]**  
**# section homothetic**

/  
**CARA =/| "H1" | "H2" | "EP1" | "EP2",**

/  
**| "HY1" | "HZ1" | "HY2" | "HZ2",**  
**| "EPY1" | "EPY2" | "EPZ1" | "EPZ2",**  
**VALE = goes,**

**[L\_R]**  
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*# section closely connected*

/  
*CARA = | “HY” | “EPY” | “HZ1”,*  
*| “EPZ1” | “HZ2” | “EPZ2”,*  
*VALE = goes,*  
*[l\_R]*

/  
*SECTION = “CIRCLE”,*

*VARI\_SECT*

=  
*“CONSTANT” [DEFECT]*  
*“HOMOTHETIC”,*  
*# constant section*

/  
*CARA=*  
*| “R” | “EP”,*  
*VALE*

=  
*goes,*  
*[l\_R]*

*# section homothetic*

/  
*CARA = | “R1” | “R2” | “EPI” | “EP2”,*  
*VALE = goes,*  
*[l\_R]*

*MODI\_METRIQUE*  
*=/“YES”,*

/  
*“NOT”,*  
*[DEFECT]*  
*TUYAU\_NSEC =/nsec,*  
*[I]*

/ 16,  
*[DEFECT]*  
*TUYAU\_NCOU =/ncou,*  
*[I]*

/  
3,  
*[DEFECT]*

**FCX**

=

**fv,****[FUNCTION]****PREC\_AIRE**

=

/

**precis, [R]**

/

**0.01,****[DEFECT]****PREC\_INERTIE**

=

/

**precis, [R]**

/

**0.1,****[DEFECT]**

),

)

### **9.3 Rules**

#### **of use**

#### **Note:**

***The orientation of the elements of beams is done by the key word ORIENTATION [§10]. The angle of gimlet***

***(which makes it possible to direct the transverse section of the beam around its neutral fibre) is always given to direct the principal axes of the section what is not very practical because these axes are in general unknown before the calculation of the geometrical characteristics of the section (cf MACR\_CARA\_POUTRE [U4.42.02]).***

- It is possible starting from version 6 to directly provide (via variables python) them characteristics of the sections (general) resulting from a calculation with MACR\_CARA\_POUTRE.***

***This******is implemented in test SLL107F.***

- The various names of characteristics arguments of operand CARA are described further for each argument of the operand SECTION.***

- For a given mesh:***



- One cannot overload a type of variation of section (constant or variable) by another.
- One cannot overload a type of section (CIRCLE, RECTANGLE, GENERAL) by another.
- For the beams non-prismatic, the names with suffix 1 or 2 are incompatible with names without suffix. Example: A is incompatible with A1 and A2.
- "H" is incompatible with "HZ" and "HY" (like H1, H2,...)
- "EP" is incompatible with "EPY" and "EPZ" (like EP1, EP2,...).
- "RY", "RZ" and "RT" intervene only for the calculation of the constraints.

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## **9.4 Operands**

### **9.4.1 Operand**

**VARI\_SECT**

*Allows to define the type of variation of section between the two nodes ends of the element of beam (elements **POU\_D\_E** and **POU\_D\_T** [R3.08.01]).*

*The possibilities are:*

*Section Closely connected Homothetic*

*ring not yes*

*rectangle*

*yes (according to Z)*

*yes*

*general not*

*yes*

- *“Closely connected” means that the surface of the section varies in a linear way between the two nodes.  
dimensions in the direction are there constant (HY, EPY) and that in direction Z vary linearly (HZ1, HZ2, EPZ1, EPZ2).*
- *“Homothetic” means that 2 dimensions of the section vary linearly between values given to the two nodes, the surface of the section thus evolves/moves in a quadratic way.*

#### **9.4.2 Operand**

##### **MODI\_METRIQUE**

*Allows to define for the elements PIPE the type of integration in the thickness (modelings TUYAU\_3M, TUYAU\_6M):*

- *MODI\_METRIQUE = “NOT” resulted in assimilating in integrations the ray to the average radius. This is thus valid for the pipes low thickness (relative with the ray),*
- *MODI\_METRIQUE = “YES” implies a complete integration, more precise for pipings thick, but being able in certain cases to lead to oscillations of the solution.*

#### **9.4.3 Operand**

##### **SECTION = “GENERAL”**

##### **9.4.3.1 Section**

*constant*

**CARA**

*Significance*

*Default value*

*With*

*Surface of the section*

*Obligatory*

*IZ*

*Geometrical moment of inertia principal compared to GZ Obligatoire*

*IY*

*Geometrical moment of inertia principal compared to GY Obligatoire*

*Obligatory if POU\_D\_T,*

*AY*

*Coefficient of shearing in direction GY*

*POU\_C\_T, POU\_D\_TG*

*0. if POU\_D\_E*

*AZ*

*Coefficient of shearing in direction GZ*

*idem*

**EY**

*Eccentricity of the center of torsion*

0.

*(component of CG following GY)*

**EZ**

*Eccentricity of the center of torsion*

0.

*(component of CG following GZ)*

**JX**

*Constant of torsion*

*Obligatory*

**RY**

*Distance from an external fibre measured according to y*

1.

**RZ**

*Distance from an external fibre measured according to Z*

1.

**RT**

*Effective ray of torsion*

1.

**JG**

*Constant of warping (POU\_D\_TG, POU\_D\_TGM)*

**IYR2**

*Necessary to the calculation of geometrical rigidity*

*(POU\_D\_TG and POU\_D\_TGM)*

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## **IZR2**

*Necessary to the calculation of geometrical rigidity*

*(POU\_D\_TG and POU\_D\_TGM)*

## **AI**

*Surface of the bypass section of the fluid inside the obligatory one for one beam.*

*modeling FLUI\_STRU*

## **9.4.3.2 Section**

### **homothetic**

*One defines the characteristics for each mesh, with the two nodes.*

## **CARA**

### **Significance**

### **Default value**

*A1, A2*

*Surface of the section*

*Obligatory*

*IZ1, IZ2*

*Geometrical moment of inertia principal per report/ratio*

*Obligatory*

*with GZ*

*IY1, IY2*

*Geometrical moment of inertia principal per report/ratio*

*Obligatory*

*with GY*

*Obligatory if POU\_D\_T,*

*AY1, AY2*

*Coefficient of shearing in direction GY*

*POU\_C\_T, POU\_D\_TG*

*0. if POU\_D\_E*

*AZ1, AZ2*

*Coefficient of shearing in direction GZ*

*idem*

*EY1, EY2*

*Eccentricity of the center of torsion*

*0.*

*(component of CG following GY)*

*EZ1, EZ2*

*Eccentricity of the center of torsion*

*0.*

*(component of CG following GZ)*

*JX1, JX2*

*Constant of torsion*

*Obligatory*

*RY1, RY2*

*Distance from an external fibre measured according to y*

*1.*

*RZ1, RZ2*

*Distance from an external fibre measured according to Z*

*1.*

*RT1, RT2*

*Effective ray of torsion*

*1.*

*JG1, JG2*

*Constant of warping (POU\_D\_TG)*

*IYR21, IYR22*

*Necessary to the calculation of geometrical rigidity*

*(POU\_D\_TG and POU\_D\_TGM)*

*IZR21, IZR22*

*Necessary to the calculation of geometrical rigidity*

*(POU\_D\_TG and POU\_D\_TGM)*

*AI1, AI2*

*Surfaces of the bypass section of the fluid with*

*obligatory for one*

*interior of the beam.*

*modeling*

*FLUI\_STRU*

**Y**

**Y**

**RT**

**X**

*by (T)*

**RY**

*neutral fibre*

**T**

**Z**

**G**

*G*  
*EY*  
*Z*  
*C*  
*EZ*  
*RZ*

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*Definition of the characteristics:*

*IZ =*

*y 2ds*

*IY = Z 2ds*

*S*

*S*

*2*

*With*

*With*

*y m*

*2*

*2*

*y (y)*

*With*

*With*

$z_2 m_z (Z)$

*RY*

*AY =*

=

=

=

,

2

,

2

:

*with y*

=

*With*

*IZ*

*y1 B*

*Y*

*y (y) Dy*

*AZ*

*With*

*IY*

*z1 B*

*Z*

*Z (Z) dz*

*m (y)*

*Tb (T) dt*

*y*

*y*

*by (T) thickness*

*according to*

*Z, in Z = T*

*with:*

*A', A'*

*Y*

*Z: sheared reduced surfaces*

*With*

*l*

$A' =$   
*front*

$AY$   
 $EC.$

$I$  or  $A' = K A$  with  $K$

$Y$   
 $=$

$I$   
 $AY$

$Y$   
 $y$   
 $y$   
 $AY$

· *coefficients of shearing A, A*

$Y$

*Z are used by elements POU\_D\_T, POU\_C\_T and*

*POU\_D\_TG, POU\_D\_TGM, for the calculation of the matrices of rigidity and mass and for the calculation of*

*constraints [R3.08.01]. In particular, stresses shear transverse are expressed by:*

$Z$

$V$

$Z$

*With*

*With*

$=$

$= V$

,

$Y$

$xz$

$Z$

$xz = Y$

$V$

,

$kz A$

*With*

*With*

· *in the case of the beams of Euler (POU\_D\_E) which do not take account of transverse shearing,*



*one neglects the corresponding terms in the calculation of rigidity and the mass while taking*

*WITH = A*

*Y*

*Z = 0. On the other hand, the constraints [R3.08.01] of shearing are calculated by:*

*Z*

*V*

*=*

*,*

*Y*

*V*

*xz*

*xz =*

*.*

*With*

*With*

*Characteristics RY, RZ, RT are used for calculation of torsion and bending stresses*

*[R3.08.01] for options "SIGM\_ELNO\_DEPL" or "SIPO\_ELNO\_DEPL" of CALC\_ELEM [U4.81.01].*

*My*

*In inflection, one a: xx =*

*. RZ*

*Iy*

*M*

*or*

*Z. RY*

*Iz MT*

*In torsion,*

*=*

*xz*

*xy =*

*. RT*

*JX*

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#### **9.4.4 Operand**

**SECTION = "RIGHT-ANGLED"**

**CARA**

**Significance**

**Default values**

**Constant section**

**HY**

*Dimension of the rectangle following GY*

*Obligatory*

**HZ**

*Dimension of the rectangle following GZ*

*Obligatory*

**H**

*Dimension of the square (if the rectangle is square)*

*Obligatory*

**EPY**

*Thickness according to GY in the case of a hollow tube*

**HY/2**

**EPZ**

*Thickness according to GZ in the case of a hollow tube*

**HZ/2**

**EP**

*Thickness along the two axes in the case of a tube*

*Full tube*

*hollow*

**Homothetic section**

**H1, H2**

*Dimension of the square at each end for one*

**H1=H2=H**

*variable section*

*HY1, HY2*

*Dimension of the rectangle following GY at each end*

*HY1=HY2=HY*

*for a variable section*

*HZ1, HZ2*

*Dimension of the rectangle following GZ at each end*

*HZ1=HZ2=HZ*

*for a variable section*

*EP1, EP2*

*Thickness along the two axes in the case of a tube*

*EP1=EP2=EP*

*hollow, at each end in the case of a section*

*variable*

*EPY1, EPY2*

*Thickness according to GY in the case of a hollow tube, with*

*EPY1=EPY2=EPY*

*each end in the case of a variable section*

*EPZ1, EPZ2*

*Thickness according to GZ in the case of a hollow tube, with*

*EPZ1=EPZ2=EPZ*

*each end in the case of a variable section*

*Y*

*EPY*

*Z*

*HY*

*G*

*EPZ*

*HZ*

*The characteristics calculated by Aster are [R3.08.03]:*

*HY. HZ<sup>3</sup> (HY - 2EPY). (HZ - 2EPZ) <sup>3</sup>*

*I<sub>y</sub> =*

*-*

*12*

*12*

*HZ. HY<sup>3</sup> (HZ - 2EPZ). (HY - 2EPY) <sup>3</sup>*

*I<sub>z</sub> =*

*-*

*12*

*12*

12

*HY*

*HZ*

*RY =*

*RZ =*

2

2

· *If the tube is hollow:*

*AY = AZ = 15*

·

*2 EPY.EPZ (HY - EPY) 2 (HZ - EPZ) 2*

*JX =*

*HY.EPY + HZ.EPZ - EPY 2 - EPZ2*

*JX*

*RT = 2EPZ (HY - EPY) (HZ - EPZ)*

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· *If the tube is full:*

*HY*

*HZ*

*one poses*

*has =*

, *B =*

*if HY > HZ*

*2*

*2*

*HZ*

*HY*

*has =*

*, B =*

*if HZ > HY*

*2*

*2*

*6*

*-*

*coefficients of shearing AY = AZ =*

*5*

*16*

*B*

*b5*

*-*

*J = has b3*

*- 3 3*

*. 6*

*+ 0 2*

*. 8*

*3*

*has*

*a5*

*J (3a + 18*

*. b)*

*-*

*RT =*

*8a2 b2*

***Note:***

*The computed values can be printed with the key word INFORMATION = 2.*

### ***9.4.5 Operand***

***SECTION = "CIRCLE"***

***CARA***

***Significance***

***Default value***

***Constant section***

*R*

*Ray external of the tube*

*Obligatory*

*EP*

*Thickness in the case of a hollow tube*

*Full tube (EP=R)*

***Variable section***

*R1, R2*

*Rays external at the two ends for one*

*R1=R2=R*

*variable section*

*EP1, EP2*

*Thicknesses at the two ends in the case of one*

*EP1=EP2=EP*

*variable section*

*Y*

*G*

*Z*

*R*

*EP*

*The computed values by Aster are [R3.08.03]:*

*JX*

*R4*

*(R - EP) 4*

*I = I*

*y*

*Z =*

*=*

*-*

*2*

*4*

*4*

*RT = RY = RZ = R*

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· full tube:  $AY = AZ = 10/9$

· thick hollow tube:

*R - EP*

if

$< 9$

·

0

that is to say  $EP >$

1

·

0 R

R

*R - EP*

that is to say =

$AY = AZ = -0.905\ 3 + 1156\ 2$

·

·

+ 0 634

·

+1093

·

R

· if not (thin tube)  $AY = AZ = 2$ .

## 9.5 Operand

**FCX**

FCX

=

$f_v$

Assignment of a function describing the dependence of the force distributed with respect to the speed of wind relative (see test SSNL118 [V6.02.118]). The loading of the wind type is applicable on elements of bar of cable and beam (modelings POU\_D\_E, POU\_D\_T, POU\_D\_T, POU\_D\_TG, POU\_D\_TGD, POU\_D\_TGM).

## 9.6 Operands

**TUYAU\_NSEC/TUYAU\_NCOU**

TUYAU\_NSEC =/nsec,

TUYAU\_NCOU =/ncou,

A number of layers in the thickness (ncou by defect = 3) and of sectors (nsec by defect = 16) on the circumference used for integrations in the elements PIPE [R3.08.06].

## 9.7 Operands

**PREC\_AIRE/PREC\_INERTIE**

PREC\_AIRE

=/precise,

PREC\_INERTIE

=/precise,

The use of the multifibre beams (POU\_D\_EM or POU\_D\_TGM) requires to provide additional information, compared to key words VALE and CARA, using the key words AFFE\_SECT and/or AFFE\_FIBRE [§12.3].

The objective is to check the coherence of the information (SURFACE and INERTIA) provided on the one hand by the key word BEAM and in addition by key words AFFE\_SECT and AFFE\_FIBRE. The criterion of error is based on the error relating and is compared either with the default value or to that given by the user via key words PREC\_AIRE and PREC\_INERTIE.

If the criterion is not satisfied a fatal error is generated.



*The relative error is calculated in the following way:*

$$\frac{SURFACE (BEAM) - (SURFACE (AFFE\_SECT) + AIRE (AFFE\_FIBRE))}{SURFACE (BEAM)} \leq PREC\_AIRE$$

$$\frac{INERTIA (BEAM) - (INERTIA (AFFE\_SECT) + INERTIE (AFFE\_FIBRE))}{INERTIA (BEAM)} \leq PREC\_INERTIE$$

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**Note:**

· *SURFACE (AFFE\_SECT) is calculated by making the sum of the surfaces of the elements defined in grid, under key word MAILLAGE\_SECT in operand AFFE\_SECT.*

· *SURFACE (AFFE\_SECT) is calculated by making the sum of the surfaces of fibres defined in the operand  
AFFE\_FIBRE.*

· *INERTIA (AFFE\_SECT) is calculated by making the sum of the  $s.d^2$  elements defined in grid, under key word MAILLAGE\_SECT in operand AFFE\_SECT. (S: represent surface of an element and D the distance between the centre of gravity of the element and the axis defined by*

*key word CARA\_AXE\_POUTRE under operand AFFE\_SECT).*

· *INERTIA (AFFE\_FIBRE) is calculated by making the sum of the  $s.d^2$  fibres defined in operand AFFE\_FIBRE. (S: represent the surface of a fibre and D the distance between fibre and the axis defined by key word CARA\_AXE\_POUTRE under operand AFFE\_FIBRE).*

**Note:**

*When the section is defined by a grid (key word MAILLAGE\_SECT under the operand AFFE\_SECT) the total calculation of the inertia of the surface whole of the elements does not hold account*

*inertia suitable for each element. It is thus necessary to define a sufficient number of fibre so that this error is weak and remains lower than PREC\_INERTIE.*

*For example a rectangular section cut out uniformly in the height in “N” elements conduit with the following errors, on the values of inertias:*

*Cutting*

2 3 4 5 6

*Inertia error*

25%

11.11% 6.25% 4.00% 2.77%

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**10 Word**

**key**

**ORIENTATION**

**10.1 Characteristics**

**easily affected**

*This key word makes it possible to affect the **orientations**:*

- of the principal axes of the cross sections of the elements of the beam type,*
- of the **discrete elements** assigned to nodes or meshes of the type PO11 (discrete elements nodal) or with meshes of the type SEG2 (discrete elements of connection).*

**Note:**

*There is always a local reference mark by defect attached to the elements of the BEAM type or DISCRETE*

*even if the operand ORIENTATION is not used. It corresponds to ANGL\_VRIL = 0 for elements attached to a mesh SEG2 (beams or discrete) and ANGL\_NAUT = (0. , 0. , 0.) for nodal discrete elements,*

*For the elements of the PIPE type, the key word ORIENTATION makes it possible to define a generating line*

*continue defining for each section the angular origin.*

**10.2 Syntax**

**ORIENTATION = (**

**\_F (**

**/**

**GROUP\_MA**

**=**

**lgma,**

**[l\_gr\_maille]**

**/MESH**

**= lma**

**,**

**[l\_maille]**

**/**

**GROUP\_NO**

**=**

**lgn,**

**[l\_gr\_noeud]**

**/NODE**

**= lno**

**,**

**[l\_noeud]**

**VALE**

**=**

**langl,**

**[l\_R]**

**CARA =/"VECT\_Y",**

**/"ANGL\_VRIL",**

**/"VECT\_X\_Y",**

**/"ANGL\_NAUT",**

**/"GENE\_TUYAU",**

**CRITERION =/“RELATIVE”, [DEFECT]  
/“ABSOLUTE”,  
PRECISION  
=  
/  
eps,  
[R]  
/  
1.E-4,  
[DEFECT]  
,  
)**

### **10.3 Rules of use**

***One can assign successively to the same mesh or the same node, several values of orientation: the orientation finally taken is the composition of the orientations.***

#### **Example:**

**ORIENTATION= (  
\_F (  
CARA = ' ANGL\_NAUT', VALE= (1. , 1. , 1.), MESH = “P1”),  
\_F (  
CARA = ' ANGL\_VRIL', VALE = 45. , MESH = “M1”),  
\_F (  
CARA = ' ANGL\_VRIL', VALE = 90. , MESH = “m2”),  
)**

- to define the local reference mark associated with a mesh of the type PO11 or a node (discrete element), it is necessary to use either ANGL\_NAUT, or VECT\_X\_Y,*
- to define the local reference mark around the axis defined by a mesh SEG2 (beam or discrete), it is necessary to use either ANGL\_VRIL, or VECT\_Y,*
- to define a generating line on the elements pipe, it is necessary to use GENE\_TUYAU.*

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## **10.4 Operands**

**VECT\_X\_Y/ANGL\_NAUT**

*/CARA = "ANGL\_NAUT", VALE = (,)*

*[V5.01.100]*

*The nautical angles, provided in degrees, are the angles making it possible to pass from the reference mark*

*total of definition of the co-ordinates of nodes (P, X, Y, Z) to the local reference mark (P, x2, y2, z2).*

*This one*

*is obtained by 3 rotations:*

- a rotation of angle around Z, transforming (P, X, Y, Z) in (P, x1, y1, Z) [Figure 10.4-a],*
- a rotation of angle - around y1, transforming (P, x1, y1, Z) in (P, x2, y1, z1) [Figure 10.4-b],*
- a rotation of angle around x2, transforming (P, x2, y1, z1) in (P, x2, y2, z2) [Figure 10.4-c].*

*Y*

*Z*

*Y1*

*Z1*

*X1*

*X2*

**P**

**P**

*X*

*X1*

*Z*

*Y1*

**Appear 10.4-a**

**Appear 10.4-b**

Z1  
Z2  
Y2  
**P**  
Y1  
X2

**Appear 10.4-c**

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*the local reference mark is: (P, x2, y2, z2)*

Z  
Z  
Z  
X  
Z  
Y  
Y  
**P**

Y1  
Y  
X  
X1

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(*L L L D D D*  
*X, X, X, y, y, y*  
*1*  
*2*  
*3*  
*1*  
*2*  
*3 )*  
*/CARA = "VECT\_X\_Y", VALE =*

*L*  
*L*  
*L*  
*X, X, X*  
*1*  
*2*  
*3 are the 3 components, in the total reference mark, of a vector defining the local axis X.*  
*2*



*D*

*D*

*D*

*y, y, y*

*1*

*2*

*3 are the 3 components, in the total reference mark, of a vector D*

*y, of which projection*

*on the orthogonal level with X local axis Y. local axis Z will provide supplements the reference mark then for*

*2*

*2*

*2*

*that the trihedron (P, X, y, Z are direct [Figure 10.4-d].*

*2*

*2*

*2 )*

*yd*

*y2*

*x2*

*P*

***Appear 10.4-d***

***10.5 Operand***

***ANGL\_VRIL/VECT\_Y***

*In the case of the meshes SEG2, axis X is already carried by the mesh (the direction of X is defined by*

*2*

*2*

*classification of two nodes of the mesh). It is thus enough to define y and Z, is by rotation around*

*2*

*2*

*X (key word*

*2*

*ANGL\_VRIL) is by defining a vector (key word VECT\_Y).*

*/CARA = "ANGL\_VRIL", VALE =*

*is the angle (in degrees) of rotation around X, transforming (P, X, y, Z in (P, X, y, Z.*

*2*

*2*

*2 )*

*2*

1  
1 )  
2  
D  
D  
D  
/CARA = "VECT\_Y", VALE = y, y, y

1  
2  
3  
D  
D  
D  
y, y, y

1  
2  
3 are the 3 components of a vector D  
y of which projection on the orthogonal level with X  
2  
the local axis y will provide [Figure 10.4-d]. Axis Z is such as (P, X, y, Z is direct.

2  
2  
2 )  
2  
2  
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## **10.6 Operand** **“GENE\_TUYAU”**

*Relate to only the elements PIPE (modelings TUYAU\_3M or TUYAU\_6M).*

*VALE = (Z1, Z2, Z3) then contains the 3 components of a vector Z directing the generator of the pipe (continuous line traced on the pipe, defining for each element the origin of the angle used for to express ovalization and warping).*

*This vector must be defined in a node or a GROUP\_NO end of the pipe. The geometry is then built automatically for all the related elements of PIPE.*

*N2*

*generator*

*Z*

*N2*

*N1*

*U*

*ur*

## **10.7 Operands** **PRECISION/CRITERION**

*This precision is used for the construction of the generator like defining the limit enters a right pipe section and an element curve (distinction based on the alignment of the 3 or 4 nodes element).*

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## **11 Word**

**key**

**DEFI\_ARC**

### **11.1 Characteristics**

**easily affected**

*Allows to assign to curved beams (POU\_C\_T) (elements with 2 nodes) of the characteristics related to curve of the element (radius of curvature and orientation of the plan of the arc). Those can be defined in the choice by the key words: POIN\_TANG, CENTRE or (ORIE\_ARC and).*

### **11.2 Notice**

**The key words of DEFI\_ARC are used to define the geometrical characteristics (radius of curvature and**

**plan of the elbow) of the curved element of beam. The principal reference mark of inertia is not defined here, and must**

**to be given as for the right beams by the key word ORIENTATION (ANGL\_VRIL/VECT\_Y), in supposing that the element is right (segment NR NR**

**I**

**J).**

### **11.3 Syntax**

**DEFI\_ARC = (**

```
_F (  
/MESH  
=  
lma  
,  
[l_maille]  
/  
GROUP_MA  
=  
lgma,  
[l_gr_maille]  
  
/POIN_TANG  
=  
(xt  
,  
yt  
,  
zt),  
[l_R]  
/NOEUD_POIN_TANG  
= No,  
[node]  
/GROUP_NO_POIN_TG  
=  
gno,  
[gr_noeud]  
/  
CENTER  
=  
(xc  
,  
yc  
,  
zc),  
[l_R]  
/NOEUD_CENTRE  
= No,  
[node],  
/  
GROUP_NO_CENTRE  
=  
gno,
```

**[gr\_noeud]**

/

**ORIE\_ARC = arc,**

**[R]**

**RAY**

=

**R,**

**[R]**

**/COEF\_FLEX**

=

**cflex,**

**[R]**

/

**COEF\_FLEX\_XY**

=

**cflex\_xy,**

**[R]**

**COEF\_FLEX\_XZ**

=

**cflex\_xz,**

**[R]**

**/INDI\_SIGM**

=

**isigm,**

**[R]**

/

**INDI\_SIGM\_XY**

=

**isigm\_xy,**

**[R]**

**INDI\_SIGM\_XZ**

=

**isigm\_xz,**

**[R]**

**PRECISION**

=

/

**eps,**

**[R]**

/  
1.0E-03 [DEFECT]  
CRITERION =/"ABSOLUTE",  
/  
"RELATIVE", [DEFECT]  
)  
)  
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## **11.4 Operands**

**POIN\_TANG/NOEUD\_POIN\_TANG/GROUP\_NO\_POIN\_TG**

**/POIN\_TANG**

= (xt, yt, zt)

**/NOEUD\_POIN\_TANG**

= "NT"

**/GROUP\_NO\_POIN\_TG**

= "GNT"

*The point of intersection T of the tangents defines in the arc in its two ends (intersection of lines of diagram), either by its co-ordinates (xt, yt, zt) in the total reference mark, or by the name of node located in this point ("NT"), is by the name of a group of nodes ("GNT") container only one node corresponding to this point.*

Ni

T

*Nj*  
*C*

### ***11.5 Operands***

***CENTER/NOEUD\_CENTRE/GROUP\_NO\_CENTRE***

***/CENTER***

***= (xc, yc, zc)***

***/NOEUD\_CENTRE***

***= "NC",***

***/GROUP\_NO\_CENTRE***

***= "GNC",***

*The center of curve C of the element defines. Angle (C, Nj, Ni) must be strictly lower than 2.*

*The point C is defined either by its co-ordinates (xc, yc, zc) in the total reference mark, or by the node located out of C given by its name ("NC") or by the name of a group ("GNC") containing only it node.*

### ***11.6 Operands***

***PRECISION/CRITERION***

*The precision for the checking defines that C is well the center of the arc of circle NR NR*

***I***

***J:***

***C NR - C NR***

***I***

***J < eps***

***(CRITERION: "ABSOLUTE")***

***C NR - C NR < eps C NR***

***I***

***J***

***I***

***(CRITERION: "RELATIVE")***

### ***11.7 Operands***

***RAY/ORIE\_ARC***

***ORIE\_ARC***

***=***

***arc***



*Angle of orientation of the arc of the element (in degrees). The angle arc defines rotation around the axis*

*room  $x_l$  (determined by the two ends of arc  $N_i$  and  $N_j$ ) allowing to pass from  $(M, x_l, y_l, z_l)$  with  $(M, x_l, y_l, z_l)$  [Figure 11.7-a].*

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*RAY = Rcourb*

*Radius of curvature of the element. It makes it possible to calculate the center C of the arc [Figure 11.7-b].*

*Z1*

*ZL*

*arc*

*YL*

*arc*

*M*

*Y1*

*XL*

*Appear 11.7-a*

*Z1*

*ZL*

*YL*

*Ni*

*Y1*

*arc*  
*R*  
*arc*  
*court*  
*M*  
*B*  
*Nj*  
*XL*  
*C*

*Appear 11.7-b*

*Note:*

- *the reference mark (M, xl, y1, z1) is calculated automatically starting from Ni, Nj, ends of meshes belonging to lma or lgma, following the same principle as for the key word ORIENTATION [Figure 10.4-a] and [Figure 10.4-b],*
- *the local axis yl is directed C towards Mr.*

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*11.8 Operand COEF\_FLEX, COEF\_FLEX\_XZ, COEF\_FLEX\_XY: coefficients of flexibility*

*COEF\_FLEX*

*= cflex*

*COEF\_FLEX\_XZ*

$= cflex_{xz}$   
 $COEF\_FLEX\_XY$   
 $= cflex_{xy}$

*For the modeling of the elbows of pipings the representation by elements of beam circular is insufficient to represent the flexibility of a thin hull. The coefficient of flexibility corrects the geometrical data (geometrical moments of inertia) in accordance with rules of construction. For example, rules  $RCC\_M$  lead, to make the calculation of rigidity of inflection with one geometrical moment of inertia:*

$I_y, Z$  (tube)

$I$   
 $=$   
 with  $cflex$   
 $y, Z$   
 $> .$   
 $I$   
 $cflex$

*A traditional value of  $cflex$ , for a piping thickness  $E$  and average radius  $R_{moy}$ , is*

$65$   
 $\cdot$   
 $I$   
 $E R$   
 given by:  
 $courb$   
 $cflex =$   
 with  
 $=$   
 $\cdot$   
 $2$

$R_{moy}$   
*This value can be calculated directly in the command file (see test  $FORMA01A$  for example).*

$I$  (tube)  
 $y$   
 $I_y = cflex_{xz}$

*If 2 coefficients are given, one obtains:*

$I$  (tube)  
 $I$   
 $Z$

$Z = cflex\_xy$

*By defect,  $cflex = cflex\_xz = cflex\_xy = 1$  (not of modification of geometrical inertias).*

### ***11.9 Operands INDI\_SIGM/INDI\_SIGM\_XZ/INDI\_SIGM\_XY: Index of intensification of the constraints***

***INDI\_SIGM***

***= isigm***

***INDI\_SIGM\_XZ***

***= isigm\_xz***

***INDI\_SIGM\_XY***

***= isigm\_xy***

***For the calculation of bending stresses in the curved elements of beams of section tubular, one can take account of a coefficient of intensification due to ovalization. The constraints are written then:***

***My. R***

***Mz. R***

***xx =***

***\*isigm or***

***\*isigm; with isigm 1.***

***Iy***

***Iz***

***If 2 indices are given, one a:***

***My. R***

***xx =***

***.isigm\_xz***

***Iy***

***Mz. R***

***or***

***xx =***

***.isigm\_xy***

***Iz***

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### **11.10 Notice**

***It is possible to check the characteristics of the curved elements of beams (angle, ray of curve) in the file “messages” by giving INFORMATION = 2.***

### **11.11 Example of use**

***Piping comprising two elbows (problem of Hoovgaard resulting from test SLL101B).***

-0.

-0.922

**With**

-1.828

**B**

-0.922

**0.922**

-0.

**2.75**

**Z**

=

=

**4 5**

=

**3**

**6**

=

**7**

=

**With**

**8**

**9**

**69**

**10**

**B**

**3.**

**11**

**2**

**12**

**y**

**13**

**=**

**14**

**=**

**=**

**15**

**=**

**1.96**

**=**

**X**

**1**

- *diameter external of the pipe: 0.185 m*
- *thickness of the pipe: 6.12 mm*
- *radius of curvature of the elbows: 0.922 m*

*The 2 elbows are formed of the elements:*

- *E3 (nodes 3 and 4) E4 (nodes 4 and 5)*
- *E9 (nodes 9 and 10) E10 (nodes 10 and 11)*

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**8.2**

*Titrate:*

*Operator AFFE\_CARA\_ELEM*

**Date:**

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**The values of (,) are:**

**NAME**

**TYPE**

**ALPHA**

**BETA**

**E1**

**MECA\_POU\_D\_T**

**0.000000E+00**

**-.900000E+02**

**E2**

**MECA\_POU\_D\_T**

**0.000000E+00**

**-.900000E+02**

**E5**

**MECA\_POU\_D\_T**

**0.900000E+02**

**0.000000E+00**

**E6**

**MECA\_POU\_D\_T**

**0.900000E+02**

**0.000000E+00**

**E7**

**MECA\_POU\_D\_T**

**0.900000E+02**

**0.000000E+00**

**E8**

**MECA\_POU\_D\_T**

**0.900000E+02**

**0.000000E+00**

**E11**

**MECA\_POU\_D\_T**

**0.000000E+00**

**0.000000E+00**

**E12**

**MECA\_POU\_D\_T****0.000000E+00****0.000000E+00****E13****MECA\_POU\_D\_T****0.000000E+00****0.000000E+00****E14****MECA\_POU\_D\_T****0.000000E+00****0.000000E+00****E3****MECA\_POU\_C\_T****0.900000E+02****-.675050E+02****E4****MECA\_POU\_C\_T****0.900000E+02****-.224950E+02****E9****MECA\_POU\_C\_T****0.675050E+02****0.000000E+00****E10****MECA\_POU\_C\_T****0.224950E+02****0.000000E+00****CARA\_ELE = AFFE\_CARA\_ELEM (****MODEL = model,****INFORMATION = 2,****BEAM = (****\_F (GROUP\_MA = "SEC\_1",****SECTION = "GENERAL",****# right pipe****CARA = ("A", "IZ", "IY", "AY", "AZ", "JX", "EZ", "EY",****"RY", "RZ", "RT"),****VALE = (3.4390E-3, 2\*1.3770E-5,****2\*2.0, 2.7540E-5, 2\*0., 3\*1.),****),****\_F (GROUP\_MA = "SEC\_2",****# elbows****VALE = (3.4390E-3, 2\*5.8870E-6,**



```
2*2., 2.7540E-5, 2*0., 3*1.),
),
),
DEFI_ARC = (
_F (MESH = ("E9", "E10"),
POIN_TANG = (0.0, 0.0, 0.0),
PRECISION = 1.E-3,
CRITERION = "RELATIVE",
),
_F (MESH = ("E3", "E4"),
CENTER = (0. , -1.8280, -0.9220),
PRECISION = 1.E-3,
CRITERION = "RELATIVE",
),
),
)
```

*The computed values by AFFE\_CARA\_ELEM are:*

```
KEY WORD FACTOR "DEFI_ARC" (meshs E9 E10)
KEY WORD "NETS", RCOURB: 0.9219999999999899
KEY WORD "NETS", ORIE_ARC: 0.
KEY WORD "NETS", ANGLE_ARC: 90.
KEY WORD "NETS", CENTER: 0.921999999999864, -0.921999999999864, 0.
KEY WORD FACTOR "DEFI_ARC" (meshs E3 E4)
KEY WORD "NETS", RCOURB: 0.9219999999999828
KEY WORD "NETS", ORIE_ARC: 90.
KEY WORD "NETS", ANGLE_ARC: 90.000000000000091
KEY WORD "NETS", CENTER: 0. , -1.82799999999996, -0.92199999999997
```

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**12 Words**

**keys**

**AFFE\_SECT/AFFE\_FIBRE**

**12.1 Syntax**

**AFFE\_SECT = (**

**\_F (**

**NAME**

**=**

**nomsect [TXM]**

**/GROUP\_MA**

**=**

**(“GMA1”, “GMA2”,...), [l\_gr\_maille]**

**/**

**NET**

**=**

**(“MA1”, “MA2”,...),**

**[l\_maille]**

**MAILLAGE\_SECT**

**=**

**MASEC1, [grid]**

**COOR\_AXE\_POUTRE**

**=**

**(yg, zg,)**

**[l\_R]**

**/TOUT\_SECT**

**=**

**“YES”,**

**/GROUP\_MA\_SECT**

**=**

**(“g1”, “g2”,...)**

**[l\_gr\_maille]**

**/**

**MAILLE\_SECT**

**=**

**(“m1”, “m2”,...)**

```

[l_maille]
),
),
AFFE_FIBRE = (
_F (
NAME
=
nomsect [TXM]
/GROUP_MA
=
("GMA1", "GMA2",...)
[l_gr_maille]
/
NET
=
("MA1", "MA2",...) [l_maille]

COOR_AXE_POUTRE
=
(xg, yg), [l_R]
CARA =/"SURFACE", [DEFECT]
/"DIAMETER",
VALE =
(
x1, y1, a1,
x2, y2, a2,
... .. , ...
xn
,
yn
, year
,)
[l_R]
),
)

```

*Key words used to define the section of the multifibre beams, (modelings POU\_D\_EM or POU\_D\_TGM) either using a grid (AFFE\_SECT) or fibre by fibre (AFFE\_FIBRE).*

## **12.2 Drank**

*Within the framework of a modeling of the multifibre type, there are two "levels" of modeling. It there with modeling known as "longitudinal" which will be represented by a beam (geometrical support SEG2)*

*and a modeling planes section (perpendicular to the SEG2). Key word AFFE\_SECT allows to associate a plane grid of section (read beforehand by operator LIRE\_MAILLAGE) an element beam. AFFE\_FIBRE makes it possible to describe the section in the form of specific surfaces.*

**Note:**

*It may be that in modeling section planes, several materials cohabit. By example, in a section concrete reinforced, there are at the same time concrete and reinforcements. In this case, operator CREA\_MAILLAGE allows to duplicate support SEG2 so that there is one material by support. (see for example test SSNL119 [V6.02.119]).*

**Caution:**

*The information given in AFFE\_SECT or AFFE\_FIBRE, makes it possible to calculate some integrated characteristics of the cross-sections (surface, moments static and quadratic). In spite of that, it is necessary to give coherent values for operands A, IY, IZ under the key word BEAM. A checking is carried out on the coherence of these sizes. If the relative error is too important (cf key words PREC\_AIRE, PREC\_INERTIE) a fatal error is emitted.*

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**12.3 Words**

**keys**

## ***AFFE\_SECT and AFFE\_FIBRE***

***/AFFE\_SECT***

***/AFFE\_FIBRE***

***The entities of the grid of beams concerned and the sections define which are to them affected. Key word AFFE\_SECT makes it possible to affect a section defined by a plane grid (the elements of this grid are the sections of fibres) and key word AFFE\_FIBRE allows to affect a section where the fibres are defined by points.***

***The rule of overload applies between several occurrences of the key words factors AFFE\_SECT or AFFE\_FIBRE [U1.03.00].***

### ***12.3.1 Operands commun runs with AFFE\_SECT and AFFE\_FIBRE***

***/MESH***

***/GROUP\_MA***

***These operands make it possible to define the entities of the grid of beams (elements SEG2) which are concerned with the occurrence of the key word factor:***

***Operands***

***Contents/Significance***

***NET***

***Assignment with a list of meshes***

***GROUP\_MA***

***Assignment with a list of groups of meshes***

***COOR\_AXE\_POUTRE = (yg, zg)***

***This operand makes it possible to define the co-ordinates of the neutral axis of the beam in the reference mark of***

***cross-section: integrations (static moments or of inertias) will be made compared to this center. The position (0. 0.) corresponds at the origin of the co-ordinates used for the grid surface in the case of AFFE\_SECT or in the beginning chosen to define the co-ordinates data using operand VALE in the case of AFFE\_FIBRE.***

***Z***

***G***

***zg***

**O**  
**yg**  
**y**

## **NAME**

*This operand makes it possible to define a name for the cross-section (8 characters). This name is pointed out*

*in the messages concerning this cross-section (see operand INFORMATION).*

*If NAME is not used under AFFE\_SECT, the name of the section (allotted automatically) is “SECT\_i” where I is the ième occurrence of AFFE\_SECT in the data file. The same if NAME is not used under AFFE\_FIBRE, the name of the automatic section is “PONCT\_j” where J is jème occurrence of AFFE\_FIBRE in the data file.*

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## **12.3.2 Operands specific to AFFE\_SECT**

### **MAILLAGE\_SECT**

*Name of the plane “grid” which contains the “description of the section”.*

*By “grid”, one understands a whole of triangular meshes with 3 nodes and/or quadrilaterals with 4 nodes.*

*By “description of the section”, one understands part of this “grid” specified by one of operands TOUT\_SECT, MAILLE\_SECT or GROUP\_MA\_SECT. Each mesh represents section of a fibre.*

*/TOUT\_SECT*

*/MAILLE\_SECT*

*/GROUP\_MA\_SECT*

*Operands*

*Contents/Significance*

*TOUT\_SECT*

*The section is defined by the totality of the meshes of the grid defined under*

*MAILLAGE\_SECT*

*MAILLE\_SECT*

*The section is defined by a list of meshes*

*GROUP\_MA\_SECT*

*The section is defined by a list of groups of meshes*

*Note:*

- Since it is not used as support with finite elements, the “grid” does not have obligatorily to have a connectivity, it can be composed of a whole of juxtaposed meshes which touch or do not touch themselves.*
- All the meshes defined in the “description of the section” will have the same behavior, that of the finite element of beam to which they are affected (see remark in §1).*
- The co-ordinates y and Z of the plane grid of the section (y horizontal, Z vertical) are defined in a plan perpendicular to the axis of the beam. This axis is defined using the operand COOR\_AXE\_POUTRE. To define the angle of gimlet, i.e. the angle enters the axis there of the grid plan of the section and the axis Y of the element beam, it is necessary to use the key word ORIENTATION of operator AFFE\_CARA\_ELEM (see example).*

### *12.3.3 Operands specific to AFFE\_FIBRE*

*The cross-section of the element beam is defined by a whole of “specific” fibres.*

*CARA*

*Allows to specify if the third value given for each fibre is surface (by defect) or the diameter (see VALE).*

*VALE*

*Each fibre is described by a triplet of values: y, Z and valley. It is necessary to give them*

values according to this sequence, and there are as many triplets as of fibres.

- *Y* and *Z* are the co-ordinates of the center of fibre in a plan perpendicular to the axis of beam. The position of the axis of the beam can be modified thanks to the operand *COOR\_AXE\_POUTRE*. To give an angle of gimlet, the operand *ORIENTATION* should be used.
- *Val* is either the surface of a fibre, or the diameter of a cylindrical fibre.

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**13 Word**

**key**

***DISCRETE and DISCRET\_2D***

**13.1 Characteristics**

***easily affected***

*These key words make it possible to assign directly to entities (meshs or nodes), which support elements of the type *DIS\_T*, *DIS\_TR* (*DISCRETE*) or *2D\_DIS\_T*, *2D\_DIS\_TR* (*DISCRET\_2D*), of matrices of **rigidity**, **mass** or **damping**.*

*On all the entities one can affect matrices corresponding to the degrees of freedom of translation (*T*) only or with the degrees of freedom of translation and rotation (*TR*). The matrices can be diagonals (*D*) or full. In this case, they are obligatorily symmetrical and one will only provide triangular higher, with a convention of classification of the terms imposed (see examples).*

*The matrices can be affected:*

- *with nodes or meshs of the types *POI1*; they are then known as nodal matrices (*NR*),*



· with meshes of the type *SEG2*; they are then known as matrices of connection (*L*).

In the event of assignment of matrices to meshes or nodes, the type of *DISCRETE* element must be affected, au préalable, with these meshes or these nodes by operator *AFFE\_MODELE* [U4.41.01].

## 13.2 Syntax

```

DISCRETE and DISCRET_2D = (
  _F (
    /MESH
    = lma
  ,
    [l_maille]
  /
  GROUP_MA
  =
  lgma,
  [l_gr_maille]
  /NODE
  = lno
  ,
  [l_noeud]
  /
  GROUP_NO
  =
  lgn,
  [l_gr_noeud]

# matrices
of
rigidity
/CARA
  =
  |“K_T_D_N” | “K_TR_D_N” | “K_T_D_L” | “K_TR_D_L”,
  | “K_T_N” | “K_TR_N” | “K_T_L” | “K_TR_L”,
# matrices
of
mass
  /
  CARA = | “M_T_D_N” | “M_TR_D_N”,
  | “M_T_N” | “M_TR_N” | “M_T_L” | “M_TR_L”,

```

**# matrices  
of damping**

**/  
CARA = | “A\_T\_D\_N” | “A\_TR\_D\_N” | “A\_T\_D\_L” | “A\_TR\_D\_L”,  
| “A\_T\_N” | “A\_TR\_N” | “A\_T\_L” | “A\_TR\_L”,**

**VALE = lva, [l\_R]**

**LOCATE  
= / “LOCAL”,  
/  
“TOTAL”,  
[DEFECT]**

**AMOR\_HYST  
=  
/  
0.0,  
[DEFECT]**

**/  
amnh,  
[R]  
,  
)**

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## **13.3 Operands**

### **13.3.1 Rules of use**

#### **· RIGIDITY or DAMPING**

**CARA CARA**

**ENTITY**

**DIS\_\***

**2D\_DIS\_\***

**VALE**

**VALE**

**“K\_T\_D\_N” “A\_T\_D\_N”**

**node or POII**

**3 terms**

**2 terms**

**“K\_T\_D\_L” “A\_T\_D\_L”**

**SEG2**

**3 terms**

**2 terms**

**“K\_TR\_D\_N” “A\_TR\_D\_N”**

**node or POII**

**6 terms**

**3 terms**

**“K\_TR\_D\_L” “A\_TR\_D\_L”**

**SEG2**

**6 terms**

**3 terms**

**“K\_T\_N” “A\_T\_N”**

**node or POII**

**6 terms**

**3 terms**

**“K\_T\_L” “A\_T\_L”**

**SEG2**

**21 terms**

**10 terms**

**“K\_TR\_N” “A\_TR\_N”**

**node or POII**

**21 terms**

**6 terms**

**“K\_TR\_L” “A\_TR\_L”**

**SEG2**

**78 terms**

21 terms

· MASS

**CARA ENTITY**

**DIS\_\***

**2D\_DIS\_\***

**VALE**

**VALE**

“M\_T\_D\_N”

node or POII

1 (mass)

1 (mass)

“M\_TR\_D\_N”

node or POII

10 (mass/inertia)

nonavailable

“M\_T\_N”

node or POII

6 (mass/inertia)

3 (mass/inertia)

“M\_T\_L” SEG2 21 (mass/inertia)

10 (mass/inertia)

“M\_TR\_N”

node or POII

21 (mass/inertia)

6 (mass/inertia)

“M\_TR\_L” SEG2

78 (mass/inertia)

21 (mass/inertia)

**13.3.2 Operands  $K_*$  (matrices of rigidity) or  $A_*$  (matrices of damping)**

**$K_{T_D_N/A_{T_D_N}}$**

**for a mesh of the type POII or a node, one finds in correspondence in VALE 3  $K_x$  values,  $K_y$ ,  $K_z$  in  $DIS_T$  and 2  $K_x$  values,  $K_y$  in  $2D\_DIS_T$  such as:**

**U U U**

**X**

**y**

**Z**

**U U**

**X**

**y**

***K***  
***0***  
***0***  
***X***  
***Kx***  
***0***

***K***  
***=***  
***or A =***  
***0***  
***K***  
***K or A***

***y***  
***0***  
***0***  
***K***

***y***  
***0***  
***0***  
***K***

***Z***

***K\_T\_D\_L/A\_T\_D\_L***  
***for a mesh of the type SEG2, K being the matrix previously definite:***  
***Noeud1 Noeud2***

***K***  
***- K***  
***- K***  
***K***

***it is thus enough to provide the 3 values Kx, Ky and Kz.***  
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**K\_TR\_D\_N/A\_TR\_D\_N**

**for a mesh of the type POI1 or node, one finds in correspondence in VALE 6 values Kx, Ky, Kz, KRx, KRy, KRz in DIS\_TR or 3 Kx values, Ky, KRz in 2D\_DIS\_TR such as:**

**U U U R R R**

**X**

**y**

**Z**

**X**

**y**

**Z**

**K**

**0**

**X**

**0**

**0**

**0**

**0**

**U U R**

**X**

**y**

**Z**

**0**

**K**

*y*  
*0*  
*0*  
*0*  
*0*  
*0*  
*K*  
*0*

*0*

*X*  
*0 0*  
*K*  
*K or A =*

*Z*  
*0*  
*0*  
*0*

*0*  
*K*  
*0*  
*K or A*

*y*  
*=*

*0*  
*0*  
*0*  
*KR*

*0*  
*0*  
*0*  
*0*

*X*

**KR**

**Z**

**0**

**0**

**0**

**0**

**KR**

**0**

**y**

**0**

**0**

**0**

**0**

**0**

**KR**

**Z**

***K\_TR\_D\_L/A\_TR\_D\_L***

*for a mesh of the type SEG2, K being the matrix previously definite:*

***Noeud1 Noeud2***

**K**

**- K**

**- K**

**K**

*it is enough to give the 6 values above.*

***K\_T\_N/A\_T\_N***

*for a mesh of the type POI1 or a node, one finds in correspondence in VALE 6 K1 values, K2,... K6 in DIS\_T or 3 K1 values, K2, K3 in 2D\_DIS\_T such as:*

**U U U**

**X**

**y**

**Z**



*U U*

*X*

*y*

*K*

*K*

*K*

*1*

*2*

*4*

*K*

*K*

*1*

*2*

*K*

*=*

*or A =*

*K*

*K*

*K or A*

*3*

*5*

*K*

*3*

*K*

*6*

*K\_T\_L/A\_T\_L*

*for a mesh of the type SEG2, one finds in correspondence in VALE 21 values K1, K2,..., K21 in DIS\_T or 10 K1 values, K2,... K10 in 2D\_DIS\_T and stamps it following rigidity will be affected:*

*U U U U*

*U*

*U*

*x1*

*y1*

*z1*

*x2*

*y2*

*z2*

*U U U*

*U*

*K*

*K*

*K*

*K*

*K*

*K*

*x1*

*y1*

*z2*

*y2*

*1*

*2*

*4*

*7*

*11*

*16*

*K*

*K*

*K*

*K*

*K*

*K*

*K*

*K*

*K*

*1*

*2*

*4*

*7*

*3*

*5*

*8*

*12*

*17*

***K or A =***

***K***

***K***

***K***

***K***

***K***

***K***

***K***

***3***

***5***

***8***

***K or A***

***6***

***9***

***13***

***18***

***=***

***K***

***K***

***K***

***K***

***K***

***6***

***9***

***10***

***14***

***19***

***K***

***K***

***K***

**10**  
**15**  
**20**

**K**

**21**  
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**K\_TR\_N/A\_TR\_N**  
**for a mesh of the type POI1 or a node, one finds in correspondence in VALE 21 K1 values,**  
**K2,..., K21 in DIS\_TR or 6 values K1, K2,... K6 in 2D\_DIS\_TR such as:**

**U U U R R R**  
**X**  
**y**  
**Z**  
**X**  
**y**  
**Z**  
**K**  
**K**  
**K**

**K**  
**K**  
**K**  
**1**  
**2**  
**4**  
**7**  
**11**  
**16**  
**UUR**

**K**  
**K**  
**K**  
**K**  
**K**  
**X**  
**y**  
**Z**

**3**  
**5**  
**8**  
**12**  
**17**  
**K**  
**K**  
**K**

**K**  
**K**  
**K**  
**K**  
**1**  
**2**  
**4**  
**6**  
**9**  
**13**  
**18**  
**K or A =**

**K or A =**

***K***  
***K***

***K***  
***K***  
***K***

***3***  
***5***

***10***  
***14***  
***19***

***K***

***K***  
***K***

***6***

***15***  
***20***

***K***

***21***

***K\_TR\_L/A\_TR\_L***

***for a mesh of the type SEG2, one finds in correspondence in VALE 78 values K1, K2,..., K78 in DIS\_TR.***

***U U U R R R***

***U***

***U***

***U***

***R R***

***R***

***x1***

***y1***

***z1***

***x1***

***y1***

*z1*  
*x2*  
*y2*  
*z2*  
*x2*  
*y2*  
*z2*  
*K*  
*K*  
*K*  
*K*  
*K K*  
*K*  
*K*  
*K*  
*K*  
*K*  
*1*  
*2*  
*4*  
*7*  
*11*  
*16*  
*22*  
*29*  
*37*  
*46*  
*56*  
*67*  
  
*K*  
*K*  
*K*  
*K*  
*K K*  
*K*  
*K*  
*K*  
*K*  
*K*  
*3*  
*5*

**8**  
**12**  
**17**  
**23**  
**30**  
**38**  
**47**  
**57**  
**68**

**K**  
**K**  
**K**  
**K**  
**6**  
**9**  
**13**  
**18 K**  
**K**  
**K**  
**K**  
**K**  
**K**  
**24**  
**31**  
**39**  
**48**  
**58**  
**69**

**K**  
**K**  
**K**  
  
**10**  
**14**  
**19 K**  
**K**  
**K**  
**K**



**K**  
**K**  
**25**  
**32**  
**40**  
**49**  
**59**  
**70**

**K**  
**K**

**15**  
**20 K**  
**K**  
**K**  
**K**  
**K**  
**K**  
**26**  
**33**  
**41**  
**50**  
**60**  
**71**

**K**

**21 K**  
**K**  
**K**  
**K**  
**K**  
**K**  
**27**  
**34**  
**42**  
**51**  
**61**  
**72**  
**K or A =**

**K**  
**K**  
**K**  
**K**  
**K**  
**K**

**28**  
**35**  
**43**  
**52**  
**62**  
**73**

**K**  
**K**  
**K**  
**K**  
**K**  
**36**  
**44**  
**53**  
**63**  
**74**

**K**  
**K**  
**K**  
**K**

**45**  
**54**  
**64**  
**75**

**K**

***K***  
***K***  
***55***  
***65***  
***76***

***K***  
***K***  
***66***  
***77***

***K***

***78***  
***or 21 values K, K, ..., K in 2D\_DIS\_TR such as:***

***1***  
***2***  
***21***  
***UURU***  
***U***  
***R***  
***x1***  
***y1***  
***z1***  
***x2***  
***y2***  
***z2***  
***K***  
***K***  
***K***  
***K***  
***K***  
***K***  
***1***  
***2***  
***4***  
***7***  
***11***  
***16***

***K***  
***K***  
***K***  
***K***  
***K***  
***3***  
***5***  
***8***  
***12***  
***17***

***K***  
***K***  
***K***  
***K***  
***K***  
***6***  
***9***  
***13***  
***18***  
***or A =***

***K***  
***K***  
***K***  
  
***10***  
***14***  
***19***

***K***  
***K***  
***15***  
***20***

***K21***

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**Version**

**8.2**

**Titrate:**

**Operator AFFE\_CARA\_ELEM**

**Date:**

**31/01/06**

**Author (S):**

**J-L. Key FLÉJOU**

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**13.3.3 Operands  $M$  Matrices of mass**

**$M\_T\_D\_N$**

**for a mesh of the type POI1 or a node, one finds in correspondence in VALE a value  $Mr$ .  
The matrix of following mass will be affected:**

**$U\ U\ U$**

**$X$**

**$y$**

**$Z$**

**$m\ 0\ 0$**

**$M =$**

**$0\ m$**

**$0$**

**$0\ 0\ m$**

**$M\_TR\_D\_N$  (nonavailable in 2D\_DIS\_TR)**

**for a mesh of the type POI1 or a node, one finds in correspondence in VALE a value of**

**mass  $m$ , 6 values of the tensor of inertia (mass):  $I, I, I, I, I, I$**

**$xx$**

**$yy$**

**$zz$**

**$xy$**

**$yz$**

**$xz$ , and 3 components**

**vector of eccentricity of the mass compared to its node:  $E, E, E$**

**$X$**

**$y$**

**$Z$ . The matrix of mass**

**following will be affected:**

**$U$**

**$2$**

**$2$**

**$X$**

**$U$**

**$y$**

**$U$**

**$Z$  X-ray  $Ry$   $Rz$**

**$V_{xx} = I_{xx} + m (e_z + e_y)$**

**$m$**

**$0$**

**$0$**

**$0$**

**$- m e$**

**$2$**

**$2$**

**$Z$**

**$m e$**

**$y$**

**$V_{yy} = I_{yy} + m (e_x + e_z)$**

**$m$**

**$0$**

**$m e$**

**Z**  
**0**

**- mex**

**V**  
**2**  
**2**

$$zz = I zz + m (E y + ex)$$

**M =**  
**m**

**- me**

**y**  
**me**

**X**  
**0**

$$Vxy = I xy - m E$$

**X E**

**y**

**V**

**xx**

**V**

**xy**

**V**

**xz**

**V**

$$yz = I yz - m E$$

**y E**

**Z**

**V**

**yy**

V  
yz

V

V

$$xz = I xz - m E$$

X E

Z

zz

Z

y

G

Node

X

**Caution:**

*The eccentricity must be expressed in the total reference mark: co-ordinates of vector NG (eccentricity) directed node towards the mass.*

*M\_T\_N  
for a mesh of the type POI1 or node, one finds in correspondence in VALE 6 values M1, m2, ..., M6 in DIS\_T or 3 M1 values, m2, m3 in 2D\_DIS\_T and stamps it of following mass will be affected:*

U U U

X

y

Z

U U

M

M

M

X

y



***1***

***2***

***4***

***M***

***M***

***1***

***2***

***M =***

***M***

***M***

***M***

***3***

***5***

***=***

***M***

***3***

***M***

***6***

***See for example test SDLD27 [V2.01.027].***

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*M\_TR\_N*

*for a mesh of the type POI1 or node, one finds in correspondence in VALE 21 M1 values, M2,..., M21 in DIS\_TR or 6 values M1, m2,..., M6 in 2D\_DIS\_TR and stamp it of mass following will be affected:*

*U U U R R R*

*X*

*y*

*Z*

*X*

*y*

*Z*

*M*

*M*

*M*

*M*

*M*

*M*

*1*

*2*

*4*

*7*

*11*

*16*

*U U R*

*M*

*M*

*M*  
*M*  
*M*  
*X*  
*y*  
*Z*

*3*  
*5*  
*8*  
*12*  
*17*  
*M*  
*M*  
*M*

*M*  
*M*  
*M*  
*M*  
*1*  
*2*  
*4*  
*6*  
*9*  
*13*  
*18*

*M =*  
*M =*  
*M*  
*M*

*M*  
*M*  
*M*

*3*  
*5*  
  
*10*  
*14*  
*19*

*M*

*M*

*M*

6

15

20

*M*

21

*M\_T\_L*

*for a mesh of the type SEG2, one finds in correspondence in VALE 21 values M1, m2, ..., M21 in DIS\_T or 10 M1 values, m2, ..., M10 in 2D\_DIS\_T and stamp it of following mass will be affected:*

*U U U U*

*U*

*U*

*x1*

*y1*

*z1*

*x2*

*y2*

*z2*

*M*

*M*

*M*

*M*

*M*

*M*

1

2

4

7

11

16

*U U U*

*U*

*x1*

*y1*

*x2*

*y2*

*M*

*M*

*M*

*M*

*M*

*M*

*M*

*M*

*M*

*3*

*5*

*8*

*12*

*17*

*1*

*2*

*4*

*7*

*M*

*M*

*M*

*M*

*M*

*M*

*M*

*M*

*6*

*9*

*13*

*18*

*=*

*M*

3  
5  
8  
=

*M*  
*M*  
*M*  
  
*M*

*10*  
*14*  
*19*  
*6*  
*M9*

*M*  
  
*M*  
*15*  
*20*

*M*

*10*

*M*

*21*

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*M\_TR\_L*

*for a mesh of the type SEG2, one finds in correspondence in VALE 78 values M1, m2,..., M78 in DIS\_TR and the matrix of following mass will be affected:*

*U U U R R R U*

*U*

*U*

*R R R*

*x1*

*y1*

*z1*

*x1*

*y1*

*z1*

*x2*

*y2*

*z2*

*x2*

*y2*

*z2*

*M*

*M*

*M*

*M*

*M*

*MR. M*

*M*

*M*

*M*

*M*

*M*

1  
2  
4  
7  
11  
16  
22  
29  
37  
46  
56  
67

*M*  
*M*  
*M*  
*M*  
*MR. M*

*M*  
*M*  
*M*  
*M*  
*M*  
3  
5  
8  
12  
17  
23  
30  
38  
47  
57  
68

*M*  
*M*  
*M*  
*MR. M*  
*M*

6



9  
13  
18  
24  
31  
M  
M  
M  
M  
39  
48  
58  
69

M  
M  
M

10  
14  
19 M  
M  
M  
M  
M  
M  
25  
32  
40  
49  
59  
70

M  
M

15  
20 M  
M  
M  
M

*M*  
*M*  
26  
33  
41  
50  
60  
71

*MR. M*

*M*  
*M*  
*M*  
*M*  
*M*

*M*  
21  
=  
27  
34  
42  
51  
61  
72

*M*  
*M*  
*M*  
*M*  
*M*  
*M*

28  
35  
43  
52  
62  
73

*M*  
*M*  
*M*  
*M*  
*M*  
36  
44  
53  
63  
74

*M*  
*M*  
*M*  
*M*

45  
54  
64  
75

*M*  
*M*  
*M*  
55  
65  
76

*M*  
*M*  
66  
77

*M*

78

*or 21 values M,*

*M*

...,

*M*

*in*

*1*

*2*

*21*

*2D\_DIS\_TR*

*U U R U*

*U*

*R*

*x1*

*y1*

*z1*

*x2*

*y2*

*z2*

*M*

*M*

*M*

*M*

*M*

*M*

*1*

*2*

*4*

*7*

*11*

*16*

*M*

*M*

*M*

*M*

*M*

3  
5  
8  
12  
17

*M*  
*M*  
*M*  
*M*  
*M* =  
6  
9  
13  
18

*M*  
*M*  
*M*  
10  
14  
19

*M*  
*M*  
  
15  
20

*M21*

**Note:**

*Two options  $M_{T_L}$  and  $M_{TR_L}$  do not correspond in general to an option of modeling having a mechanical significance. They are usable to only import in Aster of matrices of masses discretized on a mesh of the type SEG2 by another software. Indeed, one affect usually values of specific mass and inertia (mesh POI1) by  $M_{T_D_N}$  or  $M_{TR_D_N}$ .*

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### **13.3.4 Operand *AMOR\_HYST***

***AMOR\_HYST = amor\_h,***

*Allows to assign to a discrete element a coefficient to build a matrix of rigidity complex (hysteretic modeling of damping) the built matrix is:*

(1+

)

**J**

***amor\_H K***

*where K is the  $K_*$  matrix whose values are provided in the same occurrence of the key word DISCRETE. The matrix of rigidity complexes will be actually built at the time of a call to CALC\_MATR\_ELEM [U4.61.01] with option AMOR\_HYST (see test SDLD313) and [R5.05.04].*

### **13.3.5 Operand *LOCATES***

***LOCATE***

***=/“LOCAL”,***

***/“TOTAL”,***

*By defect the values of the matrices provided for the discrete elements are used for*

*to express the corresponding quantities in the REFERENCE MARK = "TOTAL".*  
*If one wishes to define a particular reference mark in a node (or nets of type PO11) one will specify LOCATE = "LOCAL" by defining this reference mark by the key word ORIENTATION [§10].*  
*For a matrix defined on a mesh of the type SEG2 the operand LOCATES = "LOCAL" allows to refer to the local reference mark attached to the mesh (initial node, final node) supplemented if necessary of an angle of gimlet defined by the key word ORIENTATION [§10].*

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*14 Word*  
*key*  
*SOLID MASS*

*14.1 Characteristics*  
*easily affected*

*Allows to assign to elements 3D or 2D of the local axes (which can for example be used to define directions of orthotropism (cf DEFIN\_MATERIAU [U4.43.01])). These local axes are defined by the key words:*

- ANGL\_REP (3 nautical angles) or (ANGL\_AXE and ORIG\_AXE) in 3D,*
- ANGL\_REP (1 only angle) in 2D.*

*14.2 Syntax*

```

SOLID MASS = (
  _F (
/MESH
=
lma
,
[l_maille]
/
GROUP_MA
=
lgma,
[l_gr_maille]

/ANGL_REP = (,
[l_R]
/
ANGL_AXE = (,
[l_R]

ORIG_AXE
=
(x1
,
x2
,
x3),
[l_R]
),
)

```

### **14.3 Operand**

#### **ANGL\_REP**

*are the 3 nautical angles (as for the key word **ORIENTATION**, cf [§10]) defining the axes buildings (X, y, Z), which correspond to the reference mark of orthotropism (L, T, NR). In 2D, it is necessary to only give, what defines reference mark (LT) in the plan.*

### **14.4 Operands**

#### **ANGL\_AXE/ORIG\_AXE**

*These key words are to be given in 3D only to define local axes for which one will use a property of symmetry of revolution, or transverse isotropy (for example: structure with symmetry*



*cylindrical orthotropic).*

*ANGL\_AXE = (, ) defines the axis of revolution x1, (, ) being the first two nautical angles,*

*ORIG\_AXE = (x1, x2, x3) defines a O1 point of the axis.*

*Z*

*x1*

*1*

*O*

*0*

*B*

*y*

*has*

*X*

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*15 Word*

*key*

*ASSE\_GRIL*

*15.1 Syntax*

*ASSE\_GRIL = (*

*\_F (*

*/*

**GROUP\_MA**

=

*lgma,**[l\_gr\_maille]*

/

**NET**

=

*lma,**[l\_maille]***CARA =** | “**K\_TR\_D\_N**” | “**K\_TR\_D\_L\_T**” | “**K\_TR\_D\_L\_N**”,**VALE**

=

*lva*

,

*[l\_R]***PAS\_T**

=

*Pt,**[R]***PAS\_N**

=

*pn*

,

*[R]***COEF\_ECHELLE =** *ech*

,

*[R]***ANGL\_REP**

=

*l\_ang,**[l\_R]*

),

)

## **15.2 Characteristics easily affected**

*This key word factor makes it possible to define the characteristics of rigidity of the finite element (quadrangle in four nodes) associated modeling “ASSE\_GRIL” (cf orders AFFE\_MODELE [U4.41.01]).*

*This modeling relates to the representation of the grids of the fuel assemblies, by one technique of homogenisation. It must be associated modeling "ASSE\_GRIL", allowing to model by homogenisation a network, periodical of beams, bathed in a fluid incompressible (cf [R4.07.05], cf key word factor POUTRE\_FLUI).*

### **15.3 Operand**

#### **GROUP\_MA/MESH**

*Place of employment of the elementary characteristics:*

- list meshes (key word NETS),*
- list of groups of meshes (key word GROUP\_MA).*

### **15.4 Operand**

#### **ANGL\_REP**

*ANGL\_REP = (,)*

*A reference mark (L, T, NR) is associated each mesh. The direction L is the direction perpendicular to the plan means of the mesh.*

*The angles in degree (,) make it possible to define compared to the reference mark of reference the vector to project on the average level of the mesh and which will indicate the direction T (as for the key word HULL, operand ANGL\_REP [Figure 8.3.3-c]).*

### **15.5 Operand**

#### **PAS\_T/PAS\_N/COEF\_ECHELLE**

*These operands define the geometrical characteristics of the characteristic periodic cell grid. COEF\_ECHELLE defines the coefficient of homothety making it possible to transform the cell periodical real in the basic periodic cell with which the homogenized coefficients are calculated.*

*PAS\_T and PAS\_N define dimensions of the rectangular basic cell along the axes T, NR local reference mark.*

### **15.6 Operands**

#### **CARA/VALE**

*These operands make it possible to define all rigidities of the springs associated with this modeling (HI-75/96/074/0).*

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*NR*

*RT*

*RO*

*RO*

*R*

*R*

*NR*

*NR*

*PAS\_N*

*RT*

*T*

*.R*

*R*

*O*

*O*

*L*

*PAS\_T*

*CARA = "K\_TR\_D\_L\_T"*

*(kTL, kTT, kTN, CTL, CTT, CTN*

*D*

*D*

*D*

*D*

*D*

*D*

)  
VALE =

*Differential rigidities (3 in translation, 3 in rotation) common to springs RT, relative to directions L, T, NR.*

CARA = "K\_TR\_D\_L\_N"

NL

NT

NN

NL

NT

NN

VALE = (K

, K

, K

, C

, C

, C

D

D

D

D

D

D

)

*Differential rigidities (3 in translation, 3 in rotation) common to springs RN, relative to directions L, T, NR.*

CARA = "K\_TR\_D\_N"

(\* , \* , \* , CL, CT, CN

L

L

L)

VALE =

*Local rigidities (3 in rotation) common to the Ro springs. 3 rigidities in translation are been unaware of.*

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**16 Word**

**key**

***POUTRE\_FLUI***

**16.1 Syntax**

***POUTRE\_FLUI = (***

***\_F (***

***/***

***GROUP\_MA***

***=***

***lgma,***

***[l\_gr\_maille]***

***/***

***NET***

***=***

***lma,***

***[l\_maille]***

***B\_T***

***=***

***LT,***

***[R]***

***B\_N***

***=***

***bn,***

***[R]***

**B\_TN**

=

**btn,****[R]****A\_FLUI**

=

**aflui,****[R]****A\_CELL**

=

**acell,****[R]****COEF\_ECHELLE = ech**

,

**[R]**

),

)

## **16.2 Characteristics**

*easily affected*

*This key word factor makes it possible to define the characteristics of the finite elements (hexahedron in 8 or 20*

*nodes) associated modeling “3D\_FAISCEAU” (cf orders AFFE\_MODELE [U4.41.01]). This modeling relates to the representation of a periodic network of tubes bathed by a fluid incompressible (cf [R4.07.05]). An example is given in test SDLV111 [V2.04.111].*

## **16.3 Operand**

**GROUP\_MA/MESH**

*Place of employment of the elementary characteristics:*

- *list meshes (key word NETS),*
- *list of groups of meshes (key word GROUP\_MA).*

## **16.4 Operands**

**A\_FLUI/A\_CELL/COEF\_ECHELLE**

*The periodic cell of the medium to be homogenized is two-dimensional.*

**NR**

*The basic periodic cell which is used to calculate*

*the homogenized coefficients is obtained by homothety starting from the periodic cell*

*Tube*

*real of the medium.*

*Fluid*

*L*

*T*

*A\_FLUI: surface of the part occupied by the fluid in the basic periodic cell*

*A\_CELL: surface of the basic periodic cell*

*COEF\_ECHELLE: coefficient of homothety allowing to transform the real periodic cell into basic periodic cell*

### *16.5 Operands B\_T/B\_N/B\_TN*

*Homogenized coefficients of the problem fluid-structure calculated in the reference mark (T, NR) [R4.07.05].*

*The orientation of this reference mark is fixed by the key word factor ORIENTATION. The direction L is inevitably parallel with the beam axis of tubes.*

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*:*

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*17 Word*

*key*

*ROAST*



## 17.1 Syntax

**ROAST** = (  
 \_**F** (  
 /  
**NET**  
 =  
**lma**,  
 [**l\_maille**]  
 /  
**GROUP\_MA**  
 =  
**lgma**,  
 [**l\_gr\_maille**]  
  
**SECTION** =  
**S1**,  
 [**R**]  
 /**ANGL\_REP** = (,  
 [**l\_R**]  
 /  
**ORIG\_AXE**  
 =  
 (**xr**,  
**yr**,  
**Zr**)  
 [**l\_R**]  
**CENTER** = (**vx**,  
**vy**,  
**vz**)  
 [**l\_R**]  
**OFFSETTING**  
 = **ez**,  
 [**R**]  
**GRILLE\_NCOU**  
 =  
 /  
**ncou**,  
 [**I**]  
 /  
 1  
**[DEFECT]**

**COEF\_RIGI\_DRZ**

=/kz,

**[R]**

/

**1.E-10, [DEFECT]**

),

)

**17.2 Characteristics***easily affected*

*Allows to define characteristics of a lattice (modeling of tablecloth of reinforcements for the hulls out of reinforced concrete) (see for example test SSNS100 [V6.05.100]), affected with modelings*

**ROASTS** or**GRILLE\_MEMBRANE.**

*These characteristics are used to define an element of plate orthotropic, usable only, or more often superimposed with an element of concrete plate.*

**17.3 Description of the operands**

*The following geometrical data are necessary to model the tablecloth of reinforcements:*

- **OFFSETTING = ez:** *offsetting ez (constant for all the nodes of the mesh) of tablecloth of reinforcements compared to the mesh support (distance measured on the normal of net support), (modeling only ROASTS).*
  - **SECTION = S1:** *section of the reinforcements in direction 1.*
  - **ANGL\_REP =** *to see key word HULL [§8]. This key word makes it possible to define the reference axis (x1). It*
- also defined the reference mark in which the deformations are calculated, constraints, curves,...*
- **COEF\_RIGI\_DRZ =** *to see key word HULL [§8].*
  - **ORIG\_AXE, AXIS =** *in the case of a cylindrical hull, these key words make it possible to define the angle of the reinforcements, constant in a cylindrical reference mark in the following way: if D is right-hand side passing by the point x0 (of co-ordinates xr yr Zr) and from axis V (vx vy vz) then in all not X of the hull, the vector Y = V X*

*1  
1 directs the reinforcements in X (with*

**X****XX, X***1 =***D**

*D projection of X on D).*

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*Plate*

*Reinforced concrete*

*Z1*

*Y1*

*Concrete*

*X1*

*T*

*ez*

*brace diameter 2*

*average layer*

*average layer*

*brace diameter*

*Equivalent tablecloth of reinforcements*

*1*

***Appear 17.3-a: Representation of the reinforcements by an equivalent tablecloth***

*To define a grid or the section of the reinforcements in the longitudinal direction and the transverse one are*

*different, it is necessary to create 2 layers of elements (order *CREA\_MAILLAGE*, key word *CREA\_GROUP\_MA*),*

*a layer of element for the longitudinal direction and a second layer of elements for transverse direction:*

*GRILLE= (*

*\_F (*

*GROUP\_MA = "GEOL",*

*SECTION = 0.02,*  
*ANGL\_REP = (0.0, 0.0,),*  
*OFFSETTING = 0.0,*  
*),*  
*\_F (*  
*GROUP\_MA = "GEOT",*  
*SECTION = 0.01,*  
*ANGL\_REP = (90.0, 0.0,),*  
*OFFSETTING = 0.01,*  
*),*  
*)*

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***18 Word***

***key***

***RIGI\_PARASOL***

***18.1 Syntax***

***RIGI\_PARASOL = (***

***\_F (***

***# Groups of meshes which make the foundation raft***

***GROUP\_MA***

```

=
l_gma,
[l_group_ma]
GROUP_MA_POII
=
l_gma,
[l_group_ma]
# Functions of distribution
/
FONC_GROUP =
l_fg, [l_fonction]
/
COEF_GROUP =
l_cg, [l_R]
# total Stiffnesses to distribute
CARA =/“K_TR_D_N” | “K_T_D_N”,
/
“A_TR_D_N” | “A_T_D_N”,
[l_TXM]
VALE = l_val, [l_R]

LOCATE =/“LOCAL”,
/
“TOTAL”,
[DEFECT]
# Centre revolves
/
GROUP_NO_CENTRE
=
gno,
[group_no]
/
NOEUD_CENTRE
=
Nd,
[node]
/
COOR_CENTRE
=
l_xyz,
[l_R]
# specific Meshs corresponding to the nodes of the foundation raft

```

/

**GROUP\_MA\_POII**

=

**gmapoi1, [group\_ma]**

),

)

## **18.2 Characteristics**

### **easily affected**

*This functionality corresponds to a methodology used by the SEPTEN to determine them characteristics of discrete elements (springs of translation and/or rotation) to apply to the nodes of a foundation raft starting from results obtained by the code PARASOL.*

*One must affect modeling "DIS\_TR" or "DIS\_T" on the group of nodes which make it up to erase.*

*The meshes which make the foundation raft (pertaining to the l\_gma groups) carry when to them one modeling of plate (DKT, DST) cf test SDLS108 [V2.03.108] or a modeling of face of 3D.*

## **18.3 Description of the operands**

- **GROUP\_MA**: list groups of meshes which make the foundation raft.
- **GROUP\_MA\_POII**: list groups of points including/understanding the nodes of the groups of meshes surface defined by **GROUP\_MA**. That makes it possible to declare the nodes of a foundation defined by surface meshes like specific meshes **POII** in order to affect the characteristics to them **RIGI\_PARASOL** what makes it possible to affect materials or behaviors to them for the use of a nonlinear operator. If it is not present, the nodes are regarded as late meshes for a strictly linear study for example.
- **FONC\_GROUP/COEF\_GROUP**: list real functions or coefficients. There are as many arguments in this list that there are groups of meshes which make the foundation raft (definite under the key word **GROUP\_MA**). The functions must have as a X-coordinate the distance to the centre of gravity (key word defined by **GROUP\_NO\_CENTRE/NOEUD\_CENTRE/COOR\_CENTRE**).
- The total stiffnesses of ground, resulting from the code **PARASOL** are provided by the user using key words **CARA** and **VALE** as for the discrete elements. One can also select nature reference mark (total or local) in which one defines the characteristics of the springs (key word **LOCATE**). Stiffnesses or the depreciation only defined in translation can also to be distributed (**K\_T\_D\_N** or **A\_T\_D\_N**, not stiffness in rotation), in this case it is only necessary to give 3 values behind **VALE** = (kx, ky, kz).
- To define the center of the foundation raft (calculated by the code **PARASOL**), one can is to give them co-ordinates (three realities given behind key word **COOR\_CENTRE**), is to give the name of a node

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*grid (for more facility, one accepts also the name of a group of nodes but this one must contain that only one node: key word *GROUP\_NO\_CENTRE* or *NOEUD\_CENTRE*).*

*· *GROUP\_MA\_POII* makes it possible to specify a group of specific meshes containing the nodes of groups of surface meshes (to erase) definite under *GROUP\_MA*. On these nodes of foundation, one will be able to affect various behaviors materials for the use by an operator not linear.*

#### ***18.4 Principle of determination of the characteristics of the elements discrete [R4.05.01]***

*One represents the foundation raft by a whole of surface elements of centre of gravity *O*. Using code *PARASOL*, one obtains 6 total sizes which characterize the coupling ground-foundation raft: three stiffnesses*

*of *Kx* translation, *Ky*, *Kz* and three stiffnesses of rotation *Krx*, *Kry*, *Krz*.*

*In each node of the grid of the foundation raft, Code\_Aster seeks the characteristics in stiffness of one discrete element of type *K\_TR\_D\_N* (*kx*, *ky*, *kz*, *krx*, *kry*, *krz*) cf [R4.05.01].*

*To determine the stiffnesses of translation, one forces that they are proportional to surface represented by the node and with a function of distribution depending on the distance to the centre of gravity*

*foundation raft. That is to say *S (P)* the surface attached to the node *P* and *F (R)* the function of distribution where *R* is the distance node *P* with the node *O*.*

*For the stiffnesses of rotation, one distributes the remainder (what remains after having removed the contributions had with the translations) in the same way that translations.*

*If one calculates the efforts and the moments resulting at the point *O* due to the distribution from the springs in*



*each node of the grid of the foundation raft and if one identifies them with the values obtained by PARASOL, one obtains the following formulas:*

$$K = K/S$$

*X*

*X*

$$(p) F (COp); K (P) = K S$$

*X*

*X*

$$(p) F (COp)$$

*P*

$$K = K/S$$

*y*

*y*

$$(p) F (COp); K (P) = K S$$

*y*

*y*

$$(p) F (COp)$$

*P*

$$K = K/S$$

*Z*

*Z*

$$(p) F (COp); K (P) = K S$$

*Z*

*Z*

$$(p) F (COp)$$

*P*

*2*

*2*

*Kr = Kr -*

+

/

;

=

*X*

*X*

*(kz (P) y K*

*COp*

*y (P) zOP)*

*S (P) F (COp) krx (P) Kr S*

*X*

*(P) F (COp)*

*P*

*P*

2

2

*Kr = Kr -*

+

/

;

=

*y*

*y*

*(kx (P) Z K*

*COp*

*Z (P) xOP)*

*S (P) F (COp) kry (P) Kr S*

*y*

*(P) F (COp)*

*P*

*P*

2

2

$Kr = Kr -$   
+  
/  
;  
=  
Z  
Z  
( $kx (P) y K$   
 $COp$   
 $y (P) xOP$   
 $S (P) F (COp) krz (P) Kr S$   
Z  
( $P) F (COp)$   
  
P  
P

**Notice 1:**

*Calculation of the area attached to the point P.*

*For each surface mesh of the foundation raft, one calculates surface, one divides it by the number of tops*

*mesh and one affect this contribution to each node of the mesh. One ensures then:*

$S$   
 $= S (P)$   
*to erase*

P  
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**Notice 2:**

*It is considered that one can apply the same formulas to carry out a distribution of elements discrete of damping.*

**18.5 Example  
of use**

```
carac = AFFE_CARA_ELEM (  
RIGI_PARASOL =  
_F (GROUP_MA = to erase,  
COEF_GROUP = 2. ,  
CARA = ("K_TR_D_N", "A_TR_D_N"),  
VALE = ((16 realities), (6 realities)),  
NOEUD_CENTRE = "P1",  
)  
)
```

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**19 Word****key****RIGI\_MISS\_3D****19.1 Syntax****RIGI\_MISS\_3D = (****\_F (****GROUP\_MA\_POI1****=****l\_gma,****[l\_group\_ma]****GROUP\_MA\_SEG2****=****l\_gma,****[l\_group\_ma]****FREQ\_EXTR****=****freq,****[R]****UNITE\_RESU\_IMPE****=****/****links,****[I]****/ 30,****[DEFECT]****),****)****19.2 Characteristics****easily affected**

***The use of this key word is dedicated to problems of separation of foundation in order to take better the carpet of springs of ground counts some than RIGI\_PARASOL does it which distributes 6 stiffnesses***

***total under a foundation proportionally on the surfaces of the elements surrounding its nodes.***

***This key word will affect the exact terms of a matrix of impedance calculated by MISS3D for all them ddl of interface (3\*nombre of nodes) and for a frequency of extraction given. The assignment of these terms (modeling "DIS\_T") is then made with specific meshes POI1 nodes of the foundation surface and possibly with the lines of the network of SEG2 superimposed on the foundation to represent***

*transverse connections between nodes.*

### *19.3 Description of the operands*

- *GROUP\_MA\_POI1: Group specific meshes of the nodes of the foundation.*
- *GROUP\_MA\_SEG2: Group meshes of SEG2 connecting the nodes of the foundation transversely.*
- *FREQ\_EXTR: Frequency of extraction of the matrix of impedance.*
- *UNITE\_RESU\_IMPE: Logical unit of the matrix of impedance calculated by MACRO\_MISS\_3D option MISS\_IMPE.*

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***Macro-order MACR\_CARA\_POUTRE***

***1 Goal***

***To calculate the characteristics of a cross section of beam starting from a grid 2D of section.***

***It makes it possible to build a table of values, usable by order AFFE\_CARA\_ELEM [U4.42.01] to assign characteristics of cross-sections to all the finite elements of beam (modelings POU\_D\_E, POU\_D\_T, POU\_C\_T, POU\_D\_TG, POU\_D\_EM, POU\_D\_TGM) or of bar (modeling BARS) unspecified section.***

***The characteristics necessary are defined in the note of reference [R3.08.03]. It is:***

***.  
the geometrical characteristics (which can be calculated on the complete grid, half grid with symmetry compared to X or with Y, quarter of grid with two symmetries by report/ratio with X and Y),***

***.  
characteristics of torsion: ray of torsion, constant of rigidity in torsion, position and eccentricity of the center of torsion for the coupling inflection-torsion,***

***.  
characteristics of shearing for the models with deformations of shearing action,***

***.  
characteristics of warping for the models of “open” torsion of the sections nonsymmetrical.***

***Product a table containing the characteristics of the section. Values contained in this table can be introduced directly (via python) into order AFFE\_CARA\_ELEM for a calculation of the beam type.***

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## 2 Syntax

*tabl\_cara\_geom = MACR\_CARA\_POUTRE (*

*UNITE\_MALLAGE =/20,*

*[DEFECT]*

*/*

*iuni,*

*[I]*

*INFORMATION*

*=*

*/*

*1*

*[DEFECT]*

*/2*

*ORIG\_INER*

*=*

*/*

*(xp, YP),*

*[l\_R]*

*/*

*(0.0,*

*0.0) [DEFECT]*

*# If one only wants the characteristics geometrical:*

*/*

/  
**SYME\_X**  
=  
**“YES”**,  
/  
**SYME\_Y**  
=  
**“YES”**,  
**GROUP\_MA**  
=  
**lgm**,  
**[l\_gr\_maille]**

*# If one wants the characteristics geometrical and mechanical of one section:*

**/GROUP\_MA\_BORD**  
=  
**lgb**,  
**[l\_gr\_maille]**  
**NODE**  
=  
**ln**,  
**GROUP\_MA\_INTE**  
=  
**lgi**,

*# If one wants the characteristics of a network of beams between two floors:*

**/GROUP\_MA\_BORD**  
=  
**lgb**,  
**[l\_gr\_maille]**  
**GROUP\_MA**  
=  
**lgm**,  
**[l\_gr\_maille]**  
**LENGTH**  
=  
**H**,  
**MATERIAL**  
=  
**to subdue**,

*[to subdue]*  
*CONNECTION =/"KNEECAP",*  
*/"EMBEDDING",*  
*NODE*

*=*  
*ln,*  
*)*

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### *3 Operands*

#### *3.1 Operand*

*UNITE\_MAILLAGE*

*UNITE\_MAILLAGE*

*Logical number of unit for the reading of the grid 2D of the section of beam which one will calculate characteristics with the format Aster: i.e. a grid which can be read by LIRE\_MAILLAGE.*

*Note:*

*If one must call several upon MACR\_CARA\_POUTRE in the same command file on the same grid or of the different grids UNITE\_MAILLAGE should then be changed.*

#### *3.2 Operands*

***SYME\_X/SYME\_Y******/ SYME\_X***

***Specify that the grid provided by the user corresponds to a half grid. The calculation of characteristics of the cross-section takes account of a symmetry compared to  $X = 0$ .***

***/ SYME\_Y***

***Specify that the grid provided by the user corresponds to a half grid. The calculation of characteristics of the cross-section takes account of a symmetry compared to  $Y = 0$ .***

***The simultaneous use of the two options makes it possible to provide only one quarter of the grid.***

***The properties of symmetry are used to accelerate the calculation of the characteristics geometrical.***

***Note:***

***Key words SYME\_X and SYME\_Y are used only for the calculation of the characteristics geometrical. Mechanical characteristics (constant of torsion, constant of warping, coefficients of shearing) do not hold account of it. To calculate them, it is necessary thus to net the section in entirety. This is why SYME\_X and SYME\_Y cannot be informed simultaneously with GROUP\_MA\_BORD.***

**3.3*****Calculation of the mechanical characteristics***

***GROUP\_MA\_BORD = lgb***

***lgb indicates one (or several) group of meshes (SEG2 or SEG3) describing the contour (closed) of the section with a grid. It is the presence of this key word which involves the calculation of the characteristics mechanics of the section (cf [U4.42.01] AFFE\_CARA\_ELEM, key word BEAM).***

***GROUP\_MA\_INTE = lgi***

***lgi indicates one or more groups of meshes describing contours of possible holes. This data is used for calculation of the constant of torsion.***

***GROUP\_MA = lgm***

***lgm corresponds to a list of groups of meshes for which the calculation of the characteristics must to be carried out independently. This functionality makes it possible in particular to seek them characteristics of beam equivalent to several disjointed sections. If one wishes the calculation of***

*mechanical characteristics for each group of mesh, it is then necessary to give a group of meshes of edge by section (using key word GROUP\_MA\_BORD). The lists lgb and lgm must then to correspond.*

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*ORIG\_INER = (xp, YP)*

*This key word defines the point where the inertial characteristics of the section are calculated. values of the moments of inertia are then provided in this point and to the centre of gravity of the section (for all the grid or for each group of mesh if GROUP\_MA is specified).*

*NODE = ln,*

*For the calculation of the coefficients of shearing (if key word GROUP\_MA\_BORD is present), one is brought to solve a thermal problem on the section (or each group of the list lgm), with for only boundary condition a source term. This can produce messages of alarm due with the presence of null pivots, without the quality of the result being affected. To avoid these messages of alarm, it is possible to give a node (or a list of nodes if lgm is data) for which the temperature is imposed.*

### **3.4**

**Case of network of beams**

*LENGTH = H,*

*MATERIAL*

*=*

to subdue,  
**CONNECTION** =  
/“KNEECAP”,  
/“EMBEDDING”,

*These three key words allow the calculation of the coefficients of shearing equivalent to one together of parallel beams (posts) located between two floors, distant the length  $h$ . The sections of these beams are defined by key word **GROUP\_MA**. They all are made up of same linear elastic material (key word **MATERIAL**). The connection with the lower floor of type “embedding is”. That with the higher floor is indicated by the key word **CONNECTION**.*

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## **4** **Definition of the produced sizes**

### **4.1** **Reference marks used for the geometrical characteristics**

*Two reference marks are used:*

- reference mark **OXY** of description of the grid 2D;*
- the principal reference mark of Gyz inertia. cross-section, whose denomination corresponds to that used with the description of the elements of neutral fibre beam **Gx** [U4.42.01].*

**Z**  
**Y**  
**Y**  
**(princi**  
**CDG\_X**  
**stake)**  
**Y\_MAX**  
**TESTSTEMXÀ**  
**\_M**  
**Z\_MAX**  
**R**  
**y (principal)**  
**X**  
**Y**  
**G**  
**\_M**  
**–**  
**Y**  
**I**  
**G**  
**NR**  
**Z\_MIN**  
**ALPHA**  
**CD**  
**X**  
**O**

## ***Definition of the geometrical magnitudes relating to a section of beam***

### **4.2**

#### ***Sizes available in the produced table***

##### ***4.2.1 Characteristics geometrical***

*These characteristics are given in the table for all the grid and each group of list lgm (which can correspond to a half or a quarter of the section if key words SYME\_X or SYME\_Y are present).*

##### ***4.2.1.1 Characteristics of the grid read***

.

*surface: AIRE\_M*

*position of the centre of gravity: CDG\_X\_M, CDG\_Y\_M*

*moments and product of inertia of surface, in the centre of gravity G in reference mark GXY:*

*IX\_G\_M*

*IY\_G\_M*

*IXY\_G\_M*

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**Code\_Aster** ®

*Version*

*7.4*

*Titrate:*

*Macro-order MACR\_CARA\_POUTRE*

*Date:*

*11/02/05*

*Author (S):*

*Key J-L.FLÉJOU*

*:*

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#### ***4.2.1.2 Characteristics of the section of beam***

*surface: SURFACE*

*position of the centre of gravity: CDG\_X, CDG\_Y*

*moments and product of inertia of surface, in the centre of gravity G in reference mark GXY:*

*IX\_G IY\_G IXY\_G*

*· principal moments of inertia of surface in the Gyz reference mark, usable for the calculation of the rigidity of*

*inflection of the beam: IY\_PRIN\_G and IZ\_PRIN\_G*

*· angle of flow of reference mark GXY to the principal reference mark of Gyz inertia: ALPHA*

*· characteristic distances, compared to the centre of gravity G of the section for calculations of*



*maximum constraints: Y\_MAX, Y\_MIN, Z\_MAX, Z\_MIN and R\_MAX.*

- *X\_P, Y\_P: not calculation of the geometrical moments of inertia*
- *IX\_P, IY\_P, IXY\_P: geometrical moments of inertia in reference mark PXY*
- *IY\_PRIN\_P, IZ\_PRIN\_P: moments of inertia in the Pyz reference mark.*
- *IXR2, IYR2, IYR2\_PRIN\_G, IZR2\_PRIN\_G, IXR2\_P, IYR2\_P: useful characteristics for the geometrical matrix of rigidity of elements POU\_D\_TG and POU\_D\_T\_GM.*

#### **4.2.2 Characteristics**

**“mechanical”**

*These characteristics are provided in the table for all the grid and each group of mesh list lgm.*

##### **4.2.2.1 Characteristics of torsion**

- *constant of torsion: CT*

*The resolution of a stationary thermal problem of unknown factor phi makes it possible to determine constant of torsion and stresses shear.*

- *ray of torsion: RT*

*The ray of torsion “RT” can vary along external contour; indeed, for a section unspecified, shearings due to torsion vary on the edge. One chooses to take the value of Rt leading to shearings maximum on the external edge, i.e. the maximum value of Rt (in absolute value) on external contour. Moreover, if the section is alveolate, there are several “several rays of torsion”:  $Rt = 2 \cdot A(K) / L(K)$  (or  $A(K)$  represents the surface of the cell K and L(K) sound perimeter).*

*If one is satisfied to seek the maximum value of shearing, it is necessary to take the maximum of Rt values obtained on the external edge and the cells.*

- *Position of the center of torsion (point C) in reference mark GXY: PCTX and PCTY. One deduces some*

*the eccentricity of the center of torsion (component of CG in the principal reference mark of Gyz inertia): EY and*

*EZ.*

- *Constante of warping (usable for modelings POU\_D\_TG and POU\_D\_TGM with 7 degrees of freedom): JG*

##### **4.2.2.2 Characteristics of shearing**

*The coefficients of shearing are given, in the principal reference mark of Gyz inertia, in the form of report/ratio (> 1) of the total surface to the actually sheared surface: AY and AZ*

#### **4.3 Assignment of the sizes in AFFE\_CARA\_ELEM**

*The values contained in this table can be in order AFFE\_CARA\_ELEM for one calculation of the beam type.*

*In AFFE\_CARA\_ELEM, the characteristics are to be provided in the principal reference mark of inertia (G, y, Z).*

*Quantities required (IY, IZ.) correspond to those calculated in the principal reference mark of inertia defined starting from G, X, Y (IY\_PRIN\_G, IZ\_PRIN...).*

*It is thus necessary to take guard with directing well the local reference mark of the elements of beam (key word*

*ORIENTATION of AFFE\_CARA\_ELEM) in order to affect the quantities correctly.*

*It is possible to directly provide (via variables python) the characteristics of the sections (general) resulting from a calculation with MACR\_CARA\_POUTRE. This is implemented in the test SSSL107F.*

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## **5 Examples of use**

### **5.1**

#### **Characteristic of a section in angle with equal wings**

(50 X 50 X 8) treated by test SLL107A [V1.01.105].

##### **5.1.1 Section studied**

Y

R1

$To = 0.0500$

E

$= 0.0080$

$R = 0.0050$

With

$R1 = 0.0025$

E

R

E

R1 X

With

##### **5.1.2 Command file**

*TCARA = MACR\_CARA\_POUTRE (GROUP\_MA\_BORD = "LSURF", NODE = "N1", INFORMATION = 2)*

*or LSURF is the group of the linear meshes of the contour of the section.*

### ***5.1.3 Characteristics geometrical obtained***

*The characteristics of the grid are identical to those of the section. They are in conformity with those found in the "Catalogue of iron and steel products OTUA: Condition of uses in construction metal - 1959 "*

*AIRE\_M*

*=*

*SURFACE*

*=*

*7.39E-4*

*CDG\_X\_M*

*=*

*CDG\_X*

*=*

*1.53148E-02*

*CDG\_Y\_M*

*=*

*CDG\_Y*

*=*

*1.53148E-02*

*IX\_G\_M*

*=*

*IX\_G*

*=*

*1.64141E-07*

*IY\_G\_M*

*=*

*IY\_G*

*=*

*1.64141E-07*

*IXY\_G\_M*

*=*

*IXY\_G*

*=*

*-9.48843E-08*

*IY\_PRIN\_G*

*=*

2.59025E-07

IZ\_PRIN\_G

=

6.92568E-08

ALPHA

= 45°

2

2

OG

=

(CDG\_X + CDG\_Y) = 2.166E-02

Y\_MIN

= - OG

= - 2.166E - 02

2

2

Y\_MAX

=

(AR +

cos/4

-

1 )

(e-R1)

(

) R

OG

1.465E

02

1

+

-

=

Z\_MIN

= - A cos (/4)

= -3.536E - 02

Z\_MAX

=

*With cos (/4)*

= 3.536E - 02

2

2

*R\_MAX*

=

*A/2 + (A cos (/4) - OG)*

= 3.792E - 02

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### ***5.1.4 Characteristics***

#### ***mechanics***

*CT =*

1.596E8

*RT =*

1.164E2

*PCT\_X = 4.665E3*

*PCT\_Y = 4.665E3*

*EY =*

1.51E2

*EZ =*

0

*AY =*

2.174

AZ =

2.174

5.2

*Full rectangle (treaty by test ZZZZ105G)*

*5.2.1 Section  
studied*

y

B

B

$B = 0.01$

GR2

H

$H = 0.025$

*3 groups of meshes are defined:*

0

X

*GR1 corresponds to the part y*

0

GR1

H

*GR2 corresponds to the part y 0*

*LR1 corresponds to the linear meshes of contour*

### **5.2.2 Order**

*TCARS = MACR\_CARA\_POUTRE (GROUP\_MA\_BORD = "LR1", NODE = "N64")*

### **5.2.3 Characteristics geometrical obtained**

*PLACE*

*AIRE\_M*

*CDG\_X\_M*

*CDG\_Y\_M*

*IX\_G\_M*

*IY\_G\_M*

*IXY\_G\_M*

*0.000003*

*1.00E-03*

*4.24E-18 -3.39E-18 2.08E-07*

*3.33E-08*

*2.65E-23*

*GR1*

*5.00E-04*

*2.20E-17 -1.25E-02 2.60E-08*

*1.67E-08*

*3.97E-23*

*GR2*

*5.00E-04*

*-8.47E-18*

*1.25E-02*

*2.60E-08*

*1.67E-08*

*5.62E-23*

*PLACE*



*SURFACE*

*CDG\_X*

*CDG\_Y IX\_G IY\_G IXY\_G IY\_PRIN\_G IZ\_PRIN\_G ALPHA*

*0.000003*

*1.00E-03 4.24E-18 -3.39E-18 2.08E-07 3.33E-08 2.65E-23 3.33E-08 2.08E-07 9.00E+01*

*GR1*

*5.00E-04 2.20E-17 -1.25E-02 2.60E-08 1.67E-08 3.97E-23 1.67E-08 2.60E-08 9.00E+01*

*GR2*

*5.00E-04 -8.47E-18 1.25E-02 2.60E-08 1.67E-08 5.62E-23 1.67E-08 2.60E-08 9.00E+01*

*PLACE*

*X\_P*

*Y\_P*

*IX\_P*

*IY\_P*

*IXY\_P*

*IY\_PRIN\_P*

*IZ\_PRIN\_P*

*0.000003*

*0.00E+00*

*0.00E+00*

*2.08E-07 3.33E-08 2.65E-23*

*3.33E-08*

*2.08E-07*

*GR1*

*0.00E+00*

*0.00E+00*

*1.04E-07 1.67E-08 -9.79E-23*

*1.67E-08*

*1.04E-07*

*GR2*

*0.00E+00*

*0.00E+00*

*1.04E-07 1.67E-08 3.31E-24*

*1.67E-08*

*1.04E-07*

*PLACE*

*Y\_MAX*

*Z\_MAX*

*Y\_MIN*

*Z\_MIN*

*R\_MAX*

0.000003

2.50E-02

1.00E-02 -2.50E-02 -1.00E-02 2.69E-02

*GR1*

2.50E-02

2.25E-02 -2.50E-02

2.50E-03 3.36E-02

*GR2*

2.50E-02

-2.50E-03 -2.50E-02 -2.25E-02 3.36E-02

*PLACE*

*CT*

*AY*

*AZ*

*EY*

*EZ*

*PCTX*

*PCTY*

*JG*

0.000003

-

-

-

-

-  
-  
-  
-

*GR1*  
*3.43E-08*  
*1.20E+00*  
*1.20E+00*  
*9.00E-17*  
*-3.97E-18*  
*2.60E-17 -1.25E-02 -*

*GR2*  
*3.43E-08*  
*1.20E+00*  
*1.20E+00*  
*-4.03E-17*  
*1.19E-16*  
*-1.27E-16 1.25E-02 -*

*PLACE*  
*RT*

*0.000003 1.93871E-2*  
*GR1*  
*1.56391E-2*  
*GR2*  
*1.56391E-2*

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*Version*  
*7.4*

*Titrate:*  
*Operator DEFI\_COQU\_MULT*

*Date:*  
*31/01/05*

*Author (S):*

*X. DESROCHES, A.M. DONORE Key*

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*Organization (S): EDF-R & D /AMA*

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*Document: U4.42.03*

*Operator DEFI\_COQU\_MULT*

*1 Goal*

*To determine the characteristics materials homogenized of a multi-layer hull from characteristics of each layer. Are taken into account the following characteristics:*

.

*thickness,*

.

*type of constitutive material,*

.

*orientation of fibres compared to a reference axis.*

*Product a structure of data of the type MATER.*

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**Operator *DEFI\_COQU\_MULT***

**Date:**

**31/01/05**

**Author (S):**

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**2 Syntax**

***MUL* [to subdue] = *DEFI\_COQU\_MULT* (**

***SLEEP***

**= (*\_F***

**(**

***THICK* =**

***EP,***

**[*R*]**

**MATER**  
= **MA**  
,  
**[to subdue]**

**ORIENTATION**  
=  
/  
**ORIEN**  
,  
**[R]**

/  
**0.**  
,  
**[DEFECT]**

))

***IMPRESSION = \_F (UNIT =/links,  
[I]***

***/ 8,***

***[DEFECT]***

***)***

***)  
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***3 Operands***

***3.1 Word***

***key***

***SLEEP***

***SLEEP = \_F***

***Key word factor for the definition of a layer of the multi-layer composite on the basis of the layer lower to the roadbase.***

***3.1.1 Operand***

***THICK***

***THICK = EP***

***Thickness of the layer.***

***3.1.2 Operand***

***MATER***

***MATER = MA***

***Concept MA contains material constitutive of the layer and is produced by the operator DEFI\_MATERIAU under the key word factor ELAS\_ORTH.***

***3.1.3 Operand***

***ORIENTATION***



**ORIENTATION** = *orien*

*Angle of the 1st direction of orthotropism (longitudinal direction or direction of fibres) in the plan tangent with the element compared to the 1st direction of the reference mark of reference defined in operator AFFE\_CARA\_ELEM by the key word factor HULL and key word ANGL\_REP [U4.42.01].*

*By defect orien is null, if not it must be provided in degrees and must lie between 90° and + 90°.*

**orien**

*xréf*

*normal*

*fibres*

*xréf*

**ANGL\_REP**

**Z**

*tangent plan with the hull*

**Y**

**X**

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**3.2 Operand**

**IMPRESSION**

*IMPRESSION = \_F (*

*Impression on the unit links (by defect the file resu) of the list of the coefficients homogenized.*

#### ***4 Example***

***MULTI = DEFI\_COQU\_MULT***

***(***

***SLEEP = (\_F (THICK = 1.E-3, MATER = MAT1, ORIENTATION = - 20.),***

***SLEEP = (\_F (THICK = 2.E-3, MATER = MAT2, ORIENTATION = 10.),***

***SLEEP = (\_F (THICK = 2.E-3, MATER = MAT2, ORIENTATION = - 10.),***

***SLEEP = (\_F (THICK = 1.E-3, MATER = MAT1, ORIENTATION = 20.),***

***)***

***corresponds to the multi-layer one:***

***Normal***

***Fibres 4th layer***

***20°***

***4***

***mat1***

***20°***

***X 1. E - 3***

3

*mat2*

- 10°

2. E - 3

X

*Locate reference*

2

*mat2*

10°

2. E - 3

X

1

*mat1*

- 20°

1. E - 3

*fibres*

*normal*

*sub-base*

*with the hull*

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*Titrate:*

*Macro-order DEFI\_CABLE\_BP*

*Date:*

01/02/05

*Author (S):*

*S. MICHEL-PONNELLE, A. ASSIRE Key*

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*Organization (S): EDF-R & D /AMA*

***Instruction manual  
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Document: U4.42.04***

***Macro-order DEFI\_CABLE\_BP***

***1 Goal***

***The goal of this order is to calculate the initial profiles of tension along the cables of prestressed of a structure concrete. The data of calculation are the tension applied at the ends and other parameters characteristic of anchorings and materials. The relations used are those prescribed by the BPEL 91.***

***The concept `cabl_precont` product can then be used by operator `AFFE_CHAR_MECA` [U4.44.01], in order to define a mechanical loading of type `RELA_CINE_BP`, with an aim of calculating the state of balance of the unit structure concrete/cables of prestressing. The resolution is carried out by operator `CALC_PRECONT` [U4.42.05] or by `STAT_NON_LINE` [U4.51.03].***

***Product a Structure of Data of the `cabl_precont` type.***

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***Titrate:***

## ***Macro-order DEFI\_CABLE\_BP***

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***Author (S):***

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### ***2 Syntax***

***cabl\_pr***

***[cabl\_precont] = DEFI\_CABLE\_BP***

***(***

***MODEL***

***=***

***model, [model]***

***CHAM\_MATER =***

***chmat,***

***[cham\_mater]***

***CARA\_ELEM***

***=***

***caelem, [cara\_elem]***

***GROUP\_MA\_BETON***

***=***

***l\_grmabe,***

***[l\_gr\_maille]***

**DEFI\_CABLE =**

(

/

**GROUP\_MA**

=

*grmaca, [gr\_maille]*

/

**NET**

=

*l\_maca, [l\_maille]*

**/NOEUD\_ANCRAGE**

=

*l\_noa,*

*[l\_noeud]*

/

**GROUPE\_NO\_ANCRAGE =**

*l\_gnoa, [l\_gr\_noeud]*

)

*TYPE\_ANCRAGE*

=

*l\_tya,*  
*[l\_tx]*

*TENSION\_INIT*

=

*f0,*  
*[R]*

*RECU\_L\_ANCRAGE*

=

*delta,*  
*[R]*

*CONE = (*

*RAY*

=

*ray,*  
*[R]*

*LENGTH*

=

*length,*  
*[R]*

*PRESENT* =  
*l\_pre*,  
*[l\_tx]*

)  
*GRID*  
=  
*my*,  
*[grid]*

*RELIEVING* = (

*R\_J*  
=  
*rj*,  
*[R]*



)

*TITRATE*

=

*l\_titr, [l\_tx]*

);

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***3 Operands***

***3.1 Operand***

## **MODEL**

**MODEL = model**

**Concept produced by operator AFFE\_MODELE [U4.41.01] allowing to define the types finite elements assigned to the meshes of the grid.**

### **3.2 Operand**

**CHAM\_MATER**

**CHAM\_MATER = chmat**

**Concept produced by operator AFFE\_MATERIAU [U4.43.02] allowing to affect materials with the meshes of the grid.**

### **3.3 Operand**

**CARA\_ELEM**

**CARA\_ELEM = caelem**

**Concept produced by operator AFFE\_CARA\_ELEM [U4.42.01] allowing to affect mechanical and geometrical characteristics with the elements of the studied structure.**

### **3.4 Operand**

**GROUP\_MA\_BETON**

**GROUP\_MA\_BETON = l\_grmabe**

**Name of (or of) the group (S) of meshes of the grid representing the structure concrete. One defines thus**

**precisely the locus of projection of the cables, preliminary stage to the determination relations kinematics between the DDL of the nodes of the cables and the DDL of the nodes of structure concrete.**

**Note: the groups of concrete meshes can have elastoplastic properties different but the characteristics specific to BPEL\_BETON () must be identical.**

### **3.5 Key word**

**DEFI\_CABLE**

**DEFI\_CABLE**

**Key word factor allowing the definition of a cable by designation of the topological entities of grid which represent it. The multiple occurrences are authorized, in order to be able to define several cables.**

***/GROUP\_MA = grmaca***

***Name of the group of meshes of the grid representing the cable.***

***/***

***NET***

***=***

***l\_maca***

***List meshes of the grid representing the cable. Functionality incompatible with key word CONE (to use GROUP\_MA).***

***/NOEUD\_ANCRAGE = l\_noa***

***List nodes defining anchorings of the cable, i.e the ends. This list must to comprise 2 arguments, neither more nor less.***

***/***

***GROUPE\_NOEUD\_ANCRAGE***

***=***

***l\_gnoa***

***List groups of nodes defining anchorings. The cardinal of this list must be less than or equal to 2. In each group of node, one will not retain like anchoring that the first node of the group.***

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### **3.6 Operand**

#### **TYPE\_ANCRAGE**

**TYPE\_ANCRAGE = l\_tya**

*List arguments of the text type characterizing anchorings of the cable: “ACTIVE” or “PASSIVE” (only licit arguments). This list must comprise 2 arguments, neither more nor less, and must be ordinate compared to the list of the nodes defining anchorings (operand NOEUD\_ANCRAGE above). It should be noted that if several cables are defined in DEFI\_CABLE then the first argument of TYPE\_ANCRAGE applies to all the first nodes which define anchorings. Idem for the second argument.*

#### **Note:**

*The operator reconstitutes the driving related way of the first to the second anchoring of the cable by traversing the meshes which represent it. Nonthe existence of a related way enters two anchorings causes a program stop in fatal error.  
Active anchorings are those where an initial tension is applied.*

### **3.7 Operand**

#### **TENSION\_INIT**

**TENSION\_INIT = f0**

*Value of the initial force applied to active anchorings of the cables.  
This value must be positive.*

### **3.8 Operand**

#### **RECU\_L\_ANCRAGE**

**RECU\_L\_ANCRAGE = delta**

*Value of the retreat to active anchorings of the cables.  
This value must be positive.*

### **3.9 Key word**

#### **CONE**

#### **CONE**

*This key word factor makes it possible to define a geometrical volume around anchorings, and to affect, in exit of AFFE\_CHAR\_MECA key word RELA\_CINE\_BP, with all the nodes (concrete and cable) contained*

*in this volume, a kinematic relation of type LIAISON\_SOLIDE (rigid body). The definition this volume makes it possible to attenuate the constraints which the tensions at the ends generate of cables on the concrete. In reality, this phenomenon is avoided thanks to the installation of a cone of diffusion of constraint (material harder than the concrete) which distributes the force of prestressed on a great surface of the concrete. In practice, the practically right cone being, one defined a volume cylindrical:*

*ray*

*length*

*Real situation*

*Modeling EF*

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---

**Code\_Aster** ®

Version

7.4

*Titrate:*

*Macro-order* **DEFI\_CABLE\_BP**

*Date:*

01/02/05

*Author (S):*

**S. MICHEL-PONNELLE, A. ASSIRE** Key

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*It should be noted that several rigid cones and thus several blocks are defined if the key word **PRESENT** two “YES” (a block per end of the cable contains) and/or if several cables are defined under **DEFI\_CABLE**.*

**Note:**

*In practice, the cylinder is defined by order **DEFI\_GROUP** option **TUNNEL**. methodology of extraction of the nodes contained in the cone is described in the document **U4.22.01** (order **DEFI\_GROUP**).*

*/RAY = ray*

*Ray of the cone.*

*/*

**LENGTH**

=

*length*

*Length of the cone, with the curvilinear direction X-coordinate on the cable. One defines the cone as a succession of cylinder while stopping when the overall length of the cylinders is equalize with the parameter length.*

*/PRESENT = l\_pre*

*This list must comprise 2 arguments, neither more nor less, and must be ordered in glance list of the nodes defining anchorings (operand **NOEUD\_ANCRAGE** above). The only valid arguments are “YES” or “NOT”, and make it possible to define the cone on*

two anchorings (  
**PRESENT** = (“YES”, “YES”,)  
 ), on the first anchoring  
 (**PRESENT** = (“YES”, “NOT”,)) or on the second anchoring  
 (**PRESENT** = (“NOT”, “YES”,)). It should be noted that if several cables are defined in  
**DEFI\_CABLE** then the first argument of **PRESENT** applies to all the first  
 nodes which define anchorings. Idem for the second argument.

### **3.10 Key word GRID**

**GRID**

Name of the grid on which one works. This concept is obligatory since the key word **CONE**  
 is well informed. It will be removed in version 8.

### **3.11 Key word RELIEVING**

**RELIEVING**

Key word factor allowing the definition of a parameter for the taking into account of the losses of  
 tension by relieving of steel. This key word factor being optional, by defect losses of  
 tension by relieving of steel are not taken into account.

$R_J = r_j$

Value of the adimensional function  $R(J)$  characterizing the evolution of the relieving of steel  
 in time; for example the BPEL 91 recommends:

$J$   
 $R(J) =$   
 with  $J$  in days  
 $J + 9 \times r_m$

surface of the concrete section  
 and  $r_m =$   
 average radius  
 perimeter of the concrete section

This value must be positive or null.

$J$  corresponds to the date (in days) for which one wants to estimate the state of stress in  
 structure. For the case where, in the structural analysis, the bars would be modelled with one  
 behavior of the type creep, one should not inform this key word in **DEFI\_CABLE\_BP**.

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### **3.12 Operand**

**TITRATE**

*TITRATE = l\_titr*

*List arguments of the text type defining a title attached to the concept [cabl\_precont].*

**4**

***Theoretical complement: estimate of the losses of tension in a cable of prestressed according to the regulations of BPEL***

*The evolution of the tension (in Newton) along a cable of prestressing is calculated by using them relations prescribed by the BPEL. These relations are as follows:*

**4.1**

***Evolution of the tension in the vicinity of anchoring***

~

~

5

*F (S)*

~



$$F(S) = F(S) - X$$

$$\mu$$

$$flu \times F_0 + xret \times F_0 + R(J) \times$$

$$\times$$

$$-$$

$$\times F(S)$$

$$0$$

1000

100

S

 $\times y$  has

where  $S$  indicates the curvilinear  $X$ -coordinate along the cable. Parameters introduced into this expression are:

.  
 $F_0$   
 initial tension (NR);

.  
 $X_{flu}$   
 standard rate of loss of tension by creep of the concrete, compared to the tension initial;

.  
 $xret$   
 standard rate of loss of tension by shrinking of the concrete, compared to the tension initial;

.  
 1000 relieving of steel at 1000 hours, expressed in %;

.  
 $I_{ts}$   
 surface of the cross-section of the cable defined in  $AFFE\_CARA\_ELEM$ ;

.

$y$   
stress ultimate elastic steel;

$\mu_0$   
adimensional coefficient of relieving of prestressed steel.

$R(J)$  is an adimensional function characterizing the evolution of relieving in time:

$J$   
surface of the concrete section  
 $R(J) =$   
with  $J$  in days and  $R =$   
average radius  
 $J + 9 \times R$   
 $m$   
 $m$   
perimeter of the concrete section

The function  $R(J)$  depend on the geometry of the structure, the value used is defined in operator  $DEFI\_CABLE\_BP$ .

$F(S)$  is the evolution of the tension in the vicinity of anchoring after taking into account of the loss by retreat of anchoring and the losses by contact between the cable and the concrete.

$F(S)$   
2  
is defined by the relation:  $FC(S) \times F(S) = [FC(D)]$

$FC(S)$  indicates the evolution of the tension along the cable after taking into account of the losses by contact between the cable and the concrete:  $FC(S) = F_0 \exp(p - F - S)$   
indicate the cumulated angular deviation and the parameters introduced into the expression of  $FC(S)$  are:

$F$  coefficient of friction of the cable on the partly curved concrete, in rad1;  
coefficient of friction per unit of length.

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**Note:**

.

The coefficients  $F$ ,

$\gamma$  and  $\mu$

1000

0 are to be informed in operator *DEFI\_MATERIAU*

under key word *BPEL\_ACIER*,

.

$X$  and  $X$

*flu*

ret is to be informed in operator *DEFI\_MATERIAU* under the key word

*BPEL\_BETON*.

~

The length  $D$  intervening in the expression of  $F(S)$  is the length to which the loss applies of tension by retreat to anchoring. This length is estimated using the relation

$D$

~

$Ea Its =$

$(FC(S) - F(S)) ds$

0

where  $Ea$  is the Young modulus of steel and the value of the retreat to anchoring. Thus  $Ea Its$  represents the deformation energy (of the cable) due to the retreat with anchoring.

## ***4.2 Evolution of the tension beyond the length where they apply losses of tension by retreat to anchoring***

5  
*F*

*C(S)*

$$F(S) = F$$

$$\mu$$
$$C(S) - X_{flu} \times F_0 + x_{ret} \times F_0 + R(J) \times$$
$$\times$$

-  
 $\times F$   
1000  
0  
*C(S)*  
100  
*S*

$\times y$  has

*with the same notations as those introduced in the preceding paragraph.*

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Titrate:

Macro-order **CALC\_PRECONT**

Date:

01/02/05

Author (S):

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*Organization (S): EDF-R & D /AMA*

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Document: U4.42.05*

*Macro-order CALC\_PRECONT*

### *1 Goal*

*This macro-order makes it possible to put in tension the cables in a structure (cf [R7.01.02]), of such kind that, at the end of this calculation, the structure either balances some and the tension or equal to the tension*

*data by rules BPEL91, calculated by order DEFI\_CABLE\_BP.*

*It also allows:*

*.  
to apply prestressing in a progressive way, in order to be able to treat the case where concrete will plasticize or damage themselves according to the model of behavior selected,*

*to practise the phasage of setting in prestressing, i.e. the setting in tension of the cables in a sequential way.*

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*Count*

*matters*

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## **2 Syntax**

**statnl [evol\_noli] = CALC\_PRECONT**

**(**

**reuse**

**=**

**statnl,**

**MODEL**

**=**

**Mo**

**,**

**[model]**

**CHAM\_MATER**

**=**

**chmat**

**,**

**[cham\_mater]**

**CARA\_ELEM**

**=**

**carac**

**,**

**[cara\_elem]**

**EXCIT**

**= (\_F (**

**CHARGE**

**=**

**chi**

/

**[char\_meca]**

**/[char\_cine\_meca]**

), ),  
**COMP\_INCR = (see the document [U4.51.03]**  
)

**INCREMENT =\_F (**  
**LIST\_INST**  
**=**  
**litps**  
**,**

**[listr8]**

**INST\_INIT**  
**=**  
**instini,**  
**[R]**  
**INST\_FIN**  
**=**  
**instfin,**  
**[R]**

**PRECISION**

**=/1.0E-3**

**, [DEFECT]**

**/**

**prec**

**,**

**[R]**

**SUBD\_PAS**

**=**

**/**

**1,**

**[DEFECT]**

**/subpas**

**, [I]**

**SUBD\_PAS\_MINI**

**=**

**submini,**

**[R]**

**COEF\_SUBD\_PAS\_1**

**= / 1.**

**, [DEFECT]**

**/coefsub, [R]**

**),**

**CABLE\_BP**

**=**

**l\_cabl\_pr**

**,**

**[cable\_precont]**

**CABLE\_BP\_INACTIF**

**=**

***l\_cabl\_pr***

,

***[cable\_precont]***

***ETAT\_INIT***

= *(see the document [U4.51.03]*

*),*

***NEWTON***

=

(

*to see the document [U4.51.03]*

*),*

***RECH\_LINEAIRE***

= *(see the document [U4.51.03]*

*),*

***PARM\_THETA***

= *(see the document [U4.51.03]*

*),*

***SOLVEUR***

=

(

*to see the document [U4.50.01]),*

***CONVERGENCE***

= *(see the document [U4.51.03]*

*),*

***LAGR\_NON\_LOCAL*** = *(see the document [U4.51.03]*

*),*

***SOLV\_NON\_LOCAL*** = *(see the document [U4.50.01]*

*),*

***INFORMATION*** =

/ 1

,  
[DEFECT]

/ 2

,

*TITRATE*

=

*tx [kN]*

)

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### **3 Operands**

#### **3.1 Operands**

**MODEL/CHAM\_MATER/CARA\_ELEM**

**MODEL = Mo**

*Name of the model whose elements are the subject of mechanical calculation.*

**CHAM\_MATER** = *chmat*

*Name of the affected material field on the grid. Attention, all meshes of the model must be associated a material.*

**CARA\_ELEM** = *carac*

*Name of the characteristics of the elements of hull, beam, pipe, bars, discrete cable and elements affected on the model Mo.*

### **3.2 Word**

*key*

**EXCIT**

**EXCIT** =

*This key word factor makes it possible to describe a load with each occurrence. It is necessary to provide them*

*boundary conditions for the structure, possibly of the instantaneous loadings like*

*gravity as well as the connections kinematics related to the cables having already been put in tension by a preceding call to CALC\_PRECONT. To in no case, one should not include the loading of the cable that one wants to put in tension by the call to this macro-order.*

#### **3.2.1 Operands**

**CHARGE**

**CHARGE** = *chi*

*CH is the mechanical loading specified with the ième occurrence of*

*I*

**EXCIT**.

### **3.3 Word**

*key*

**COMP\_INCR**

*The syntax of this key word common to order STAT\_NON\_LINE is described in the document [U4.51.03].*

### **3.4 Word**

*key*

**INCREMENT**

**INCREMENT** =

*Defines the intervals of time taken in the incremental method.*

### **3.4.1 Operands**

#### ***LIST\_INST***

*LIST\_INST = litps*

*The moments of calculations are those defined in the concept litps by the operator DEFILIST\_REEL [U4.34.01]. This list must be ordered in a chronological way (increasing).*

#### **Note:**

*Even if calculation is carried out with several steps of time, only the last step of time is stored in the concept result.*

*During the process of setting in tension of the cables, moments are generated automatically in addition to those provided by the user. It is thus completely normal to see to appear in the file of message of calculations with STAT\_NON\_LINE at moments that the user did not specify. These moments are not stored in the concept result.*

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### **3.4.2 Operands**

#### ***INST\_INIT/INST\_FIN***

*INST\_INIT*

= *instini*

*The initial moment of the calculation (which thus (Re) is not calculated) must be indicated by its value.*

*If this initial moment is not recomputed, the defect is calculated in the following way:*

.  
*if an initial state is specified (operand ETAT\_INIT) and if it definite one moment corresponding (by EVOL\_NOLI or INST\_ETAT\_INIT) then the initial moment is that defined by the initial state,*

.  
*if there is no initial state (operand ETAT\_INIT) or that it does not define a moment corresponding (the fields are given in ETAT\_INIT without specifying INST\_ETAT\_INIT), then one takes the first moment of the list of moments litps (NUME\_INST\_INIT =0).*

*INST\_FIN*

=

*instfin*

*The final moment (last calculated step) is indicated same manner as the initial moment, except that it is not possible to refer to the moment of the initial state.*

### **3.4.3 Operand PRECISION**

*PRECISION*

=

*prec (cf [U4.71.00])*

### **3.4.4 Operand SUBD\_PAS/SUBD\_PAS\_MINI/COEF\_SUBD\_PAS\_1**

*SUBD\_PAS = subpas,*

*SUBD\_PAS\_MINI = submini,*

*COEF\_SUBD\_PAS\_1 = coefsub,*

*Allows to carry out an automatic recutting of the step of time when the algorithm of Newton do not converge.*

*The step of time is redécoupé in subpas under step. By defect there is no recutting (SUBD\_PAS = 1). The automatic subdivision stops when the new steps created are more*



*small that SUBD\_PAS\_MINI. The new steps created are of identical size, except the first who is equal to this size multiplied by COEF\_SUBD\_PAS\_1 (by defect 1). This allows best to take into account the problems of discharge of the structure (change of tangent matrix) without using the elastic matrix (PREDICTION = ' ELASTIQUE' or MATRIX = "ELASTIC" under the operand NEWTON).*

### **3.5 Word**

*key*

**CABLE\_BP**

$CABLE\_BP = l\_cabl\_pr$

*It is a question here of providing a list of the concepts of the cabl\_precont type produced by the operator DEFI\_CABLE\_BP [U4.42.04]. All the cables concerned will be tended at the end of this calculation.*

### **3.6 Word**

*key*

**CABLE\_BP\_INACTIF**

$CABLE\_BP\_INACTIF = l\_cabl\_pr$

*It is a question here of providing a list of the concepts of the cabl\_precont type produced by the operator DEFI\_CABLE\_BP [U4.42.04]. The macro-order is given the responsibility to generate the connections kinematics related to these inactive cables, and does not take into account the rigidity of these cables.*

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### **3.7 Word**

*key*

**NEWTON**

*The syntax of this key word common to order STAT\_NON\_LINE is described in the document [U4.51.03].*

### **3.8 Word**

*key*

**ETAT\_INIT**

*The syntax of this key word common to order STAT\_NON\_LINE is described in the document [U4.51.03].*

### **3.9 Word**

*key*

**RECH\_LINEAIRE**

*The syntax of this key word common to order STAT\_NON\_LINE is described in the document [U4.51.03].*

### **3.10 Operand**

**PARM\_THETA**

*The syntax of this key word common to order STAT\_NON\_LINE is described in the document [U4.51.03].*

### **3.11 Word**

*key*

**SOLVEUR**

*The syntax of this key word common to several orders is described in the document [U4.50.01].*

### **3.12 Word**

*key*

**CONVERGENCE**

*The syntax of this key word common to order STAT\_NON\_LINE is described in the document [U4.51.03].*

### **3.13 Operand**

**SOLV\_NON\_LOCAL**

*The syntax of this key word is identical to key word SOLVEUR describes in the document [U4.50.01].*

*With  
to use for a nonlocal model.*

### **3.14 Operand LAGR\_NON\_LOCAL**

*The syntax of this key word common to order STAT\_NON\_LINE is described in the document [U4.51.03].*

### **3.15 Operand INFORMATION**

*The syntax of this key word common to order STAT\_NON\_LINE is described in the document [U4.51.03].*

### **3.16 Operand TITRATE**

*TITRATE = tx*

*tx is the title of calculation. It will be printed at the head results. See [U4.03.01].*

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#### **4 Example**

***One details here the principal stages of a structural analysis containing of the cables of prestressing (case-test SSNV164)***

##### **4.1**

***Before using the macro-order***

***Definition of the cables***

***In the event of setting in not-simultaneous tension of all the cables, it is necessary to make (at least) as many *DEFI\_CABLE\_BP* as of stages of loading.***

```
CAB_BP1=DEFI_CABLE_BP (MODELE=MO,  
CHAM_MATER=CMAT,  
CARA_ELEM=CE,  
GROUP_MA_BETON=' VOLTOT',  
TYPE_ANCRAGE= ("ACTIVE", "PASSIVE"),  
DEFI_CABLE= (_F (GROUP_MA=' CAB1',  
GROUP_NO_ANCRAGE= ("PC1D", "PC1F"),),),  
_F (GROUP_MA=' CAB2',  
GROUP_NO_ANCRAGE= ("PC2D", "PC2F"),),),  
TENSION_INIT=3.750000E6,  
RECU_L_ANCRAGE=0.001,)
```

```
CAB_BP3=DEFI_CABLE_BP (MODELE=MO,  
CHAM_MATER=CMAT,
```

**CARA\_ELEM=CE,  
GROUP\_MA\_BETON='VOLTOT',  
TYPE\_ANCRAGE= ("ACTIVE", "PASSIVE"),  
DEFI\_CABLE= (\_F (GROUP\_MA=' CAB3',  
GROUP\_NO\_ANCRAGE= ("PC3D", "PC3F")),),  
\_F (GROUP\_MA=' CAB4',  
GROUP\_NO\_ANCRAGE= ("PC4D", "PC4F")),),),  
TENSION\_INIT=3.750000E6,  
RECU\_L\_ANCRAGE=0.001,)**

**CAB\_BP5=DEFI\_CABLE\_BP (MODELE=MO,  
CHAM\_MATER=CMAT,  
CARA\_ELEM=CE,  
GROUP\_MA\_BETON='VOLTOT',  
TYPE\_ANCRAGE= ("ACTIVE", "ACTIVE"),  
DEFI\_CABLE=\_F (GROUP\_MA=' CAB5',  
GROUP\_NO\_ANCRAGE= ("PC5D", "PC5F")),),),  
TENSION\_INIT=3.750000E6,  
RECU\_L\_ANCRAGE=0.001,  
)**

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***Macro-order CALC\_PRECONT***

***Date:***

***01/02/05***

***Author (S):***

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***Definition of the loadings***

*It is necessary to distinguish:*

- 
- loadings related to the boundary conditions plus the possible instantaneous loadings,*
- 
- the loading related to the cables containing only the connections kinematics,*
- 
- posterior not-instantaneous loadings with the setting in tension of the cables.*

```
CLIM =AFFE_CHAR_MECA (MODELE=MO,  
DDL_IMPO= (  
_F (GROUP_NO=' PP',  
DX=0.0, DY=0.0),  
_F (GROUP_NO=' PX',  
DY=0.0),  
_F (GROUP_NO=' PY',  
DX=0.0),  
_F (GROUP_NO=' SU3',  
DZ=0.0),),  
PESANTEUR= (9.8100000000000005, 0.0, 0.0, - 1.0),)
```

```
CMCAB1=AFFE_CHAR_MECA (MODELE=MO,  
RELA_CINE_BP=_F (CABLE_BP=CAB_BP1,  
SIGM_BPEL=' NON',  
RELA_CINE=' OUI',),)
```

```
CMCAB3=AFFE_CHAR_MECA (MODELE=MO,  
RELA_CINE_BP=_F (CABLE_BP=CAB_BP3,  
SIGM_BPEL=' NON',  
RELA_CINE=' OUI',),)
```

```
CMCAB5=AFFE_CHAR_MECA (MODELE=MO,  
RELA_CINE_BP=_F (CABLE_BP=CAB_BP5,  
SIGM_BPEL=' NON',  
RELA_CINE=' OUI',),)
```

```
CHMECA =AFFE_CHAR_MECA (MODELE=MO,  
DDL_IMPO=_F (GROUP_NO=' SU2',  
DZ=1.0),)
```

.

*Preliminary calculation before setting in tension of the cables (optional)*

*It is a question here of taking into account the loadings which apply to the structure before the setting in tension of the cables. Not to take into account the rigidity of the cables, and not to introduce one loading on the cables, it is necessary to carry out calculation is on a model not containing the cables*

*maybe in their affecting a law of behavior WITHOUT, which imposes that the constraint remains null in these elements.*

```
RES1 = STAT_NON_LINE (MODELE=MO,  
CHAM_MATER=CMAT,  
CARA_ELEM=CE,  
COMP_INCR= (_F (RELATION = "ELAS"),  
_F (RELATION = "WITHOUT",  
GROUP_MA= ("CAB1", "CAB3", "CAB5"),),),  
EXCIT = (_F (LOAD = CLIM),  
_F (LOAD = CMCAB1),  
_F (LOAD = CMCAB3),  
_F (LOAD = CMCAB5),),  
INCREMENT=_F (LIST_INST = LINST,  
INST_FIN = 150.),)
```

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*4.2*

*Use of the macro-order: setting in successive tension of 5 cables*

*One calls upon the macro-order as many once as necessary.*

```
RES1 = CALC_PRECONT (reuse=RES1,  
ETAT_INIT=_F (EVOL_NOLI=RES1),
```

**MODELE=MO,**  
**CHAM\_MATER=CMAT,**  
**CARA\_ELEM=CE,**  
**COMP\_INCR= (\_F (RELATION = "ELAS"),),**  
**EXCIT = (\_F (LOAD = CLIM,)),**  
**CABLE\_BP = (CAB\_BP1,),**  
**CABLE\_BP\_INACTIF = (CAB\_BP3, CAB\_BP5,),**  
**INCREMENT=\_F (LIST\_INST = LINST,**  
**INST\_FIN = 300. ,**  
**SUBD\_PAS = 4,**  
**SUBD\_PAS\_MINI = 0.01,))**  
**RES1 = CALC\_PRECONT (reuse=RES1,**  
**ETAT\_INIT=\_F (EVOL\_NOLI=RES1),**  
**MODELE=MO,**  
**CHAM\_MATER=CMAT,**  
**CARA\_ELEM=CE,**  
**COMP\_INCR= (\_F (RELATION = "ELAS"),),**  
**EXCIT = (\_F (LOAD = CLIM,)**  
**\_F (LOAD = CMCAB1,)**  
**CABLE\_BP = (CAB\_BP3,),**  
**CABLE\_BP\_INACTIF = (CAB\_BP5,),**  
**INCREMENT=\_F (LIST\_INST = LINST,**  
**INST\_FIN = 450. ,**  
**SUBD\_PAS = 4,**  
**SUBD\_PAS\_MINI = 0.01,))**  
**RES1 = CALC\_PRECONT (reuse=RES1,**  
**ETAT\_INIT=\_F (EVOL\_NOLI=RES1),**  
**MODELE=MO,**  
**CHAM\_MATER=CMAT,**  
**CARA\_ELEM=CE,**  
**COMP\_INCR= (\_F (RELATION = "ELAS"),),**  
**EXCIT = (\_F (LOAD = CLIM,)**  
**\_F (LOAD = CMCAB1,)**  
**\_F (LOAD = CMCAB3,)**  
**CABLE\_BP = (CAB\_BP5,),**  
**INCREMENT=\_F (LIST\_INST = LINST,**  
**INST\_FIN = 600. ,**  
**SUBD\_PAS = 4,**  
**SUBD\_PAS\_MINI = 0.01,))**

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**4.3**

**Continuation of the loading after setting in tension of the cables**

**The cables being tended, there is not any more but to continue calculation by always including the connections**

**kinematics binding the nodes of the cable to the concrete.**

**RES1 = STAT\_NON\_LINE (reuse = RES1,  
ETAT\_INIT=\_F (EVOL\_NOLI=RES1),  
MODELE=MO,  
CHAM\_MATER=CMAT,  
CARA\_ELEM=CE,  
COMP\_INCR=\_F (RELATION = "ELAS"),  
EXCIT = (\_F (LOAD = CLIM),  
\_F (LOAD = CMCAB1),  
\_F (LOAD = CMCAB3),  
\_F (LOAD = CMCAB5),  
\_F (CHARGE=CHMECA,  
FONC\_MULT = FCT),  
INCREMENT=\_F (LIST\_INST = LINST),)**

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***Operator DEF1\_MATERIAU***

***1 Goal***

*To define the behavior of a material or the parameters associated with tiredness, the damage, or with simplified methods.*

*The allowed laws of behavior currently by this operator relate to the following fields:*

*Linear mechanics and Thermics or not, Metallurgical for the modeling of steels, Hydration and Drying for the concretes, Fluid for accoustics, Thermo-Hydro-Mechanics for the modeling of the porous environments saturated with thermomechanical coupled and Soil mechanics.*

*If necessary, the same material can be defined at the time of a call to **DEFI\_MATERIAU** with several behaviors, such as rubber band, thermics,...*

*Product a Structure of data of the type **MATER**.*

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## **2 Syntax**

### **general**

*my [to subdue] =* **DEFI\_MATERIAU**

(

*# Behavior General Rubber bands [§ 3]*

//

**ELAS,**

#

*to see [§*

**3.1]**

/

**ELAS\_FO,**

/

**ELAS\_FLUI, #**

*to see [§  
3.2]*

*/ APPUI\_ELAS,  
#  
to see [§  
3.3]*

*/ CABLE,  
#  
to see [§  
3.4]*

*//  
ELAS\_ORTH, #  
to see [§  
3.5]  
/  
ELAS\_ORTH\_FO,*

*//  
ELAS\_ISTR, #  
to see [§  
3.6]  
/  
ELAS\_ISTR\_FO,*

//  
*ELAS\_COQUE,*  
#  
*to see [§*  
*3.7]*  
/  
*ELAS\_COQUE\_FO,*

*# General Nonlinear Mechanical Behaviors [§ 4]*

/  
*TRACTION,*  
#  
*to see [§*  
*4.1]*

//  
*ECRO\_LINE, #*  
*to see [§*  
*4.2]*  
/  
*ECRO\_LINE\_FO,*

//  
*PRAGER, #*  
*to see [§*  
*4.3]*  
/  
*PRAGER\_FO,*

/ *CHABOCHE*,  
#  
*to see* [§  
4.4]

//  
*CIN1\_CHAB*, #  
*to see* [§  
4.5]  
/  
*CIN1\_CHAB\_FO*,

//  
*CIN2\_CHAB*, #  
*to see* [§  
4.6]  
/  
*CIN2\_CHAB\_FO*,

//  
*TAHERI*, #  
*to see* [§  
4.7]  
/  
*TAHERI\_FO*,



//  
*POLY\_CFC,*  
#  
*to see [§*  
*4.8]*  
/  
*POLY\_CFC\_FO,*

*/ ECOU\_VISC1,*  
# *to see [§*  
*4.9]*

*/ ECOU\_VISC2,*

*/ ECOU\_VISC3,*

*/ ECRO\_CIN1,*

*/ ECRO\_CIN2,*

*/ ECRO\_ISOT1,*

*/ ECRO\_ISOT2,*

*//*

*LEMAITRE,*

*#*

*to see [§*

*4.10]*

*/*

*LEMAITRE\_FO,*

*/*  
*VISC\_SINH, # to see [§*  
*4.11]*

*//*

*LEMA\_SEUIL,*

*#*

*to see [§*

*4.12]*

*/*

*LEMA\_SEUIL\_FO,*

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*/ ZIRC\_CYRA2,*  
*#*  
*to see [§*  
*4.13]*

*/ ZIRC\_EPRI, #*  
*to see [§*  
*4.14]*

*/ VISC\_IRRA\_LOG, #*  
*to see [§*  
*4.15]*

*//*  
*LMARC,*  
*#*  
*to see [§*  
*4.16]*

*/*  
*LMARC\_FO,*

*# Behaviors related to the damage and the rupture [§ 5]*

*//  
ROUSSELIER,  
#  
to see [§  
5.1]  
/  
ROUSSELIER\_FO,*

*//  
VENDO\_CHAB,  
#  
to see [§  
5.2]  
/  
VENDO\_CHAB\_FO,*

*/ ENDO\_ORTH\_BETON,  
#  
to see [§  
5.3]*

*/ NON\_LOCAL, #  
to see [§  
5.4]*

//  
*RUPT\_FRAG*, #  
to see [§  
5.5]  
/  
*RUPT\_FRAG\_FO*,

| *CORR\_ACIER*,  
#  
to see [§  
5.6]

#  
*Behaviors*  
*Thermics*  
[§  
6]

//  
*THER*,  
#  
to see [§  
6.1]  
/  
*THER\_FO*,  
/  
*THER\_ORTH*, #  
to see [§  
6.2]  
/  
*THER\_NL*,  
#  
to see [§  
6.3]  
/

*THE<sub>R</sub>\_COQU, #*

*to see [§*

*6.4]*

*/*

*THE<sub>R</sub>\_COQU\_FO,*

*# Behaviors specific to the concretes [§ 7]*

*/ THE<sub>R</sub>\_HYDR, #*

*to see [§*

*7.1]*

*/ SECH\_GRANGER,*

*#*

*to see [§*

*7.2]*

*/ SECH\_MENSI,*

*#*

*to see [§*

*7.3]*

*/ SECH\_BAZANT,*

*#*

*to see [§*

*7.4]*

*/ SECH\_NAPPE,  
#  
to see [§  
7.5]*

*/ PINTO\_MENEGOTTO,  
#  
to see [§  
7.6]*

*/ BPEL\_BETON  
and  
BPEL\_ACIER,  
#  
to see [§  
7.7]*

*/ BETON\_DOUBLE\_BP,  
#  
to see [§  
7.8]*

*/  
GRANGER\_FP, GRANGER\_FP\_INDT and V\_GRANGER\_FP,  
#  
to see [§  
7.9]*

*/ NADAI\_B,  
#  
to see [§  
7.10]*

*/ BAZANT\_FD, #  
to see [§  
7.11]*

*/ LABORD\_1D, #  
to see [§  
7.12]*

*//  
MAZARS, #  
to see [§  
7.13]*

*/  
MAZARS\_FO,*

*/ BETON\_UMLV\_FP, #  
to see [§  
7.14]*



*/ BETON\_ECRO\_LINE,*  
#  
*to see [§*  
*7.15]*

*/ GLRC,*  
#  
*to see [§*  
*7.16]*

*/ JOINT\_BA,*  
#  
*to see [§*  
*7.17]*

#  
*Behaviors*  
*Metal-worker-mechanics*  
*[§*  
*8]*

*/ META\_ACIER,*  
#  
*to see [§*  
*8.1]*  
*META\_ZIRC, #*  
*to see [§*  
*8.2]*

*/ DURT\_META, #*

*to see [§  
8.3]*

*//  
ELAS\_META, #  
to see [§  
8.4]  
/  
ELAS\_META\_FO,*

*/ META\_ECRO\_LINE,  
#  
to see [§  
8.5]*

*/ META\_TRACTION, #  
to see [§  
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*/ META\_VISC, #  
to see [§  
8.7]*

*/ META\_PT,  
#  
to see [§  
8.8]*

*/ META\_RE,  
#  
to see [§  
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*# Behaviors Thermo-Hydro-Mechanics and of the grounds [§ 9]*

*COMP\_THM = ^LIQU\_SATU ` , # to see [§ 9.1]*

*^LIQU\_GAZ ` ,*

*^GAS ` ,*

*^LIQU\_GAZ\_ATM ` ,*

*^LIQU\_VAPE\_GAZ ` ,*

*^LIQU\_VAPE ` ,  
^LIQU\_SATU\_GAT ` ,  
^LIQU\_NSAT\_GAT ` ,  
^LIQU\_AD\_GAZ\_VAPE ` ,*

*/ THM\_INIT,  
#  
to see [§  
9.2]*

*/ THM\_LIQU,  
#  
to see [§  
9.3]*

*/ THM\_GAZ,  
#  
to see [§  
9.4]*

*/ THM\_VAPE\_GAZ,  
#  
to see [§  
9.5]*

*/ THM\_AIR\_DISS,*

#

*to see [§  
9.6]*

*/ THM\_DIFFU, #*

*to see [§  
9.7]*

*/ SURF\_ETAT\_SATU,*

#

*to see [§  
9.8]*

*/ SURF\_ETAT\_NSAT,*

#

*to see [§  
9.9]*

*/ CAM\_CLAY\_THM,*

#

*to see [§  
9.10]*

*/ CAM\_CLAY,*

#

*to see [§  
9.11]*

*/ CJS, #  
to see [§  
9.12]*

*/ LAIGLE, #  
to see [§  
9.13]*

*/ DRUCKER\_PRAGER,  
#  
to see [§  
9.14]*

*/ BARCELONA, #  
to see [§  
9.15]*

*/ HOEK\_BROWN,  
#  
to see [§  
9.16]*

*# Behavior specific to the elements 1D [§ 10]*

//  
*VMIS\_POUTRE,*  
#  
*to see [§*  
*10.1]*  
/  
*VMIS\_POUTRE\_FO,*

/  
*ECRO\_FLEJOU,*  
#  
*to see [§*  
*10.2]*

/  
*ECRO\_ASYM\_LINE,*  
#  
*to see [§*  
*10.3]*

#  
*Behaviors*  
*private individuals*  
*[§*  
*11]*

/  
*LEMAITRE\_IRRA, #*  
*to see [§*  
*11.1]*

*/ LMARC\_IRRA,  
#  
to see [§  
11.2]*

*/ DIS\_GRICRA,  
#  
to see [§  
11.3]*

*/ GATT\_MONERIE,  
#  
to see [§  
11.4]*

*/ DIS\_CONTACT,  
#  
to see [§  
11.5]*

*/ ASSE\_CORN, #  
to see [§  
11.6]*



*/ ARM,  
#  
to see [§  
11.7]*

*#  
Behavior  
fluid  
[§  
12]*

*/ FLUID, #  
to see [§  
12.1]*

*# Given Materials associated with postprocessings [§ 13]*

*/ TIRE,  
#  
to see [§  
13.1]*

*/ DOMMA\_LEMAITRE,  
#  
to see [§  
13.2]*

/ *CISA\_PLAN\_CRIT*,  
#  
*to see [§*  
*13.3]*

//  
*WEIBULL*,  
#  
*to see [§*  
*13.4]*

/  
*WEIBULL\_FO*,

//  
*RCCM*,  
#  
*to see [§*  
*13.5]*

*/RCCM\_FO*,

)  
**Note:**

*For the majority of the behaviors, it is possible to define constant characteristics or many characteristics depending on one or two variables. We chose to gather them two key words factors, single-ended spanner words being identical in both cases, only their arguments are characterized by the type of associated concept.*

*In the syntax of each behavior, one will adopt following convention to indicate it or the variables of which can depend the concepts of the function type.*

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[function \*]

“TEMP” “X”, “Y”, “Z” (two variables among four),

[function \*\*]

“TEMP”

[function \*\*\*]

“EPSI” “TEMP”

[function \*\*\*\*] “ABSC”

[function +]

“INST”

[function ++]

“NORM”

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**3**

***General elastic behaviors***

**3.1**

***Key words factor ELAS/ELAS\_FO***

*Definition of the constant linear elastic characteristics or functions of the parameter “TEMP”.*

**3.1.1 Syntax**

/

/

***ELAS***

=

***\_F***

(

***E***

=

***yg***

,

***[R]***

***NAKED =***

***naked, [R]***

***RHO =***

***rho***  
***, [R]***

***ALPHA***  
***= dil***  
***, [R]***

***/AMOR\_ALPHA***  
***=***  
***, [R]***  
***AMOR\_BETA***

***=***  
***,***  
***[R]***  
***/***  
***AMOR\_HYST***

***=***  
***, [R]***

)  
/  
**ELAS\_FO**  
=  
**\_F**  
(  
  
**E**  
=  
  
**yg**  
,  
**[function \*\*]**

**NAKED**  
=  
**naked**  
,  
**[function \*\*]**

***RHO***

=

***rho***  
***, [R]***

***ALPHA***

= ***dil***

***, [function \*\*]***

***/AMOR\_ALPHA***

=

***, [function \*\*]***

***AMOR\_BETA***

=

***, [function \*\*]***

/

***AMOR\_HYST***

=

***, [function \*\*]***



***TEMP\_DEF\_ALPHA = Tdef, [R]***

***PRECISION***

***=/, [R]***

***/***

***1***

***,***

***[DEFECT]***

***K\_DESSIC =/K, [R]***

***/***

***0***

***,***

***[DEFECT]***

***B\_ENDOGE =/E, [R]***

***/***

***O***

***,***

***[DEFECT]***

***FONC\_DESORP***

***=***

***/F, [function]***

***)***

### ***3.1.2 Operands***

***E/NAKED***

***E = yg***

***Young modulus. It is checked that E 0.***

***NAKED = naked***

***Poisson's ratio. That -1. naked 0.5 are checked.***

### ***3.1.3 Operand***

## ***RHO***

***RHO = rho***

***Real constant density (one does not accept a concept of the function type). Not checking of about size.***

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### ***3.1.4 Operands***

***ALPHA/TEMP\_DEF\_ALPHA/PRECISION***

***ALPHA =***

***[function \*\*]***

***Isotropic thermal dilation coefficient.***

***The thermal dilation coefficient is an average dilation coefficient which can depend on the temperature T.***

***The values of the dilation coefficients are determined by tests of dilatometry which have place at the ambient temperature (0°C or more generally 20°C).***

***So one in general has the values of the dilation coefficient defined compared to 20°C (temperature to which one supposes the null thermal deformation).***

*Certain studies require to take a temperature of reference different from ambient temperature (null thermal deformation for another temperature that ambient temperature). It is then necessary to carry out a change of reference mark in the calculation of thermal deformation [R4.08.01].*

**TEMP\_DEF\_ALPHA = Tdef**  
**[R]**

*It is the value of the temperature to which the values of the thermal dilation coefficient have summer determined, and were well informed under the key word ALPHA.*

*This key word becomes obligatory as soon as ALPHA was informed.*

*The calculation of the thermal deformation is done by the formula [R4.08.01]:*

*(T) T - T*  
*- T*  
*T*  
*- T*  
*HT*  
*(def) (ref.) (ref. def)*  
*(T)*  
*= \$ (T) (T - Re*  
*T F) with \$ (T) =*  
*T - ref.*  
*T*

*and*  
*HT (ref.*  
*T) = 0*

**PRECISION: /prec**

/

1.

**[DEFECT]**

*This key word is used when key word TEMP\_DEF\_ALPHA is specified.*

*It is a reality which indicates with which precision a temperature  $T_i$  (of the list of the temperatures being used for the definition of  $(T_i)$ ) is close to the temperature of reference  $T$ ,  $i=$ ,*

***1 NR***

***ref.***

***This reality is used for calculation of the function \$  
(Ti). The mathematical formula allowing the calculation of  
\$***

***(Ti) is different according to whether T T  
or T = T***

***I***

***ref.***

***I***

***ref.***

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***3.1.5 Operands***

***AMOR\_ALPHA/AMOR\_BETHA/AMOR\_HYST***

***/AMOR\_ALPHA***

***=***

***AMOR\_BETA***

***=***

***Coefficients and allowing to build a matrix of viscous damping***

*proportional to rigidity and/or the mass  $[C] = [K] + [M]$ . One will refer to the documents of modeling of the mechanical cushioning [U2.06.03] and [R5.05.04].*

*/AMOR\_HYST =*

*Damping coefficient hysteretic allowing to define the complex Young modulus (viscoelastic material) from which the matrix of complex rigidity will be created allowing the calculation of the harmonic answer [U2.06.03] and [R5.05.04].*

### *3.1.6 Operands*

*K\_DESSIC/B\_ENDOGE*

*/K\_DESSIC = K*

*Coefficient of withdrawal of dessication.*

*/K\_ENDOGE = E*

*Coefficient of withdrawal of endogenous.*

*These characteristics are used with the behavior defined by key words **BETON\_DOUBLE\_BP**, **GRANGER\_FP** and **BAZANT\_FD**.*

### *3.1.7 Operand*

*FONC\_DESORP*

*FONC\_DESORP: curve of sorption-desorption [R7.01.12] giving the hygroscoy  $H$  according to water content  $C$ . Operand obligatory with law **BAZANT\_FD** [R7.01.01].*

## *3.2*

*Key word factor **ELAS\_FLUI***

*Key word **ELAS\_FLUI** makes it possible to define the equivalent density of a tubular structure with internal and external fluid, by taking of account the effect of containment.*

*This operation lies within the scope of the study of the dynamic behavior of a configuration of type "beam of tubes under transverse flow". The study of the behavior of the beam is brought back to the study of a single tube representative of the whole of the beam.*

*The equivalent density of the structure  $eq$  is defined by:*

*1*

*2*

*2*

*2*

2

$eq = ($

$I, I$

$D + T.E$

$D - I$

$D + E. E$

$D Q$

2

2

$E$

$D - I$

$D) [$

$($

$) ]$

$2.Cm^2$

2

$. E$

$D$

$eq$

$D =$

,,

$I$

$E$

$T$

*are respectively the density of the fluid intern, of the external fluid and the structure.*

$E$

$D, I$

$D$

*are respectively the external diameter and intern of the tube.*

$Cm$

*is a coefficient of added mass (containment defines).*

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*Titrate:*

## **Operator *DEFI\_MATERIAU***

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### **3.2.1 Syntax**

**/ELAS\_FLUI = \_F**

**(**

***RHO***

**=**

***rho***

**[R]**

***E***

**=**

***yg***

**[R]**



***NAKED***

=

***naked***

***[R]***

***PROF\_RHO\_F\_INT***

=

***rhoi***

***[function \*\*\*\*]***

***PROF\_RHO\_F\_EXT***

=

***rhoe***

***[function \*\*\*\*]***

***COEF\_MASS\_AJOU = fonc\_cm [function \*\*\*\*]***

)

### **3.2.2 Operand**

#### ***ELAS\_FLUI***

***/***  
***ELAS\_FLUI = \_F***

***(***  
***Key word factor allowing to calculate the equivalent density of a structure beam with internal and fluid external (this relation of behavior cannot be used that with elements of beam).***

***RHO = rho***

***Density of material.***

***E = yg***

***Young modulus.***

***NAKED = naked***

***Poisson's ratio.***

***PROF\_RHO\_F\_INT = rhoi***

***Concept of the type [function] defining the profile of density of the fluid interns it length of the tube. This function is parameterized by the curvilinear X-coordinate.***

***PROF\_RHO\_F\_EXT = rhoe***

***Concept of the type [function] defining the profile of density of the external fluid along the tube. This function is parameterized by the curvilinear X-coordinate, "ABSC".***

***COEF\_MASS\_AJOU = fonc\_cm***

**Concept of the type [function] produced by operator FONC\_FLUI\_STRU [U4.35.02].**

**This constant function, parameterized by the curvilinear X-coordinate, provides the value of coefficient of added mass Cm.**

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**3.3**

**Key word factor APPUI\_ELAS**

**/APPUI\_ELAS = \_F (**

**E\_N**

**=**

**rign**

**,**

**[R]**

**E\_TAN**

**=**

/  
**0.**  
,  
**[DEFECT]**  
/  
**rigt**  
,  
**[R]**

)

*This key word factor makes it possible to define the characteristics of material associated with modeling*

*“APPUI\_REP” [U4.41.01]. This modeling relates to only the elements of the face type of modeling “3D” associated with the “MECHANICAL” phenomenon.*

*One models the action of a medium characterized by the normal and tangential surface stiffness on faces of three-dimensional elements.*

*In the case of the elements of hull, it is necessary to duplicate the meshes thanks to the order CREA\_MALLAGE [U4.23.02] and to assign modeling “3D” to these new meshes.*

**E\_N**  
=  
**rign,**  
**[R]**

*Value of the normal surface stiffness.*

**E\_TAN = rigt,**

**[R]**

*Value of the tangential surface stiffness.*

### 3.4

#### ***Key word factor CABLE***

***Definition of the elastic characteristic nonlinear, constant, for the cables: two behaviors different rubber bands in traction and compression, defined by the Young moduli E and EC. (module in compression).***

***The standard characteristics of elastic material are to be informed under the key word factor ELAS.***

#### ***3.4.1 Syntax***

***/  
CABLE  
=  
\_F (  
EC\_SUR\_E =/ecse,***

***[R]  
/  
1.D-4,  
[DEFECT]***

***)***

#### ***3.4.2 Operands of elasticity***

***EC\_SUR\_E = ecse***

**Report/ratio of the modules to compression and traction. If the module of compression is null, it total linear system with displacements can become singular. It is the case when a node is connected only to cables and that those all enter in compression.**

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### **3.4.3 Operand of mass**

**RHO = rho**

**Density.**

### **3.4.4 Operand of dilation**

**ALPHA = dil**

**Thermal dilation coefficient average compared to the temperature of reference defined under AFFE\_MATERIAU.**

### **3.4.5 Operands of damping**

**AMOR\_ALPHA =**

**AMOR\_BETA =**

*Coefficients and allowing to build a matrix of viscous damping proportional to rigidity and/or with the mass  $[C] = [K] + [M]$ . One will refer to the document modeling of mechanical cushioning [U2.06.03].*

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*3.5*

*Key words factor ELAS\_ORTH/ELAS\_ORTH\_FO*

*Definition of the constant orthotropic elastic characteristics or functions of the temperature for elements of hull and solid elements isoparametric or layers constitutive of one composite (cf DEFI\_COQU\_MULT).*

*3.5.1 Syntax*

*/*

*ELAS\_ORTH*

*=*

*\_F*

*(*

*E\_L =*

*ygl*

*, [R]*

**$E_T =$**   
 **$ygt$**   
 **$, [R]$**

**$E_N =$**   
 **$ygn$**   
 **$, [R]$**

**$G_{LT} =$**   
 **$glt$**   
 **$, [R]$**

**$G_{TN} =$**



***gtn***  
***, [R]***

***G\_LN =***  
***gln***  
***, [R]***

***NU\_LT =***  
***nult,***  
***[R]***

***NU\_TN =***  
***nutn,***  
***[R]***

***NU\_LN =***  
***nuln,***  
***[R]***

***ALPHA\_L =***  
***/dil,***  
***[R]***  
***/***  
***0.0,***  
***[DEFECT]***

***ALPHA\_T =***  
***/known as,***  
***[R]***  
***/***  
***0.0,***  
***[DEFECT]***

***ALPHA\_N =***  
***/DIN,***  
***[R]***  
***/***  
***0.0,***  
***[DEFECT]***

***RHO =***  
***/rho,***  
***[R]***  
***/***  
***0.0,***  
***[DEFECT]***

***XT =***  
***/trl,***  
***[R]***  
***/***  
***1.0,***  
***[DEFECT]***

***XC =***  
***/collar,***  
***[R]***  
***/***  
***1.0,***  
***[DEFECT]***

***YT =***  
***/trt,***  
***[R]***  
***/***  
***1.0,***  
***[DEFECT]***

***YC =***  
***/cot,***  
***[R]***  
***/***  
***1.0,***  
***[DEFECT]***

*S\_LT =*  
*/cis,*  
*[R]*  
*/*  
*1.0,*  
*[DEFECT]*

)  
*/*  
*ELAS\_ORTH\_FO*  
*=\_F*  
*(E\_L =*  
*ygl*  
*, [function \*\*]*

*E\_T =*  
*ygt*  
*, [function \*\*]*

***E\_N =***  
***ygn***  
***, [function \*\*]***

***G\_LT =***  
***gl***  
***, [function \*\*]***

***G\_TN =***  
***gtn***  
***, [function \*\*]***

***G\_LN =  
gln  
, [function \*\*]***

***NU\_LT =  
nult,  
[function \*\*]***

***NU\_TN =  
nutn,  
[function \*\*]***

***NU\_LN =  
nuln,  
[function \*\*]***

***ALPHA\_L***

=

***dil***

***, [function \*\*]***

***ALPHA\_T***

=

***known as***

***, [function \*\*]***

***ALPHA\_N***

=

***DIN***

***, [function \*\*]***



***RHO =***  
***/rho,***  
***[R]***  
***/***  
***0.0,***  
***[DEFECT]***

***TEMP\_DEF\_ALPHA = Tdef, [R]***

***PRECISION***  
***= /,***  
***[R]***  
***/***  
***1.,***  
***[DEFECT]***

)  
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### **3.5.2 Operands of elasticity**

**The reader will be able to refer to following documentations:**

**[U4.42.03] DEF1\_COQU\_MULT**

**[U4.42.01] AFFE\_CARA\_ELEM**

**to define the reference mark of orthotropism (*L, T, NR*) related to the elements.**

**$E_L$  = *ygl* longitudinal Modulus Young.**

***NR***

***T***

***L***

***L, T* and *NR*: directions of orthotropism  
longitudinal, transverse and normal**

**$E_T$  = *ygt* transverse Modulus Young.**

*$E_N$  = ygn normal Modulus Young.*

*$GL_T$  = glt Modulus of rigidity in plan LT.*

*$G_{TN}$  = gtn Modulus of rigidity in plan TN.*

*$G_{LN}$  = gln Modulus of rigidity in plan LN.*

*Note:*

*For the hulls, the transverse moduli of rigidity are not obligatory; in it case, one calculates in thin hull by assigning an infinite rigidity to transverse shearing (DST elements, DSQ and Q4G).*

*$NU_{LT}$  = nult Poisson's ratio in plan LT.*

*Important remarks:*

*ygt  
nult is not equal to nutl. In fact, one with the relation:  $nult =$   
nult  
\**

*ygl  
nult must be interpreted in the following way:*

*if one exerts a traction according to the axis L giving place to a deformation according to this axis equalizes with  
L*

*L  
L =  
, there is a deformation according to the axis T equalizes with:  $T = - nult^*$*

*ygl  
ygl*

*The various moduli of elasticity  $E_L$ ,  $G_{LN}$  and  $NU_{LN}$  cannot be selected of unspecified way: physically, it is necessary always that a nonnull deformation causes one strictly positive deformation energy. That results in the fact that the matrix of Hooke must be definite positive. Operator  $DEFI\_MATERIAU$  calculates the eigenvalues of this matrix and emits an alarm if this property is not checked.  
For the models 2D, like the user its  $MODELING$  ( $D\_PLAN$  did not choose yet,*

*C\_PLAN,...), one checks the positivity of the matrix in the various cases of figure.*

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*NU\_TN = nutn Poisson's ratio in plan TN.*

*NU\_LN = nuln Poisson's ratio in plan LN.*

*The remark made for NU\_LT is to be applied to these the last two coefficients. One has them thus relations:*

*ygt*

*nunt =*

*\* nutn*

*ygn*

*ygl*

*nunl =*

*\* nuln*

*ygn*

*3.5.3 Operand*

*RHO*

*RHO = rho*

*Density.*

### **3.5.4 Operands**

**ALPHA\_L/ALPHA\_T/ALPHA\_N**

**ALPHA\_L = dil**

**Thermal dilation coefficient average longitudinal.**

**ALPHA\_T = known as**

**Thermal dilation coefficient average transverse.**

**ALPHA\_N = DIN**

**Thermal dilation coefficient average normal.**

### **3.5.5 Operands**

**TEMP\_DEF\_ALPHA/PRECISION**

**One will refer to the paragraph [§3.1.4]. This key word becomes obligatory as soon as one informed ALPHA\_L, or ALPHA\_T or ALPHA\_N.**

### **3.5.6 Criteria of rupture**

**These various criteria can be used by order CALC\_ELEM under the key word “CRIT\_ELNO\_RUPT” [U4.81.01], [R4.01.01].**

**XT = trl**

**Criterion of rupture in traction in the longitudinal direction (first direction of orthotropism).**

**XC = collar**

**Criterion of rupture in compression in the longitudinal direction.**

**YT = trt**

**Criterion of rupture in traction in the transverse direction (second direction of orthotropism).**

**YC = cot**

**Criterion of rupture in compression in the transverse direction.**

**S\_LT = cis**

**Criterion of rupture in shearing in plan LT.**

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### **3.6**

**Key words factor** *ELAS\_ISTR/ELAS\_ISTR\_FO*

*Definition of the constant elastic characteristics or functions of the temperature in the case of transverse isotropy for the elements of hull and the solid elements isoparametric.*

*By taking again the same notations as for the orthotropism [§3.4], the transverse isotropy means here, isotropy in the plan (L, T).*

#### **3.6.1 Syntax**

/  
**ELAS\_ISTR**

=  
**\_F**

(  
**E\_L =**

**ysl**  
**, [R]**

***E\_N =***  
***ygn***  
***, [R]***

***G\_LN =***  
***gln***  
***, [R]***

***NU\_LT =***  
***nult,***  
***[R]***

***NU\_LN =***  
***nuln,***  
***[R]***



**ALPHA\_L =**  
**/dil,**  
**[R]**  
**/**  
**0.0,**  
**[DEFECT]**

**ALPHA\_N =**  
**/DIN,**  
**[R]**  
**/**  
**0.0,**  
**[DEFECT]**

**RHO =**  
**/rho,**  
**[R]**  
**/**  
**0.0,**

**[DEFECT]**

)

/

**ELAS\_ISTR\_FO**

**=\_F**

**(E\_L =**

**ygl**

**, [function \*\*]**

**E\_N =**

**ygn**

**, [function \*\*]**

**G\_LN =**

**gln**

**, [function \*\*]**

*NU\_LT =  
nult,  
[function \*\*]*

*NU\_LN =  
nuln,  
[function \*\*]*

*ALPHA\_L  
=  
dil  
, [function \*\*]*

**ALPHA\_N**  
=  
**DIN**  
, [function \*\*]

**RHO =**  
**/rho,**  
**[R]**  
**/**  
**0.0,**  
**[DEFECT]**

**TEMP\_DEF\_ALPHA = Tdef, [R]**

**PRECISION**  
= /,  
**[R]**

/

1.,  
**[DEFECT]**

)

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**3.6.2 Operands**

**of elasticity**

**The reader will be able to refer to following documentations:**

**[U4.42.03] DEF1\_COQU\_MULT**

**[U4.42.01] AFFE\_CARA\_ELEM**

**to define a reference mark (L, T, NR) related to the elements and defining the transverse isotropy of material, it**

*the last being isotropic in plan LT.*

*Note:*

*The directions L and T are arbitrary in plan LT.*

**NR**

**T**

**L**

*L and T define the plan in which  
the material is isotropic*

$$E_L = ygl$$

*Young modulus in plan LT.*

$$E_N = ygn$$

*Normal Young modulus.*

$$GL_N = gln$$

*Modulus of rigidity in plan LN.*

*Note:*

*The modulus of rigidity in plan LT is defined by the usual formula for materials*

**E**

**ygl**

*isotropic: G = (*

*that is to say here glt =*

**.**

**2 I+ )**

**(**

**2 I+ naked)**

**lt**

$$NU_{LT} = nult$$

*Poisson's ratio in plan LT.*

$$NU_{LN} = nuln$$

*Poisson's ratio in plan LN.*

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**Important remarks:**

*nult = nultl since the material is isotropic in plan LT, but nuln is not not equal to nunl.*

*ygl*

*One with the relation: nunl =*

*\* nuln*

*ygn*

*nult must be interpreted in the following way:*

*if one exerts a traction according to the axis NR giving place to a deformation of traction according to this*

*axis equalizes with*

*NR*

*NR*

*NR =*

*, there is a compression according to the axis L equalizes with: nuln \**

*.*

*ygn*

*ygn*

*The various moduli of elasticity  $E_L$ ,  $G_{LN}$  and  $NU_{LN}$  cannot be selected of unspecified way: physically, it is necessary always that a nonnull deformation causes one strictly positive deformation energy. That results in the fact that the matrix of Hooke must be definite positive. Operator  $DEFI\_MATERIAU$  calculates the eigenvalues of this matrix and emits an alarm if this property is not checked. For the models 2D, like the user its  $MODELING$  ( $D\_PLAN$  did not choose yet,  $C\_PLAN$ ,...), one checks the positivity of the matrix in the various cases of figure.*

### **3.6.3 Operand $RHO$**

$RHO = rho$

*Density.*

### **3.6.4 Operands $ALPHA\_L/ALPHA\_N$**

$ALPHA\_L = dil$

*Thermal dilation coefficient average in plan  $LT$ .*

$ALPHA\_N = DIN$

*Thermal dilation coefficient average normal.*

### **3.6.5 Operands $TEMP\_DEF\_ALPHA/PRECISION$**

*One will refer to the paragraph [§3.1.4]. This key word becomes obligatory as soon as the word was informed*

*key  $ALPHA\_L$  or  $ALPHA\_N$ .*

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3.7

*Key word factor ELAS\_COQUE/ELAS\_COQUE\_FO*

*ELAS\_COQUE makes it possible the user to directly provide the coefficients of the matrix of elasticity (broken up into membrane and inflection) of the orthotropic thin hulls in linear elasticity [R3.07.03].*

3.7.1 Syntax

/

*ELAS\_COQUE =*

*\_F (*

*/ELAS\_COQUE\_FO*

*= \_F*

*MEMB\_L*

=

*C1111*

,

*[R]*

*or*

*[function \*\*]*

*MEMB\_LT = C1122, [R]*

*or*

*[function \*\*]*

***MEMB\_T***  
=  
***C2222***  
,  
***[R]***  
***or***  
***[function \*\*]***

***MEMB\_G\_LT***  
=***C1212***  
, ***[R]***  
***or***  
***[function \*\*]***

***FLEX\_L***  
=  
***D1111***  
,  
***[R]***  
***or***  
***[function \*\*]***

***FLEX\_LT = D1122, [R]***

***or***

***[function \*\*]***

***FLEX\_T***

***=***

***D2222***

***,***

***[R]***

***or***

***[function \*\*]***

***FLEX\_G\_LT***

***= D1212***

***, [R]***

***or***

***[function \*\*]***

***CISA\_L***

***=***

***G11***

***, [R] or [function \*\*]***

*CISA\_T*

=

*G22*

, [R] or [function \*\*]

*RHO*

=

*rho*

, [R] or [function \*\*]

*ALPHA*

=

*alpha*

,

[R]

or

[function \*\*]

*M\_LLLL*

=  
***H1111***  
,  
***[R]***  
***or***  
***[function \*\*]***

***M\_LLTT***  
=  
***H1111***  
,  
***[R]***  
***or***  
***[function \*\*]***

***M\_LLLT***  
=  
***H1112***  
,  
***[R]***  
***or***  
***[function \*\*]***

***M\_TTTT***  
=  
***H2222***

,  
**[R]**  
**or**  
**[function \*\*]**

***M\_TTLT***  
**=**  
***H2212***

,  
**[R]**  
**or**  
**[function \*\*]**

***M\_LTLT***  
**=**  
***H1212***

,  
**[R]**  
**or**  
**[function \*\*]**

***F\_LLLL***  
**=**  
***A1111***

,  
**[R]**

*or*  
*[function \*\*]*

*F\_LLLL*  
=  
*A1111*  
,  
*[R]*  
*or*  
*[function \*\*]*

*F\_LLLT*  
=  
*A1112*  
,  
*[R]*  
*or*  
*[function \*\*]*

*F\_TTTT*  
=  
*A2222*  
,  
*[R]*  
*or*  
*[function \*\*]*

***F\_TTLT***  
=  
***A2212***  
,  
***[R]***  
***or***  
***[function \*\*]***

***F\_LTLT***  
=  
***A1212***  
,  
***[R]***  
***or***  
***[function \*\*]***

***MF\_LLLL = B1111, [R]***  
***or***  
***[function \*\*]***



***MF\_LLTT = B1111, [R]***

***or***

***[function \*\*]***

***MF\_LLLT = B1112, [R]***

***or***

***[function \*\*]***

***MF\_TTTT = B2222, [R]***

***or***

***[function \*\*]***

***MF\_TTTL = B2212, [R]***

***or***

***[function \*\*]***

***MF\_LTLT = B1212, [R]***

***or***

***[function \*\*]***

***MC\_LLLZ = E1111, [R]***

***or***

***[function \*\*]***

***MC\_LLTZ = E1111, [R]***

***or***

***[function \*\*]***

***MC\_TTLZ = E1112, [R]***

***or***

***[function \*\*]***

***MC\_TTTZ = E2222, [R]***

***or***

***[function \*\*]***

***MC\_LTLZ = E2212, [R]***  
***or***  
***[function \*\*]***

***MC\_LTTZ = E1212, [R]***  
***or***  
***[function \*\*]***

***FC\_LLLZ = F1111, [R]***  
***or***  
***[function \*\*]***

***FC\_LLTZ = F1111, [R]***  
***or***  
***[function \*\*]***

***FC\_TTLZ = F1112, [R]***  
***or***  
***[function \*\*]***

***FC\_TTTZ = F2222, [R]***  
***or***  
***[function \*\*]***

***FC\_LTLZ = F2212, [R]***  
***or***  
***[function \*\*]***

***FC\_LTTZ = F1212, [R]***  
***or***  
***[function \*\*]***

***C\_LZLZ***  
***=***  
***G1313***  
***,***  
***[R]***  
***or***  
***[function \*\*]***

***C\_TZTZ***  
=  
***G2323***  
,  
***[R]***  
***or***  
***[function \*\*]***

***C\_TZTZ***  
=  
***G1323***  
,  
***[R]***  
***or***  
***[function \*\*]***

)  
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**The matrix of behavior intervening in the matrix of rigidity in isotropic homogeneous elasticity is form:**

**Membrane:**

**Inflection:**

**Shearing:**

**1 0**

**1 0**

**3**

**1 0**

**Eh**

**Eh**

**C =**

**1 0**

**D =**

**1 0**

**5Eh**

**1**

**2**

**-**

**(**

**12 1**

**2**

**-)**

**G =**

**(**

**0 1**

**12 1 +)**

**1 -**

**0 0**

**1 -**

2

0 0 2

*For the orthotropic hulls whose moduli of elasticity are obtained by a method of homogenisation, it is not possible in the case general to find a Young modulus equivalent  $E_{eq}$ , and an equivalent thickness  $h_{eq}$  to find the preceding expressions.*

*The matrices of rigidity are thus given directly in the form:*

*Membrane:*

*Inflection:*

*Shearing:*

$C_{1111} \ C_{1122} \ 0$

$D_{1111} \ D_{1122} \ 0$

$G_{11} \ 0$

$C = C_{1122} \ C_{2222} \ 0$

$D = D_{1122} \ D_{2222} \ 0$

$G = 0$

$G_{22}$

0

0

$C_{1212}$

0

0

$D_{1212}$

*On the other hand, one limits oneself to the cases where the thermal dilation coefficient is homogeneous isotropic.*

*These coefficients are to be provided in the local reference mark of the element. It is defined by key word ANGL\_REP*

*AFFE\_CARA\_ELEM [U4.42.01].*

*Notice concerning the taking into account of transverse shearing following the models of hulls:*

*If one wishes to use ELAS\_COQUE with transverse shearing it is necessarily necessary to employ DST modeling. If one uses modeling DKT, transverse shearing will not be taken into account, some are the values of  $G_{11}$  and  $G_{22}$ . Correspondence for one isotropic material is as follows:*

.

*The material ELAS\_COQUE, DST modeling with  $CISA_* = 5/12 * (Eh/(1+\nu))$  is equivalent with the material ELAS, DST modeling.*

•  
*The material ELAS\_COQUE, DST modeling with  $CISA_* = 5/12 * (Eh/(1+\nu)) * N$ , where NR is one great number (for example 105), is equivalent to the material ELAS, modeling DKT.*

•  
*The material ELAS\_COQUE, modeling DKT is equivalent to the material ELAS, modeling DKT.*

*Matrices of behavior connecting the efforts generalized to the deformations for the elements of plate and fascinating account the terms of coupling are in the following way defined:*

*Membrane:*

*Inflection:*

*Membrane - inflection:*

*H1111 H1122 H1112*

*A1111 A1122*

*A1112*

*B1111 B1122 B1112*

*HM = 0*

*H2222 H2212 HF = 0*

*A2222 A2212 HMF = 0*

*B2222 B2212*

*0*

*0*

*H1212*

*0*

*0*

*A1212*

*0*

*0*

*B1212*

*Membrane shearing:*

*Inflection - shearing:*

*Shearing:*

*E1113 E1123*

*F1113 F1123*

*G1313 G1323*

*HMC = E2213 E2223*

*HFC = F2213 F2223*

*HC = G1323 G2323*

*E1213 E1223*

*F1213 F1223*

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**4**

**General nonlinear mechanical behaviors**

***In general, the definition of a nonlinear mechanical behavior requires on the one hand the definition elastic properties and in addition those relating to the nonlinear aspect itself.***

***In Code\_Aster, these 2 types of data are separately defined, except some exceptions.***

**4.1**

**Key word factor** *TRACTION*

***Definition of a traction diagram (elastoplasticity of von Mises with nonlinear isotropic work hardening or nonlinear elasticity).***

**4.1.1 Syntax**

**/**  
**TRACTION = \_F**

**(**

**SIGM**

**=**

**sigm\_f**

,  
**[function \*\*\*]**

)

#### **4.1.2 Operand SIGM**

**SIGM = sigm\_f**

**Curve according to (one checks that the concept function depends many only parameters EPSI and possibly TEMP).**

**The ordinate of the first point defines the yield stress of material, it is thus imperative of not to define of point of null X-coordinate.**

**Note:**

**For multiphase materials, the characteristics of work hardening are defined by META\_ECRO\_LINE or META\_TRACTION.**

#### **4.2 Key words factor ECRO\_LINE/ECRO\_LINE\_FO**

**Definition of a linear curve of work hardening or a whole of curves depending on temperature.**

##### **4.2.1 Syntax**

/  
**ECRO\_LINE = \_F**  
**(D\_SIGM\_EPSI**  
**=**  
**dsde, [R]**

***SY***  
=  
***sigm***  
,  
***[R]***

)

***/ ECRO\_LINE\_FO***  
***=\_F***  
***(D\_SIGM\_EPSI***  
***=***  
***dsde, [function \*\*]***

***SY***  
**=**  
***sigm***  
,  
**[function \*\*]**

)

#### ***4.2.2 Operands***

***D\_SIGM\_EPSI = dsde (AND)***

***Slope of the traction diagram.***

***SY = sigm***

***Elastic limit.***

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*The curve of work hardening used in  
E  
models of behavior is then:  
T*

*sigm  
R (p) = + H  
y  
p  
E. AND  
E  
with H =*

*E - AND  
I  
It is thus necessary to respect: E  
E  
T <*

*The Young modulus E is to be specified by key words ELAS or ELAS\_FO.*

**4.3**  
*Key words factor PRAGER/PRAGER\_FO*

*When the way of loading is not monotonous any more, work hardenings isotropic and kinematic are not more equivalent. In particular, one can expect to have simultaneously a kinematic share and one isotropic share. If one seeks to precisely describe the effects of a cyclic loading, it is desirable to adopt modelings sophisticated (but easy to use) such as the model of Taheri, for example, cf [R5.03.05]. On the other hand, for less complex ways of loading, one can wish to include only one linear kinematic work hardening, all nonthe linearities of work hardening being carried by the isotropic term. That makes it possible to follow a curve precisely of traction, while representing nevertheless phenomena such as the Bauschinger effect [R5.03.16].*

*The characteristics of work hardening are then given by a traction diagram and a constant, said of Prager, for the term of kinematic work hardening linear. Key word PRAGER makes it possible to define the constant of PRAGER, used in the models with mixed work hardening (kinematic linear compound with isotropic) VMIS\_ECMI\_LINE or VMIS\_ECMI\_TRAC.*

### 4.3.1 Syntax

/  
***PRAGER = \_F***  
***(C = C, [R]***

)

/  
***PRAGER\_FO = \_F***  
***(C = C, [function \*\*]***

)

*The identification of C is described in [R5.03.16].*

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***4.4 Word***  
***key***  
***CHABOCHE***

***Behavior of the model of Chaboche describes in the document [R5.03.04].***

***Briefly these relations are:***

***(***  
***- X - X***  
***1***  
***2 )***  
***- R (p) 0***

***eq***

***p***  
***3***  
***(~ - X - X***  
***1***  
***2 )***

***& = &p***

***éq***  
***4.4-1***

***2***  
***(~ - X - X***  
***1***  
***2) eq***

**&****2*****p*** **$X = C$** ***has******I******I******I*** **$(p) \& - Xi \&$** **3*****p******with:*** **$R(p) = R +$** **-** **$(R - R$** **0****)  $E LP$**  **$(p) = 1 + (K -) I e-wp$** ***and of the traditional relations of plasticity.******Note:*****~*****represent the diverter of the constraints and () eq the equivalent within the meaning of von Mises.******This model does not make it possible to take into account the variation of the coefficients with temperature.******With this intention, it is necessary to use VMIS\_CIN1\_CHAB\_FO or VMIS\_CIN2\_CHAB\_FO.*****4.4.1 Syntax**



/  
*/CHABOCHE = \_F*  
(

*R\_I*  
=  
*Rinfi,*  
*[R]*

*R\_0*  
=  
*Rzero,*  
*[R]*

*B =*  
  
*B,*  
*[R]*

***K*** =

***K***,  
***[R]***

***W*** =

***W***,  
***[R]***

***AI*** =

***aI***,  
***[R]***

***A2 =***

***a2,***  
***[R]***

***C1 =***

***C1,***  
***[R]***

***C2 =***

***C2,***  
***[R]***

)

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**4.5**

**Key words factor CIN1\_CHAB/CIN1\_CHAB\_F0**

**Behavior of the model of Chaboche (news version with only one kinematic variable) described in the document [R5.03.04].**

**Briefly these relations are:**

(  
 **$F, R, X = (\sim$**

**$- X) - R (p$**

**eq**

**)**

**~**

**3**

**- X**

**&p = & F**

**=**

**&**

2

$(\sim - X) eq$

2

$\&p = \& =$

$\&p \&p$

:

*éq 4.5-1*

3

*if  $F < 0$  or  $\&F < 0 \& = 0$*

*if  $F = 0$  and*

$\&F = 0 \&$

*éq*

*4.5-2*

0

2

$X = C(p),$

3

*éq*

*4.5-3*

*p*

$\& = \& - (p) \&p$

*The functions  $C(p)$  ( $p$ ) and  $R(p)$  are defined by:*

$R(p) = R +$

-

$(R - R$

0

)  $E LP$

$C(p) = C(1 + (K -$

$1 e-wp)$

$(p) = 0$

-

***I***  
***(has +***

***(1 - has) E LP***

)  
***Note:***

~  
***represent the diverter of the constraints and () eq the equivalent within the meaning of von Mises.***

***The definition of X in the form [éq 4.5-3] makes it possible to keep a formulation which takes in count the variations of the parameters with the temperature. These terms are necessary because them not taken into account would lead to inaccurate results.***

#### ***4.5.1 Syntax***

***CINI\_CHAB (CINI\_CHAB\_FO)***  
***= \_F (***

***R\_0 =***  
***R\_0***  
***,***  
***[R]***  
***or***  
***[function \*\*]***

***R\_I***  
***= R\_I, (useless if B=0) [R] or [function \*\*]***

***B =***  
***B***  
***, (defect: 0.)***

***[R] or [function \*\*]***

***C\_I =***  
***C\_I,***  
***[R]***  
***or***  
***[function \*\*]***

***K =***  
***K***  
***, (defect: 1.)***

***[R] or [function \*\*]***

***W =***  
***W***  
***, (defect: 0.)***

**[R] or [function \*\*]**

**G\_0**  
=  
**G\_0,**  
**[R]**  
**or**  
**[function \*\*]**

**A\_I**  
= **A\_I, (defect: 0.)**

**[R] or [function \*\*]**

)

**Note:**

**A viscoplastic version of the model of Chaboche to a true kinematics is also available (cf [R5.03.04]). It requires to define viscous characteristics using key word factor LEMAITRE or LEMAITRE\_FO, by putting parameter UN\_SUR\_M obligatorily to zero.**

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***Operator DEF1\_MATERIAU***

***Date:***

***22/02/06***

***Author (S):***

***Key J.P. LEFEBVRE***

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## 4.6

***Key words factor CIN2\_CHAB/CIN2\_CHAB\_FO***

***Behavior of the model of Chaboche (news version with two variables kinematics) described in the document [R5.03.04].***

***Briefly these relations are:***

***(  
F, R, X) = (~***

***- X - X***

***1  
2 )***

***- R (p)***

***eq***

***~***

***3***

***- X - X***

***&p = & F***

***=***

***&***

***1***

***2***

***2***

$(\sim - X - X$

$1$

$2) eq$

$\&p = \&$

$2$

$=$

$\&p \&p$

$:$

*éq 4.6-1*

$3$

*if  $F < 0$  or  $\&F < 0$  &  $= 0$*

*éq 4.6-2*

*if*

*$F = 0$  and*

*$\&F = 0$  &  $0$*

$2$

$X = C p,$

$1$

$1($

$)$

$3$

$1$

$2$

$X = C p,$

2  
2 (  
)  
3  
2

*éq 4.6-3*

*p*  
&  
=

*l*  
& -  
*p p*  
*l*(  
) *l* &

*p*  
&  
=

*2*  
& -  
*p p*  
*2* (  
) *2* &

*The functions C (p) C (p) (p) (p*

*l*  
*2*  
*l*  
*2*  
) and *R (p) are defined by:*

*R (p) = R +*  
-

*(R - R*  
*0*

) ***E LP***

***C***

***1***

***1***

***1 (p) = C***

***1 (+ (K -) e-wp)***

***C***

***1***

***1***

***2 (p) = C***

***2 (+ (K -) e-wp)***

***0***

***p =***

***+ 1 has - has E-LP***

***1(***

***)***

***1 ((***

***)***

***)***

***0***

***p =***

***+ 1 has - has E LP***

***-***

***2 (***

***)***

***2( (***

***)***

***)***

***Note:***

***~***

***represent the diverter of the constraints and () eq the equivalent within the meaning of von Mises.***

***The definition of X and X in the form [éq 4.5-3] makes it possible to keep a formulation which takes in***

***1***

***2***

***count the variations of the parameters with the temperature. These terms are necessary because them not taken into account would lead to inaccurate results.***

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Author (S):

Key **J.P. LEFEBVRE**

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#### **4.6.1 Syntax**

*CIN2\_CHAB (CIN2\_CHAB\_FO)*

= *\_F (*

*R\_0 =*

*R\_0,*

*[R]*

*or*

*[function \*\*]*

*R\_I*

= *R\_I, (useless if B=0) [R] or [function \*\*]*

$B =$

$B$

, (defect: 0.)

[R] or [function \*\*]

$C1_I = C1_I,$

[R]

or

[function \*\*]

$C2_I = C2_I,$

[R]

or

[function \*\*]

$K = K,$  (defect

:

1.)

[R] or [function \*\*]

$W = W$ , (*defect*

:  
0.)  
[R] or [function \*\*]

$G1_0$

=  
 $G1_0$ ,  
[R]  
or  
[function \*\*]

$G2_0$

=  
 $G2_0$ ,  
[R]  
or  
[function \*\*]



*A\_I*  
 =  
*A\_I*, (defect:  
 0.)  
 [*R*] or [function \*\*]

)

**Note:**

*A viscoplastic version of the model of Chaboche with two variables kinematics is also available (cf [R5.03.04]). It requires to define characteristics viscous using the key word factor LEMAITRE or LEMAITRE\_FO, while putting obligatorily parameter UN\_SUR\_M to zero.*

**4.7**  
**Key words factor TAHERI/TAHERI\_FO**

*Definition of the coefficients of the model of cyclic behavior of elastoplasticity of Said Taheri [R5.03.05].*

*Briefly we have to solve, for an elastoplastic increment:*

/  
 1 2  
 ~  
 3  
 3  
 - X  
 with (X) =  
 T  
 X X  
 & =

*eq*

2

*p*

*&p*

2

( ~

- X)

*eq*

$$R = D (A + R0)$$

= ( -

*N*

*p*)

$$X = C ($$

*S*

-

*p*

*p p*)

(

- X) -

$$R = 0$$

$$= \max X$$

$$+ R$$

*eq*

*p*

*T (eq*

)

.

*p*

- LP 1 -

*&* -

*S*

*p*

$$\&R - (X)$$

$\} = 0 D = 1 - me$   
*eq*

*P*  
*- LP 1 -*

*N*

*S*  
 $\& = 0$   
 $C = C + C$

*P*

*E*  
*1*

*where the various parameters of material are S, C*  
*C B*  
*, m A*

*,*  
*and*

*,*  
*R*

*,*

*.*

*,*

*1*

*0*

*The various parameters can depend on the temperature, in this case one will employ the key word*  
*TAHERI\_FO.*

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### ***4.7.1 Syntax***

*/*

*/*

***TAHERI***

*=*

***\_F***

*(*

***R\_0***

***= R, [R]***

***ALPHA =, [R]***

**$M = m, [R]$**

**$WITH = A, [R]$**

**$B = B, [R]$**

**$CI$   
 $=$   
 $CI$   
,**

**$[R]$**

**$C\_INF = Cinf_i,$**   
**[R]**

**$S = S, [R]$**

)  
/  
**TAHERI\_FO**  
=  
**\_F**  
(  
**R\_0**  
**= R, [function \*\*]**

***ALPHA =, [function \*\*]***

***M = m, [function \*\*]***

***With = A, [function \*\*]***

***B = B, [function \*\*]***

*C1*  
=  
*C1*  
,  
[function \*\*]

*C\_INF = Cinf,*  
[function \*\*]

*S = S,* [function \*\*]

)



**Note:**

*A viscoplastic version of the model of TAHERI is also available (cf [R5.03.05]). It requires to define viscous characteristics using the key word factor LEMAITRE or LEMAITRE\_FO.*

**4.7.2 Syntax**

*//OHNO:*

*/  
OHNO\_FO: \_F (  
R\_0: R0  
[R]  
or [function \*\*]*

*R\_I: Rinf [R]  
or [function \*\*]*

*PHI: phi\_inf [R]  
or [function \*\*]*

*B: B [R]*  
*or [function \*\*]*

*A1*  
*:*  
*C1*  
*[R]*  
*or [function \*\*]*

*A2*  
*:*  
*C2*  
*[R]*  
*or [function \*\*]*

*A3*  
*:*  
*C3*  
*[R]*  
*or [function \*\*]*

*A4*

*:*

*C4*

*[R]*

*or [function \*\*]*

*A5*

*:*

*C5*

*[R]*

*or [function \*\*]*

*GAMMA1*

*: g1*

*[R]*

*or [function \*\*]*

## *GAMMA2*

:

*g2*

*[R]*

*or [function \*\*]*

## *GAMMA3*

:

*g3*

*[R]*

*or [function \*\*]*

## *GAMMA4*

:

*g4*

*[R]*

*or [function \*\*]*

## *GAMMA5*

:

*g5*

*[R]*

*or [function \*\*]*

*M1*

*:*

*m1*

*[R]*

*or [function \*\*]*

*M2*

*:*

*m2*

*[R]*

*or [function \*\*]*

*M3*

*:*

*m3*

*[R]*

*or [function \*\*]*

*M4*

:

*m4*

*[R]*

or *[function \*\*]*

*M5*

:

*m5*

*[R]*

or *[function \*\*]*

)

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**4.8**  
***Key word factor POLY\_CFC/POLY\_CFC\_FO***

*Definition of the coefficients of the model of polycrystalline behavior of the School of the Mines of Paris [R5.03.13]. In addition to these characteristics, constant the rubber bands must be defined under the word key ELAS by the real coefficients or ELAS\_FO by the coefficients depending on the temperature.*

***Total behavior: definition of the deformations on a point scale of Gauss***

$$= E + HT + vp$$

$$vp = F$$

$$vpg$$

*F:*

*of*

*granulates*

*of*

*proportion*  
*orientatio “*

*NG ”*

*ij*

*ij*

*ij*

*ij*

*ij*

*G ij*

*G*

*G*

***Intragranular behavior:***

*vp*

*l*

*& G*

*S*

*S*

*S*

*ij*

*=*

***mij &***

*ij*

*m = (in lj + L J in)*

*2*

*S G*

*F S N*

*&ps =/ & S*

*/=*

*with <x>=0 if x<0 and <x>=x if x>0*

*K*

*Criterion:*

*S*

*S*

*S*

*S*

*l C*

*F = - X - - R +*

*(sx) 2*

*0*

*2D*

*S = G: ms*

*ij*

*ij*



*X S*

*C S*

*S*

*X S*

=

+

=

+

*S*

*has*

*has*

&

*S = & S - S &ps*

*D*

*Rs*

*(H Q s1) + Q q2s*

= *Q1*

*rs*

2

*R S*

*qis*

*& = B 1*

*(- qis) PS*

*I*

&

*(I =, 12)*

*H = H*

*rs*

*(1-rs) + with =1 if R = S and = 0 if R S*

*rs*

*rs*

*rs*

***Relations of scaling***

*G*

*1 E*

= +  $\mu$

-

$\mu$

=

*ij*

*ij*

(

*G*

*ij*

*B*

*ij*)

2 *1+*

*G*

*G*

*vpg*

*G*

*vpg*

*vp*

*G*

=

&

*ij*

*B*

*F G*

= &

--

*ij*

*ij*

*ij*

*D*

*ij*

*ij*

*ij*

&

*G*

where the various parameters of material are:  $D$ ,  $N$ ,  $K$ ,  $Q$ ,  $B$ ,  $H$ ,  $Q$ ,  $B$ ,  $C$ ,  $D$ , have

0  
1  
1  
2  
2  
.

various parameters can depend on the temperature, in this case one will employ the key word **POLY\_CFC\_FO**.

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### **4.8.1 Syntax**

***The model is accessible in Code\_Aster in 3D, plane deformations ( $D\_PLAN$ ), forced plane ( $C\_PLAN$ ) and axisymmetric ( $AXIS$ ) starting from key word  $COMP\_INCR$  of the order  $STAT\_NON\_LINE$ . The whole of the parameters of the model is provided under the key word factor  $POLY\_CFC$  or  $POLY\_CFC\_FO$ :***

/

***POLY\_CFC***

=

***\_F***

(

***DL***

=  
***D,***  
***[R]***

***DA***  
***= delta,***  
***[R]***

***NR***  
***=***  
***N,***  
***[R]***

***K***  
***=***  
***K,***  
***[R]***

***TAU\_0 = tau0,***

**[R]**

**$Q1 = Q1,$**   
**[R]**

**$B1 = b1,$**   
**[R]**

**$HL$**   
**=**  
 **$H,$**   
**[R]**

**$Q2 = Q2,$**   
**[R]**

***B2 = b2,***  
***[R]***

***C1***  
***=***  
***C,***  
***[R]***

***D1***  
***=***  
***D,***  
***[R]***

***C2***  
***=***  
***has,***  
***[R]***

)  
/  
**POLY\_CFC\_FO**  
**=\_F**  
(  
**DL**  
**=**  
**D,**  
**[function \*\*]**

**DA**  
**= delta,**  
**[function \*\*]**

**NR**  
**=**  
**N,**  
**[function \*\*]**

***K***  
=  
***K***,  
[function \*\*]

***TAU\_0 = tau0,***  
[function \*\*]

***Q1 = Q1,***  
[function \*\*]

***B1 = b1,***  
[function \*\*]

***HL***  
=



**H,**  
**[function \*\*]**

**Q2 = Q2,**  
**[function \*\*]**

**B2 = b2,**  
**[function \*\*]**

**C1**  
**=**  
**C,**  
**[function \*\*]**

**D1**

=  
**D,**  
**[function \*\*]**

**C2**  
=  
**has,**  
**[function \*\*]**

)

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#### **4.9 Key words factors $ECOU\_VISC1$ , $ECOU\_VISC2$ , $ECOU\_VISC3$ , $ECRO\_CIN1$ , $ECRO\_CIN2$ , $ECRO\_ISOT1$ , $ECRO\_ISOT2$**

**Definition of the coefficients of the models of single-crystal or polycrystalline behavior [R5.03.11]. In more these characteristics, constant the rubber bands must be defined under key word  $ELAS$  or  $ELAS\_ORTH$  for the real coefficients or  $ELAS\_FO$  for the coefficients depending on the temperature.**

**The behavior related to each system of slip of a monocrystal or a phase of a polycrystal is (in the whole of the behaviors considered) of élasto-visco-plastic type. Owing to the fact that one be interested each time in only one direction of slip, the behavior is mono dimensional. It can break up into 3 types of equations:**

**· relation of flow:**

**=  $G, p$**

**$S$**

**( $S S S S$ )**

**· evolutions of kinematic work hardening:**

**$S = H (S, S, S, PS)$**

**· evolution of isotropic work hardening:  $R p$ , with  $p$**

**=**

**$S ($**

**$S)$**

**$S$**

**$S$**

**The relation of flow  $ECOU\_VISC1$  is:**

**-  $C - R p$**

**$S$**

**$S$**

**$S (S)$**

**$N$**

**-**

**=**

**$C$**

**$G, p =$**

**$S$**

**$S$**

**·**

**, the parameters are:  $C, K, N$**

**S**  
**(S S S S)**  
**K**  
**- C**  
**S**  
**S**

**The relation of flow ECOU\_VISC2 is:**

**N**  
**C**  
**2**

**- C - - R p has +**  
**C**

**S**  
**S**  
**S**  
**S (S)**  
**(S)**

**2**  
**- -**

**=**

**D**  
**C**  
**has**  
**G, p**

**=**  
**S**  
**S**  
**S**  
**.**  
**,**  
**S**  
**(S S S S)**

**K**  
**- C - has**  
**S**

*S*  
*S*

*the parameters are then: C, K, N, has, D*

*The relation of flow ECOU\_VISC3 is:*

-  
-

\*

*G*

*V\**

*= G, p*

*S*

*=*

*0*

*S*

*μ*

*& exp*

*exp*

*.*

*,*

*S*

*(S S S S) 0 kT*

*kT*

*S*

*the parameters are: K, Boltzmann constant, in eV/K,  
μ Seuil of flow (homogeneous to one  
constraint), \**

*& initial Rate of flow,*

*\**

*V*

*Volume of activation, G*

*Profit of bound energy on*

*0*

*0*

*crossing of obstacle.*

*Kinematic work hardening can be form ECRO\_CIN1:*

*= H, p = - D. p*

*, with for parameter: D*

*S*

*(S S S S)*

*S*

*S*

*S*

*or ECRO\_CIN2:*

*m*

*C*

*= H, p =*

*- D*

*· p*

*-*

*, parameters being then: D, M and m*

*S*

*(S S S S)*

*S*

*S*

*S*

*S*

*S*

*M*

*S*

*Isotropic work hardening can for example be form ECRO\_ISOT1*

*-*

$$R p = R + Q$$

, the parameters are  $H, Q, R$

0

$H 1 - e R$

$H$

with

$$= H 1 - +$$

$S(S)$

$NR$

$(LP$

$Sr$

)

$Sr$

(

$Sr)$

$Sr$

0,  $B$

$r=1$

Or  $ECRO\_ISOT2$ :

$R$

$1$

$2$

=

+

+

,

with

$$= 1 -$$

.

the parameters are  $H, Q$

$S(p)$

$R$

$Q$

$H Q S$

$Q Q S$

$dqis B$

0

*1*  
*rs*  
*2*  
*(qis*  
*I*  
*) dp*

*1, Q2, b1, b2,*  
*sg*

*R0.*  
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#### *4.9.1 Syntax*

*These relations are accessible in Code\_Aster in 3D, plane deformations (D\_PLAN), forced plane (C\_PLAN) and axisymmetric (AXIS) starting from key word COMP\_INCR of the order STAT\_NON\_LINE. The choice of the relations allowing to build the model of behavior of monocystal is carried out via operator DEFI\_COMPOR [U4.43.05].*

*ECOUC\_VISCI*  
*=*  
*\_F*



(  
 $C = C [R]$

$K = K,$   
 $[R]$

$NR$   
=  
 $N,$   
 $[R]$

)  
 $ECOUC_VISC1$   
=  
 $_F$   
(  
 $C = C [R]$

**$K = K,$   
 $[R]$**

**$NR$   
 $=$   
 $N,$   
 $[R]$**

**$WITH = K,$   
 $[R]$**

**$D$   
 $=$   
 $N,$   
 $[R]$**

)  
***ECOUC\_VISC3***  
=  
***\_F***  
(  
  
***K***  
=  
***K***  
***[R]***

***TAUMU =***  
***μ***  
***[R]***  
***\****

***GAMMA0***  
***= &0***  
***[R]***  
***\****

***DELTA V***  
=  
***V***

**[R]**

**DELTA0= G**

**0 [R]**

)

**ECRO\_ISOT1**

**=\_F (**

**R\_0**

**=**

**R [R]**

**Q**

**=**

**Q,**

**[R]**

**B**

**=**

***B***

***[R]***

***H***

***=***

***H***

***[R]***

***),***

***ECRO\_ISOT2 =\_F (***

***R\_0***

***=***

***R0***

***[R]***

***Q1***

***=***

***Q1***

***[R]***

***B1***

=

***b1***

***[R]***

***H***

=

***H***

***[R]***

***Q2***

=

***Q2 [R]***

***B2***

=

***b2 [R]***

),

**ECRO\_CINE1**

=\_F (

**D**

=

**D**

**[R]**),

),

**ECRO\_CINE2**

=\_F (

**D**

=

**D**

**[R]**

**GM**

=

**M**

**[R]**

**PM**  
=  
**m**  
**[R]**

**C**  
=  
**C**  
**[R]**

)  
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## 4.10 Key words factor *LEMAITRE/LEMAITRE\_FO*

*Definition of the coefficients of the non-linear relation of viscoplasticity of Lemaitre [R5.03.08].*

*The equations are as follows:*

$\sigma$   
 $\nu$   
 $\epsilon_{ij}$   
 $\epsilon_{ij} =$   
 $p_{ij}$

2 eq

1 N

$p_{ij} =$   
eq

1 m  
K p

$\nu = (-$   
 $)$

1  
1  
*The coefficients to be introduced are:  $N > 0$ ,  
and  
0.  
K  
m*

### 4.10.1 Syntax

/

**LEMAITRE**

=

**\_F**

(

**NR**

=

**N,**

**[R]**

**UN\_SUR\_K**

= **1/K**

**, [R]**

**UN\_SUR\_M =**

**/1/m**

**, [R]**

**/**

**0.0,**

**[DEFECT]**

**)**

**/**

**LEMAITRE\_FO**

=

**\_F**

(

***NR***  
**=**  
***N,***  
***[function]***

***UN\_SUR\_K***  
**= 1/K**  
**, *[function]***

***UN\_SUR\_M =***  
***1/m***  
**, *[function]***

)

***NR:***

***N***  
***UN\_SUR\_K:***

**1/K**

**UN\_SUR\_M:**

**1/m**

*If it is wished that the behavior depend on the fluence (description of behaviour of the fuel assemblies by ASSE\_COMBU in STAT\_NON\_LINE), it is necessary to also inform two key words GRAN\_IRRA and FLU\_IRRA (cf [§11] of this document).*

**Note:**

**1**

**While taking**

**= 0 (IE m = +), i.e. by putting 0. behind operand UN\_SUR\_M, one m**

**a non-linear relation of viscoelasticity of Norton obtains.**

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**4.11 Key word factor VISC\_SINH**

**Definition of the coefficients of the law of viscosity defined by the following viscoplastic potential:**

**1**

**vp**

**p**

**-1**  
**m**  
**p&**

**= - HS**  
**0**

**&0**

*The equation defining the rate of cumulated plastic deformation is thus the following one:*

**m**  
**< p >**  
**p& = & HS**  
**,**  
**0**

**0**

*expression in which < X > indicates the positive part of X and p the plastic threshold.  
This model of viscosity is available:*

- with the model of Rousselier version PETIT\_REAC: law of behavior ROUSS\_VISC*
- with the models of plasticity VMIS\_ISOT\_TRAC and VMIS\_ISOT\_LINE version SIMO\_MIEHE: laws of behavior VISC\_ISOT\_TRAC and VISC\_ISOT\_LINE.*

*The coefficients to be introduced are: ,*

**m and**

**&**

**, > .**

**0**

**0**

**0**

#### **4.11.1 Syntax**

/  
**VISC\_SINH**  
=  
**\_F**  
(

**M**  
=  
**m,**  
**[R]**

**EPSI\_0**  
= 0, **[R]**

**SIGM\_0**  
= 0, **[R]**

)

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***4.12 Word***

***key***

***LEMA\_SEUIL***

***Definition of the coefficients of the non-linear relation of viscoplasticity of Lemaitre with threshold [R5.03.08]. One places oneself on the assumption of the small disturbances and one divides the tensor of deformations in an elastic part, a thermal part, a anelastic part (known) and one viscous part. The equations are then:***

$$\begin{aligned} \text{early} &= E + HT + has + v \\ &= A (T) E \end{aligned}$$

***3 ~***

$$\&v = G (eq, T) 2 eq$$

***with:***

***2***

*: cumulated viscous deformation & =*

*&v: &v*

3

~

1

*: diverter of the constraints ~ = - Tr () I*

3

3 ~ ~

*eq: equivalent constraint*

=

:

*eq*

2

*WITH (T): tensor of elasticity*

*and:*

*if D 1 then G (, T) = 0 (purely elastic behavior)*

2

*if D > 1 then G (, T) = A*

*with A,*

0 0

3

T

1

*With: D =*

*eq (U)*

S 0

*The data materials to be informed by the user are A and S.*

*As for the parameter, it is about the flow of neutrons which bombards material. It must be indicated under the key word factor VARI\_COMM of order STAT\_NON\_LINE.*

*The Young modulus E and the Poisson's ratio v are those provided under the key words factors ELAS or ELAS\_FO.*



### **4.12.1 Syntax**

/  
**LEMA\_SEUIL**

=  
**\_F**  
(

**With**  
=  
**With,**  
**[R]**

**S**  
=  
**S,**  
**[R]**

)  
  
/  
**LEMA\_SEUIL\_FO**

=  
**\_F**  
(

**With**

=

***With,  
[function]***

***S***

=

***S,  
[function]***

)

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#### 4.13 Key word factor ZIRC\_CYRA2

*Definition of the coefficients of the non-linear relation of viscoelasticity of Zircaloy used in the code CYRANO3. This relation corresponds to a unidimensional creep test, constant constraint, who utilizes the time passed since the moment when the constraint is applied. Generalization 3D and a formulation eliminating time were introduced into Code\_Aster (cf [R5.03.08]).*

*The formulation is as follows:*

*K*

*T + T*

*rec*

*0*

*v = A E*

*[(F (T)*

*fab*

*+ T*

*1*

*) G () H (T) +*

*1*

*1*

*(F (T)*

*fab*

*+ T*

*2*

*) G ()*

*2*

*]*

*with T time in hours, T the temperature (in °C) of the point considered and the constraint (in MPa).*

***This imposes that the grid is in millimetre.***

*and where A, K, T and F, G, H, F, G*

*0*

*1*

*1 1 2*

*2 are respectively fixed constants and functions and*

*defined once and for all in the code, where the only coefficients to be introduced are:*

*Trec: temperature of annealing (°C)*

*fab: deformation of creep measured after a test of creep biaxé with (400°C, 100MPa, 250 hours)*

: *neutron flux (neutrons/cm2/S)*

**Note:**

*The effects of isotropic thermal dilation can be taken into account if the parameters of elasticity were defined under key word ELAS or ELAS\_FO.*

**4.13.1 Syntax**

/  
**ZIRC\_CYRA2**  
=  
**\_F**  
(  
**EPSI\_FAB =**  
**efab**  
,  
**[R]**

**TEMP\_RECUIT**  
=  
**Trec**  
,  
**[R]**

**FLUX\_PHI = phi, [R]**

)

#### 4.14 Key word factor ZIRC\_EPRI

*Definition of the coefficients of the non-linear relation of viscoelasticity of Zircaloy used in program ESCORE of the EPRI. This relation corresponds to a unidimensional creep test, with constant constraint, and which utilizes the time passed since the moment when one applies the constraint.*

*Generalization 3D and a formulation eliminating time was introduced into Code\_Aster (cf [R5.03.08]).*

*The formulation is as follows:*

*has*

***B***

***= ( ) ( ) ( )***

***3***

***3***

***3***

***( ) + ( ) ( ) ( )***

***4***

***4***

***4***

***(***

***C***

***D***

***F T G***

***H T R***

***F T G***

***H T RP) (cos***

***v***

***p***

***max)***

*with T time in hours, T the temperature (in °C) of the point considered and the constraint (in MPa).*

*and where has, B, C, D and F, G, H, F, G, H*

3

3

3

4

4

*4 are respectively fixed constants and functions and defined once and for all in the code, where the coefficients to be introduced are:*

**RP:**

*yield stress (MPa)*

*max: the angle of the basic plan of the crystals with a radial direction with the sheath (rad) such as*

0

<

*max*

2

*: neutron flux (neutrons/cm<sup>2</sup>/S)*

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**Note:**

*The effects of isotropic thermal dilation can be taken into account if the parameters of elasticity were defined under key word **ELAS** or **ELAS\_FO**.*

#### **4.14.1 Syntax**

/

**ZIRC\_EPRI**

**=\_F**

**(FLUX\_PHI = phi,**

**[R]**

**R\_P = RP,**

**[R]**

**THETA\_MAX**

=

*theta\_max,*

**[R]**

)

**4.15 Key word factor VISC\_IRRA\_LOG**

*Definition of a law of axial creep under irradiation of the tubes guides. This law consists of a law of primary education type and a secondary law in logarithm of the fluence (cf [R5.03.08]).*

*The formulation is as follows:*

**Q**

= A

**F**

**.exp-**

**..ln (1+. T**

)

**Q**

**+ B.exp-**

**. T**

**T**

**T**



:  
*axial deformation of creep*

*F*  
*Q*

:  
*energy of activation*

*T*:  
*temperature of activation (in °K)*

:  
*axial stress applied to the tube guides*  
*T*

:  
*neutron flux (10+20 neutrons/cm2)*

:  
*time-constant*  
*WITH, B*

*constants*

#### *4.15.1 Syntax*

/  
*VISC\_IRRA\_LOG*  
*=\_F (*

*With =*

*/1.28D-1, [DEFECT]*

/  
*has,*  
*[R]*

***B***  
=  
/  
*0.01159,*  
***[DEFECT]***  
/  
***B,***  
***[R]***

***FLUX\_PHI***  
=  
*phi,*  
***[R]***

***CSTE\_TPS = W,***  
***[R]***

***ENER\_ACT =  
Q, [R]***

)

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#### ***4.16 Key words factor LMARC/LMARC\_FO***

***Definitions of the coefficients of the élasto-viscoplastic model developed with the LMA-RC to describe it  
orthotropic viscoplastic behavior of the tubes of sheaths of the fuel pin [R5.03.10].***

*Briefly, the relations of behavior are:*

**3**

**F**

**= ~ - X - R =**

**(~ - X) T M (~ - X)**

**0**

**2**

**N**

**F**

**3M (~**

**- X)**

**2**

**~ -**

**& v**

**p = &v**

**= &v**

**=**

**v p T**

**I v p**

**~**

**&v**

**(&)**

**X**

**M - &**

**= sin H**

**2**

**-**

**&0**

**X**

**3**

**K**

*m*  
*2*  
*v p*  
*1*

*X*  
*X*  
*X& = p*  
*Y (v)*  
*()*  
*NR &*  
*- Q*  
*(X X)*

*&*  
*3*

*v - R sinh*

*m*

*NR R*  
*X0*  
*X*

*()*  
*2*  
*v p*  
*1*  
*2*  
  
*2*  
*2*

***v p***  
***2***

***X 1***  
***(v)***  
***()***  
***()***

***p***  
***Y***  
***1***  
***NR &***  
***Q (X***  
***X***  
***)***  
***()***  
***&v***  
***X***

***p***  
***Y (v)***  
***()***  
***=***  
***-***  
***-***

***NR &***  
***Q X***  
***v***  
***3***

***=***  
***-***  
***2 3***  
***&***

***3***  
***with: Y ()***  
***Y (THERE Y***  
***0***  
***) eb***  
***T***  
***v***

$\nu$   
=  
+  
-  
 $X =$   
 $X NR X$   
2

**Note:**  
~  
*represent the diverter of the constraints and ~  
- X the equivalent within the meaning of Hill.  
The matrices M, NR, R and Q make it possible to describe the anisotropy of behavior viscoplastic.*

### 4.16.1 Syntax

**//LMARC**  
=

/  
**/LMARC\_FO = \_F**  
**(R\_0**  
  
**= R0**  
**, [R] or [function \*\*]**

**DE\_0 =**  
**eps0, [R] or [function \*\*]**

***NR =***  
***N,***

***[R] or [function \*\*]***

***K =***  
***K,***

***[R] or [function \*\*]***

***Y\_0***

***=***

***y0***

***, [R] or [function \*\*]***



$Y_I$   
=  
 $y_{inf}$ ,  
[R] or [function \*\*]

$B =$   
 $B$   
,  
[R] or [function \*\*]

$A_0$   
= $X_0$ ,  
[R] or [function \*\*]

***RM***  
***= rm,***  
***[R] or [function \*\*]***

***M =***  
***m***  
***,***  
***[R] or [function \*\*]***

***P =***  
***p***  
***,***  
***[R] or [function \*\*]***

***P1***  
***= p1,***  
***[R] or [function \*\*]***

***P2***  
***= p2,***  
***[R] or [function \*\*]***

***M11***  
***= M11,***  
***[R] or [function \*\*]***

***M22***  
***= M22,***  
***[R] or [function \*\*]***

***M33***

***= M33,  
[R] or [function \*\*]***

***M66***

***= M66,  
[R] or [function \*\*]***

***N11***

***= N11,  
[R] or [function \*\*]***

***N22***

= ***M22***,  
***[R] or [function \*\*]***

***N33***

= ***N33***,  
***[R] or [function \*\*]***

***N66***

= ***N66***,  
***[R] or [function \*\*]***

***Q11***

= ***Q11***,  
***[R] or [function \*\*]***

***Q22***

***= Q22,  
[R] or [function \*\*]***

***Q33***

***= Q33,  
[R] or [function \*\*]***

***Q66***

***= Q66,  
[R] or [function \*\*]***

***R11***

= ***R11***,  
***[R] or [function \*\*]***

***R22***

= ***R22***,  
***[R] or [function \*\*]***

***R33***

= ***R33***,  
***[R] or [function \*\*]***

***R66***

= **R66**,  
**[R]** or **[function \*\*]**

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**5**  
**Behaviors related to the damage and the rupture**

**5.1**  
**Key words factor ROUSSELIER/ROUSSELIER\_FO**

**Definition of the coefficients of the model of ductile behavior of rupture of G. Rousselier (cf [R5.03.06]).**

**Briefly, one solves for an elastoplastic increment:**

**eq**



**- R (p) +  
D F**

**exp  
H  
=  
1**

**0  
5.1**

**éq  
- 1**

**1  
=**

**( -  
p  
)**

**& =  
F  
&**

**p  
p**

**f& = 3 (1 - F) p**

**H**

**~  
F  
1 3  
Df**

=  
+  
*exp*  
*H*

2  
3

*eq*  
*1*

*1 - F*  
*with =*  
*5.1*

*éq*  
-  
2

*1*

- *F*  
*R (p)*  
*0*

*by*

*entry*

*intermédia*  
*(word*

*traction*

*of*

*curve*

*of*

*anger*  
**TRACTION)**

*key*

**I**  
*identity*

*stamp*

*With the coefficients materials D,*  
*, F*  
*specific to the model of*  
**I**  
**0**  
**ROUSSELIER.**

*These various parameters can depend on the temperature, in this case one will employ the key word*  
**ROUSSELIER\_FO.**

*It is possible to modify the model in the following way:*

**.**  
*introduction of a porosity criticizes F beyond which the growth of the cavities is*  
**C**  
*accelerated:*

**p**  
**f& =**

**3**  
**To 1**  
**(- F**  
**)**  
**if**  
**>**  
**H**  
**F**  
**FC**

*two additional characteristics are then necessary: F*

*With*

*C and*

.

.

*introduction of a porosity limits F beyond which the material is considered broken.*

*L*

*behavior is then replaced by an imposed fall of the constraints:*

*&*

*= - E*

*& if F = F*

*(with E*

*)*

*L*

*ELAS*

*under*

*defined*

*two additional characteristics are then necessary: f1 and.*

.

*introduction of a voluminal rate of germination of cracks of cleavages N*

*With, modifying*

*as follows the equations [éq 5.1-1] and [éq 5.1-2].*

*eq*

*- R (p) + D*

*H*

*1 (F + A p*

*N) exp*

*= 0*

*1*

***1 - F - A p***

***N***

***=***

***1 - f0***

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***These last five parameters are independent of the temperature.***

***The following table of correspondence must be used:***

***Modeling Key words***

***D***

***D***

***SIGM\_1***

***1***

***F***

***PORO\_INIT***

***0***

***F***

***PORO\_CRIT***

***C***

*With*  
**PORO\_ACCE**

**N**

*With*  
**YEAR**

**F**

**PORO\_LIMI**

**L**

**D\_SIGM\_EPSI\_NORM**

### **5.1.1 Syntax**

/  
**/ROUSSELIER = \_F (**

**D = D, [R]**

**SIGM\_1**  
**= 1, [R]**

***PORO\_INIT***

***=f0***

***, [R]***

***PORO\_CRIT***

***=/1.D0,***

***[DEFECT]***

***/***

***FC***

***,***

***[R]***

***PORO\_ACCE***

***=/1.D0,***

***[DEFECT]***

***/***

***With,***

***[R]***

**YEAR**

=

/

**0.D0,**

**[DEFECT]**

/

**Year,**

**PORO\_LIMI**

= / 0.999,

**[DEFECT]**

/

**fl**

,

**[R]**

**D\_SIGM\_EPSI\_NORM=/1.D0, [DEFECT]**



/,  
**[R]**

)  
/  
**ROUSSELIER\_FO=\_F**  
(

**D = D, [function \*\*]**

**SIGM\_1**

**= 1, [function \*\*]**

**PORO\_INIT**

**= f0**

**, [function \*\*]**

**PORO\_CRIT**

**= /1.D0,**

**[DEFECT]**

**/fc**

**,**

**[R]**

**PORO\_ACCE**

**= /1.D0,**

**[DEFECT]**

/A  
,  
**[R]**

**YEAR**  
=  
/  
**0.D0,**  
**[DEFECT]**  
/  
**Year,**

**PORO\_LIMI**  
= /0.999  
**, [DEFECT]**

*/f*, [R]

*D\_SIGM\_EPSI\_NORM=1.D0,*  
*[DEFECT]*

*/*, [R]

)  
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**5.2 Words**

**keys**

**VENDO\_CHAB/VENDO\_CHAB\_FO**

**Definition of the coefficients of the viscoplastic law of behavior with damage of Chaboche (makes of it law of viscoplastic behavior to work hardening-viscosity multiplicative coupled to the isotropic, model damage developed by Chaboche cf [R5.03.15]).**

**Briefly, the relations are:**

**= (1 - D) E E and E = - HT - p**

**3**

**~**

**p**

**& = p&**

**2 eq**

**& = R**

**p**

**&**

**(1 - D)**

**NR**

-

**eq** **$S(1 - D)$**  **$r \& =$** 

(

 **$1$**  **$1 - D)$**  **$M$**  **$K R$**  **$() R$**  **$D =$**  **$(1 - D) - K ()$** ***With******with  $D$ , the scalar variable of isotropic damage and:*** **$() = J () + J () + (1 - -) J$**  **$0$**  **$1$**  **$2 ()$** ***where:*** ***$J0 ()$  is the maximum principal constraint*** ***$J1 () = Tr ()$***  ***$J2 () = eq$***  ***$X$ : positive part of  $X$*** ***Note:*** ***$\sim$  represents the diverter of the constraints and  $eq$  the equivalent constraint of Von Mises.*****5.2.1 Syntax**

***//VENDO\_CHAB:***

***/***  
***VENDO\_CHAB\_FO***  
***: \_F (***  
***S\_VP: [R]***  
***or [function \*\*]***

***SEDVP1: [R] or [function \*\*]***

***SEDVP2: [R] or [function \*\*]***

***N\_VP: [R]***  
***or [function \*\*]***

***M\_VP: [R]***  
***or [function \*\*]***

***K\_VP: [R]***  
***or [function \*\*]***

***A\_D: [R]***  
***or [function \*\*]***

***R\_D: [R]***  
***or [function \*\*]***



***K\_D: [R]***  
***or [function \*\*]***

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***The table below summarizes the correspondences between the symbols of the equations and the words key of Aster.***

***Parameter material***

***Symbol in***

***Key word in Aster***

***equations***

***Threshold of viscoplasticity***

***S***

***“S\_VP”***

***Coefficient 1 of the equivalent constraint of creep***

***“SEDVP1”***

***Coefficient 2 of the equivalent constraint of creep***

***“SEDVP2”***

***First exhibitor of the viscoplastic law***

***NR***

***“N\_VP”***

***Second exhibitor of the viscoplastic law***

***M***

***“M\_VP”***

***Coefficient of the viscoplastic law***

***K***

***“K\_VP”***

***Coefficient of the law of damage***

***With***

***“A\_D”***

***First exhibitor of the law of damage***

***R***

***“R\_D”***

***Second exhibitor of the law of damage***

***K [[]]***

***“K\_D”***

***Note:***

.

***“\_VP”***: coefficient intervening in an equation of the viscoplastic behavior

.

***“\_D”***: coefficient intervening in an equation of the behavior of damage

.

***“SEDVP”***: (Sigma) Equivalent in Viscoplastic Damage.

***Parameter K\_D can be defined like a constant, a function of a parameter “TEMP” or a tablecloth (variable of temperature and constraint ()). In this case, to use DEFI\_NAPPE***

*with like first parameter “TEMP” for the temperature in °C and like second parameter “X” (obligatory) for the constraints () in MPa. If K\_D depends only on (), it is necessary to use DEFI\_NAPPE in any event by introducing for example 2 times same data file in constraint for two values different from the temperature.*

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## ***5.3***

***Key word factor ENDO\_ORTH\_BETON***

***Definition of the parameters of the law of behavior ENDO\_ORTH\_BETON, allowing to describe anisotropy induced by the damage of the concrete, as well as the unilateral effects [R7.01.09]. One will defer to the documents [R7.01.09] and [V6.04.176] for the precise significance of the parameters and procedure of identification.***

### ***5.3.1 Syntax***

***ENDO\_ORTH\_BETON = \_F (***

***ALPHA***

***=***

***/***

***alpha***

***[R],***

***/***

***0.9***

***[DEFECT],***

***K0***

***=***

***k0***

***[R],***

***K1***

***=***

***k1***

***[R],***

***K2***

***=***

***/***

***k2***

***[R],***

***/***

***0.0007***

***[DEFECT]***

***ECROB***

=  
*ecrob*  
*[R]*,

*ECROD*

=  
*ecrod*  
*[R]*,

)

### *5.3.2 Operand ALPHA*

*Constant of coupling between the evolution of the damage of traction and that of the damage of compression. It must be taken between 0 and 1, rather near to 1. The value by defect is 0.9.*

### *5.3.3 Operands K0/K1/K2*

*K0 = k0*  
*Constant part of the function threshold. Allows to gauge the height of the peak in traction.*

*K1 = k1*  
*Parameter of the function threshold allowing to increase the threshold in compression.*

*K2 = k2*  
*Parameter of control of the shape of the envelope of rupture for biaxial tests. The value by defect is 7.104.*

### *5.3.4 Operands ECROB/ECROD*

*ECROB = ecrob*

*Term of blocked energy (equivalent to an energy of work hardening) relating to the evolution of*

*the damage of traction. Allows to control the shape of the peak in traction.*

***ECROD = ecrod***

*Term of blocked energy (equivalent to an energy of work hardening) relating to the evolution of the damage of compression. Allows to control the shape of the peak in compression.*

*The Young modulus E and the Poisson's ratio are to be specified by key words ELAS or ELAS\_FO.*

*In the case of a nonlocal calculation with formulation GRAD\_EPSI, the characteristic length is to specify behind key word NON\_LOCAL.*

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***5.4***

***Key word factor NON\_LOCAL***

*This key word factor makes it possible to inform the characteristics necessary to the use of models of behavior not buildings for which the response of material is not defined any more on a point scale material but with that of the structure, to also see AFFE\_MODELE [U4.41.01] and the booklet [R5.04].*

***5.4.1 Syntax***

***NON\_LOCAL***

***=***

***\_F***

(  
  
**LONG\_CARA**  
=  
**length,**  
  
**COEF\_RIGI\_MINI = coef,**

)

#### **5.4.2 Operands**

**LONG\_CARA/COEF\_RIGI\_MINI**

**LONG\_CARA:**

*Determine the length characteristic or scale length internal to material.*

**COEF\_RIGI\_MINI**

*With as for him an algorithmic role since it fixes, for the models of damage which degrades rigidity of material, the proportion of initial rigidity IE of the Young modulus defines under ELAS (0,1% for example) in on this side which one stops the damage mechanism: this residual rigidity allows to preserve the character posed well of the elastic problem.*

#### **5.5**

**Key word factor RUPT\_FRAG/RUPT\_FRAG\_FO**

*The theory of the rupture of Frankfurt and Marigo makes it possible to model the appearance and the propagation of cracks in a fragile springy medium, to see [R7.02.11]. It is based on the criterion of Griffith who compare the elastic restitution of energy and the energy dissipated during the creation of a surface fissured, provided by key word GC.*

*The joined elements use operand GC and operands SIGM\_C and SAUT\_C within the framework of the law of behavior BARENBLATT.*

### 5.5.1 Syntax

***RUPT\_FRAG***

***=\_F***

***(***

***GC***

***=***

***gc***

***,***

***[R]***

***SIGM\_C***

***=***

***sigm,***

***[R]***

***PENA\_ADHERENCE = pad, [R]***

***PENA\_CONTACT***

***=***

***/***

***pco,***

***[R]***

***/1.***

***,***

***[DEFECT]***

***)***

***RUPT\_FRAG\_FO***

***=\_F***

***(***



**GC**

=

**gc**

,  
**[function \*\*]**

**SIGM\_C**

=

**sigm,**

**[function \*\*]**

**PENA\_ADHERENCE = pad, [function \*\*]**

**PENA\_CONTACT**

=

**pco,**

**[function \*\*]**

)

### **5.5.2 Operand**

#### **RUPT\_FRAG**

*Dissipated energy is proportional to the surface of crack created, the proportionality factor being the tenacity of the Gc material.*

### **5.5.3 Operand**

#### **SIGM\_C**

*Critical stress in the beginning from which the crack will open and the constraint between the lips to decrease.*

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### **5.5.4 Operand**

#### **PENA\_ADHERENCE**

*Small parameter of regularization of the constraint in zero (for more details to see [R7.02.11]).*

**Note:**

*Parameters SIGM\_C and PENA\_ADHERENCE are only obligatory in the case of modeling PLAN\_FISSURE. They are not used for the criterion of Griffith, this is why they appear optional on the level of the catalogue.*

### **5.5.5 Operand**

#### **PENA\_CONTACT**

*Small parameter of regularization.*

## **5.6**

### **Key word factor CORR\_ACIER**

*Law CORR\_ACIER is a model of behavior of the steel, subjected to corrosion in reinforced concrete structures. This model is developed in 1D and elastoplastic 3D endommageable with isotropic work hardening and is based on the model of Lemaître [R7.01.20].*

*eq*

*- R (p) - >*

*y*

*0*

*1 - D*

*~*

$p_3$

$\&$

$Cd.$

$\& = 2 \cdot 1 - D$

In the plastic range  $D = 0$ , if not  $D =$

$(p - p$

$D)$

$eq$

$p - p$

$R$

$D$

$r\& = \& = p\& (1 - D)$

$R = 1/m$

$kp$

### 5.6.1 Syntax

**$CORR\_ACIER = \_F$**

(

**$D\_CORR$**

=

**$cd.$**

,

**$[R]$**

***ECRO\_K***

=

***K,***  
***[R]***

***ECRO\_M***

=

***m,***  
***[R]***

***SY***

=

***sy,***  
***[R]***

)

### ***5.6.2 Operand***

***D\_CORR***

***Critical coefficient of damage.***

### ***5.6.3 Operands***

***ECRO\_K, ECRO\_M***

***Coefficients of the law of work hardening***

***l m***

***R = kp***

.

## **5.6.4 Operand**

**SY**

*Initial elastic limit, noted  $y$  in the equations.*

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## **6 Behaviors**

**thermics**

*The various thermal behaviors are excluded mutually.*

### **6.1**

**Key words** factor *THER/THER\_FO*

*Definition of the constant linear thermal characteristics or function defined by a concept of function type of parameter "INST".*

#### **6.1.1 Syntax**

**/**

**/**

**THER**

**=**

**\_F**

**(**

***RHO\_CP***

=

***CP***

,

***[R]***

***LAMBDA***

=

,

***[R]***

)

/

***THER\_FO***

=

***\_F***

(

***RHO\_CP***

= ***CP***

, ***[fonction+]***

**LAMBDA**

**=, [fonction+]**

)

### **6.1.2 Operands**

**LAMBDA/RHO\_CP**

**LAMBDA =**

*Isotropic thermal conductivity.*

**RHO\_CP = CP**

*Voluminal heat with constant pressure (voluminal product bulk and heat specific). It is the coefficient appearing in the equation:*

**CP T& - div (. grad T) = F.**

### **6.2**

**Key word factor THER\_ORTH**

*Definition of the thermal characteristics for an orthotropic material.*

*The reader will be able to refer to following documentations:*

**[U4.42.03] DEFI\_COQU\_MULT**

**[U4.42.01] AFFE\_CARA\_ELEM**

*to define the longitudinal direction associated with the hulls or the nonisotropic 3D.*

**NR**

**T**

*L*  
*L, T: directions of orthotropism*  
*longitudinal and transverse*

### **6.2.1 Syntax**

/  
***THER\_ORTH***  
=  
***\_F***  
(  
***RHO\_CP =***  
***CP, [R]***

***LAMBDA\_L***  
***= lat***  
***, [R]***

***LAMBDA\_T***  
***= lat***  
***, [R]***



***LAMBDA\_N***  
***= lan***  
***, [R]***

)  
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### **6.2.2 Operands**

#### **LAMBDA/RHO\_CP**

*LAMBDA\_L = lal*

*Thermal conductivity in the longitudinal direction.*

*LAMBDA\_T = lat*

*Thermal conductivity in the transverse direction.*

*LAMBDA\_N = lan*

*Thermal conductivity in the normal direction.*

*RHO\_CP = CP*

*Voluminal heat.*

### **6.3**

**Key word factor *THER\_NL* (cf [R5.02.02])**

*Allows to describe the thermal characteristics depending on the temperature. The formulation made to intervene voluminal enthalpy.*

*. - div ((T) grad T) = F.*

#### **6.3.1 Syntax**

/  
*THER\_NL*  
=  
*\_F*  
(  
/BETA =, [function \*\*]  
/  
*RHO\_CP*  
=  
*CP*  
,  
[function \*\*]

*LAMBDA*  
=, [function \*\*]

)  
**6.3.2 Operands**  
***BETA/LAMBDA/RHO\_CP***

/BETA  
=  
*Voluminal enthalpy function of the temperature. For the enthalpy, the prolongations of function are necessarily linear.*

*/RHO\_CP = CP*  
*Voluminal heat.*

*LAMBDA*  
*=*

*Thermal conductivity isotropic function of the temperature.*

## **6.4**

### **Key words factor *THER\_COQUE/THER\_COQUE\_FO***

*Allows to define membrane and transverse conductivities and the heat capacity for homogenized heterogeneous thermal hulls.*

*Directions 1 and 2 indicate those of the plan of the plate, direction 3 is perpendicular. One admits that the tensor of conductivity in each point is diagonal and that its eigenvalues are l1, l2 and l3. The coefficients are thus defined by the user in the reference mark of orthotropism of the plate. The code makes then the change of reference mark to find the correct values in the reference mark of the element.*

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### **6.4.1 Syntax**

/  
*ATHER\_COQUE/ATHER\_COQUE\_FO*

=

*\_F (*  
*COND\_LMM = a1111, [R]*

*or*

*[fonction+]*

*COND\_TMM = a2211, [R]*

*or*

*[fonction+]*

*COND\_LMP = a1111, [R]*

*or*

*[fonction+]*

*COND\_TMP = a2211, [R]*

*or*

*[fonction+]*

*COND\_LPP = a1111, [R]*

*or*

*[fonction+]*

*COND\_TPP = a2211, [R]*

*or*

*[fonction+]*

*COND\_LSI = a1111, [R]*

*or*

*[fonction+]*

*COND\_TSI = a2211, [R]*

*or*

*[fonction+]*

*COND\_NMM = b11,*

*[R] or [fonction+]*

*COND\_NMP = b12,*

*[R] or [fonction+]*

*COND\_NPP = b22,*

*[R] or [fonction+]*

*COND\_NSI = b23,*

*[R] or [fonction+]*

$CMAS\_MM = c11$

,

*[R] or [fonction+]*

$CMAS\_MP = c12$

,

*[R] or [fonction+]*

$CMAS\_PP = c22$

,

*[R] or [fonction+]*

$CMAS\_SI = c23$

,

*[R] or [fonction+]*

)

#### **6.4.2 Operands**

***COND\_LMM/COND\_LMP/COND\_LPP/COND\_LSI/COND\_TMM/  
COND\_TMP/COND\_TPP/COND\_TSI***

*P1, P2, P3 indicate the functions of interpolation of the temperature in the thickness.*

*If A is the matrix of surface average conductivity defined in the note [R3.11.01], one has then for the membrane tensor of conductivity.*

$COND\_LMM = a1111$

*term related to the integral of  $l1 * P1 * P1$*

$COND\_LMP = a1112$

*term related to the integral of  $l1 * P1 * P2$*

*COND\_LPP = a1122*

*term related to the integral of  $l1 * P2 * P2$*

*COND\_LSI = a1123*

*term related to the integral of  $l1 * P2 * P3$*

*COND\_TMM = a2211*

*term related to the integral of  $l2 * P1 * P1$*

*COND\_TMP = a2212*

*term related to the integral of  $l2 * P1 * P2$*

*COND\_TPP = a2222*

*term related to the integral of  $l2 * P2 * P2$*

*COND\_TSI = a2223*

*term related to the integral of  $l2 * P2 * P3$*

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### **6.4.3 Operands**

**COND\_NMM/COND\_NMP/COND\_NPP/COND\_NSI**

*If  $B$  is the tensor which describes transverse conduction and the exchanges on surfaces  $\omega_{\text{ext}}$  and  $\Omega$ , defined in the note [R3.11.01], one has for the transverse tensor of conductivity:*

$COND\_NMM = b11$

*term related to the integral of  $l3*P1*P1$*

$COND\_NMP = b12$

*term related to the integral of  $l3*P1*P2$*

$COND\_NPP = b22$

*term related to the integral of  $l3*P2*P2$*

$COND\_NSI = b23$

*term related to the integral of  $l3*P2*P3$*

#### **6.4.4 Operands**

**$CMAS\_MM/CMAS\_MP/CMAS\_PP/CMAS\_SI$**

*One has finally for the tensor of heat capacity.*

$CMAS\_MM = c11$

*term related to the integral of  $RHOCP*P1*P1$*

$CMAS\_MP = c12$

*term related to the integral of  $RHOCP*P1*P2$*

$CMAS\_PP = c22$

*term related to the integral of  $RHOCP*P2*P2$*

$CMAS\_SI = c23$

*term related to the integral of  $RHOCP*P2*P3$*

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## 7 *Behaviors specific to the concretes*

### 7.1 *Key word factor THER\_HYDR*

*Allows to define the behavior associated with the hydration with the concrete.*

*The hydration of the concrete is a phenomenon which is accompanied by a release of heat depending temperature [R7.01.12].*

*D*  
*D (T)*

*+ divq = Q*  
*+ S*  
*dt*  
*dt*

*éq*  
**7.1-1**  
*Q = -*

*grad T*

*D = (*  
*With)*  
*Ea*

*exp -*

**éq 7.1-2**  
*dt*  
*RT*

#### **7.1.1 Syntax**

***THER\_HYDR =\_F (***

***LAMBDA***

***=***

***lambda***

***,***

***[function \*\*]***

***BETA =***

***beta,***

***[function \*\*]***

***AFFINITY***

***=***

***With***

***,***

***[function]***

***CHALHYDR***

***=***

***Q***

***,***

**[R]**

**QSR\_K**

=

**QsR**

**[R]**

### **7.1.2 Operands**

**LAMBDA/BETA**

**LAMBDA = lambda**

*Thermal conductivity isotropic function of the temperature.*

**BETA = beta**

*Voluminal enthalpy function of the temperature. The prolongations are has minimum linear, voluminal enthalpy being able to be defined as the integral of voluminal heat.*

### **7.1.3 Operand**

**AFFINITY**

**AFFINITY = A**

*Function of the degree of hydration determined by a calorimetric test of the concrete (function of size HYDR).*

### **7.1.4 Operand**

**CHAL\_HYDR**

**CHAL\_HYDR = Q**

*Heat released per unit of hydration (presumably constant), this function depends on the type on concrete.*

**7.1.5 Operand**

**QSR\_K**

**QSR\_K**

*Constant of Arrhenius expressed in Kelvin degree.*

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**7.2**

**Key word factor SECH\_GRANGER**

*Definition of the parameters characterizing the coefficient of diffusion (*

*D C, T) intervening in the equation*

*nonlinear of drying proposed by Granger (cf [R7.01.12]). These characteristics are*

*constants, while the coefficient of diffusion depends on the variable of calculation, i.e.*

*current concentration C out of water, (as thermal conductivity depended on the temperature).*

**7.2.1 Syntax**

**SECH\_GRANGER**

**=\_F**

$(A = has, [R]$

$B = B, [R]$

$QSR_K = QsR$

,  
 $[R]$

$TEMP\_0\_C = t0, [R]$

)

### 7.2.2 Operands

$WITH/B/QSR\_K/TEMP\_0\_C$

*These coefficients make it possible most usually to express the coefficient of diffusion in its form used in the literature and suggested by L. Granger:*

$Q 1 1$

$S$

$T - -$

$D (C, T)$

*a.e (B C  
. )  
=  
E R T T0*

*T0*

*A=  
has*

*Varying coefficient of diffusion 0.5 1013 and 2.1013 m2/s for the concrete.*

*B=  
B*

*Coefficient of about 0.05 for the concrete.*

*QSR\_K=  
QsR*

*QsR is worth 4700 in general. K. (R is the constant of perfect gases).*

*TEMP\_0\_C=  
T0*

*Temperature of reference in the law of Arrhenius. The temperature of T0 reference is in degrees Centigrade, and converted into Kelvin at the time of the resolution.*

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**7.3**

**Key word factor SECH\_MENSI**

**Definition of the parameters characterizing the coefficient of diffusion intervening in the equation not**

**linear of drying proposed by Mensi (cf [R7.01.12]). These characteristics are constants, while the coefficient of diffusion depends on the variable of calculation, i.e. the concentration C current out of water, (as thermal conductivity depended on the temperature). It is one formulation simplified of the case general, constituting the law of Mensi.**

**7.3.1 Syntax**

**SECH\_MENSI**

**=**

**\_F**

**(**

**With**

**=**

**has, [R]**

**B**

**=**

**B, [R]**

**)**

**7.3.2 Operands**

**WITH/B**

**These coefficients make it possible to express the coefficient of diffusion according to the law of**

***Mensi:***

***(b.C)***

***D (C) =.***

***E has***

***A=***

***has***

***Varying coefficient of diffusion of 0.5..1013 and 2.1013 m2/s for the concrete.***

***B=***

***B***

***Coefficient of about 0.05 for the concrete.***

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***7.4***

***Key word factor SECH\_BAZANT***

***Definition of the parameters characterizing the coefficient of diffusion intervening in the equation not***

***linear of drying proposed by Bazant (cf [R7.01.12]). These characteristics are constants, while the coefficient of diffusion depends on the variable on calculation, i.e. the concentration C current out of water, (as thermal conductivity depended on the temperature). This formulation***



*constitute the law of Bazant.*

### **7.4.1 Syntax**

***SECH\_BAZANT***

=

***\_F***

***(D1 =***

***d1,***

***ALPHA\_BAZANT***

=

,

***[R]***

***NR = N,***

***[R]***

***FONC\_DESORP = desorp,***

***[function \*\*]***

)

### 7.4.2 Operands

#### ***DI/ALPHA\_BAZANT/NR/FONC\_DESORP***

*These coefficients make it possible to express the coefficient of diffusion according to the law of Bazant:*

*1 -*

$$D(H) = D +$$

*1*

$$1 - H N$$

*1 +*

$$1 - .075$$

*where H is the degree of hydration, related to the water concentration by the curve of desorption.*

$$DI =$$

*dI*

*Coefficient of diffusion which is about 3.1013 m<sup>2</sup>/s for the concrete.*

$$ALPHA\_BAZANT =$$

*Varying coefficient from 0.025 to 0.1 for the concrete.*

$$N =$$

*N*

*Exposing about 6 for the concrete.*

$$FONC\_DESORP =$$

*desorp*

*Curve of desorption, allowing to pass from the water concentration to the degree of hydration h.*

### **Important remark:**

*desorp is a function of the variable of calculation, C, the water concentration, which is comparable for the resolution at a temperature, of type "TEMP".*

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## **7.5**

### **Key word factor SECH\_NAPPE**

*The coefficient of diffusion, characterizing the nonlinear equation of drying, is expressed using one tablecloth, tabulée function of the water concentration, variable of calculation, and the temperature, variable*

*auxiliary of calculation, given in the form of a structure of data of the evol\_ther type. For resolution of drying by operator THER\_NON\_LINE, the concentration out of water is comparable with one*

*temperature, of type "TEMP".*

*For the coherence of the data, parameters of the tablecloth, i.e. the variable of calculation and auxiliary variable cannot be of the same type. A new type of variable was added in DEFI\_NAPPE, the "type of the temperature calculated drying before", "TSEC", which corresponds indeed to a temperature.*

#### **7.5.1 Syntax**

**SECH\_NAPPE**

=

***\_F***  
***(***  
***FUNCTION***  
***= nom\_fonc, [function]***

***7.5.2 Operand***  
***FUNCTION***

*The coefficient of diffusion is expressed using a tabulée function of the parameters C and T.*

***FUNCTION = nom\_fonc***

*Name of the tablecloth.*

***7.6***  
***Key word factor PINTO\_MENEGOTTO***

*Definitions of the coefficients of the relation of cyclic behavior of elastoplasticity of the reinforcements in steel in the concrete reinforced according to the model with Pinto-Menegotto (cf [R5.03.09]).*

*The initial traction diagram (beginning of the loading) is defined by:*

***.***  
***=***  
***E as long as y; E defined under ELAS***  
***y***  
***.***  
***= for***

***y***  
***H***  
***E***  
***- 4***  
***.***  
***= -***  
***U***  
***U***

( -  
**U**  
y)  
**for**

<  
-  
**H**  
**U**  
**U**  
**H**  
(cannot exceed U)

**The curve = F () with the nth cycle is defined by:**

\*  
\*  
**1 - B**  
\*  
**has**  
**L = bL +**

(  
**1**  
**L**  
**R = 0**  
**R -**  
**1 R**  
**1+ ( \***  
**) R**

**has +**  
**L**  
)  
**with**  
**2**

**E**

*and*

*H*

*B =*

*E:*

*of*

*slope*

*écrouissag asymptotiq*

*E*

*ue*

*H*

*E*

*- n-1*

*where \* is defined by: \* =*

*R*

*N - n-1.*

*y*

*R*

*N 1*

*--*

*where \**

*is defined by: \**

*R*

*=*

*.*

*N*

*I*

*N*

*y - y*

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The ny quantity is deducted from cycle N - 1 by:

$N - n-1$

$N = N$

y

R

-1

y

R

+

E

$N = n-1$

n-1

n-1

n-1

n-1

y

y

.

(

sign

-

y

R

) + EH (-

R

y

)

The variable is defined by:

$n-1 - n-1$

= R

y

$N - n-1$

*y*  
*R*

*where n-1*

*R*

*represent the deformation reached at the end of the n-1 ème semi-cycle  
and n-1, N*

*-1*

*y*

*y represent the deformations of end of linearity of semi-cycles N  
and N.*

*B represents either the value provided by the user (key word EP\_SUR\_E) or, failing this:*

*E*

*U - y*

*B*

*H*

*=*

*with*

*E =*

*E*

*H*

*-*

*E*

*U*

*y*

*In the event of buckling, (if L/D > 5):*

*E*

*B y*

*.*

*in compression one replaces B by B = has (.  
5 0 - L/D) E*

*-*

*C*



*(- 1 1 has*

*6 (N*

*N*

*--*

*R*

*y*

*)*

*.*

*in traction, one calculates a new slope  $E = E_{has} + 10$*

*(. -)  $E_{has}$*

*R*

*with*

*5*

*5*

*5 - LD*

*a5 = 1+*

*.*

*7 5*

*.*

*represent the greatest "plastic excursion" during the loading: = my (*

*X N - N*

*R*

*y)*

*N*

*y*

*and = 4*

*LD*

*B - B*

*11 - LD*

*In the case of buckling, one adds to N*

*\**

*C*

*y the value*

*=*

*S*

*sbE*

*with =*

.  
***1 -  
S  
Cl  
C  
B***

***D  
10th  
-  
1***

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***7.6.1 Syntax***

***/  
PINTO\_MENEGOTTO = \_F  
(  
SY  
=  
sigm***

,  
[R]

***EPSI\_ULTM***  
= *epsu*, [R]

***SIGM\_ULTM***  
= *sigmu*  
, [R]

***DASH =/L/D***  
,  
[R]  
/  
4.  
,  
[DEFECT]

***EPSP\_HARD***  
***= epsh, [R]***

***R\_PM =/R0, [R]***  
***/***  
***20.***  
***,***  
***[DEFECT]***

***EP\_SUR\_E = B, [R]***

***A1\_PM =/a1, [R]***  
***/***  
***18.5***  
***,***  
***[DEFECT]***

***A2\_PM =/a2, [R]***

***/***

***0.15***

***,***

***[DEFECT]***

***A6\_PM =/a6, [R]***

***/***

***620.***

***,***

***[DEFECT]***

***C\_PM =/C, [R]***

***/***

***0.5***

***,***

***[DEFECT]***

***A\_PM =/has, [R]***

***/***

***0.006***

***,***

***[DEFECT]***

)

## 7.6.2 Operands

***SY = sigm***

*Initial elastic limit, noted y in the equations.*

***EPSI\_ULTM = epsu, noted U in the equations.***

*Ultimate deformation.*

***SIGM\_ULTM = sigmu, noted U in the equations.***

*Ultimate constraint.*

***DASH = L/D***

*Twinge of the bar (>5: buckling).*

***EPSP\_HARD = epsh, noted H in the equations.***

*Deformation corresponding at the end of the plastic stage.*

***EP\_SUR\_E = B***

*E*

*Ratio slope of work hardening/Young modulus (if no value is given, one takes B*

*H*

*=*

*).*

*E*

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*A1\_PM = a1*

*Coefficient defining the traction diagram of the model.*

*A2\_PM = a2*

*Coefficient defining the traction diagram of the model.*

*A6\_PM = a6*

*Coefficient defining the traction diagram of the model in the event of buckling.*

*C\_PM = C used in S*

*Coefficient defining the traction diagram of the model in the event of buckling.*

*A\_PM = has*

*Coefficient defining the traction diagram of the model in the event of buckling.*

*R\_PM =*

*Coefficient RO (20. By defect).*

*The Young modulus E and the thermal dilation coefficient ALPHA are to be specified by the key words ELAS or ELAS\_FO.*

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**7.7**

**Key words factor BPEL\_BETON/BPEL\_ACIER**

*Definition of the characteristics intervening in the model of behavior of the cables of prestressed [R7.01.02].*

*The linear elastic characteristics of the material concrete and the material steel must be at the same time definite under key word ELAS.*

**7.7.1 Syntax**

**/BPEL\_BETON =**

**\_F (**



**PERT\_FLUA**

**=/xflu, [R]**

**/**

**0.**

**,  
[DEFECT]**

**PERT\_RETR**

**=/xret, [R]**

**/**

**0.**

**,  
[DEFECT]**

**)**

**/BPEL\_ACIER =**

**\_F (**

**RELAX\_1000 =/rh1000**

**, [R]**

**/**

**0.**

**,  
[DEFECT]**

**MU0\_RELAX**

=

/

**mu0**

,

**[R]**

/

**0.**

,

**[DEFECT]**

**F\_PRG**

=

**fprg**

,

**[R]**

**FROT\_COURB =/F, [R]**

/

**0.**

,

**[DEFECT]**

**FROT\_LINE**

=



***PERT\_RETR = xret***

***Standard rate of loss of tension by shrinking of the concrete, compared to the initial tension.***

***F***

***ret = xret. F0 where F0 indicates the initial tension.***

***The default value is 0: in this case, one does not take account of the losses of tension by shrinking of the concrete.***

***Behavior: BPEL\_ACIER***

***Key word factor for the definition of the parameters characteristic of the material steel which intervene in the estimate of the losses of tension along the cables of prestressing. This word key factor can be used only jointly with the key word factor ELAS.***

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***RELAX\_1000 = rh1000***

***Relieving of steel at 1000 hours, expressed in %.***

***The default value is 0: in this case, one does not take account of the losses of tension by relieving of steel.***

***MU0\_RELAX = mu0***

*Adimensional coefficient of relieving of prestressed steel.  
The default value is 0.*

***F\_PRG = fprg***

*Guaranteed constraint of the maximum loading with rupture (according to the BEPL).  
If one takes account of the losses of tension by relieving of steel (well informed RELAX\_1000  
by a nonnull value), it is obligatorily necessary to inform operand F\_PRG, by a value  
nonnull.*

***FROT\_COORB = F***

*Coefficient of friction of the cable on the partly curved concrete, in rad1. The default value  
is 0.*

***FROT\_LINE = phi***

*Coefficient of friction per unit of length, partly right. The default value is 0.*

7.8

***Key word factor BETON\_DOUBLE\_DP***

*The model of behavior 3D developed in Code\_Aster is formulated within the framework of  
thermoplasticity, for the description of the nonlinear behavior of the concrete, in traction, and in  
compression, with the taking into account of the irreversible variations of the thermal characteristics  
and  
mechanics of the concrete, particularly sensitive at high temperature [R7.01.03].*

7.8.1 Syntax

***//BETON\_DOUBLE\_DP=***

***\_F***

***(***

***F\_C=***

***f' C***

***,***

***[fonction\*]***

***F\_T=***

***f' T***

***,***

***[fonction\*]***

***COEF\_BIAX=, [fonction\*]***

***ENER\_COMP\_RUPT=***

***Gc***

***,***

***[fonction\*]***

***ENER\_TRAC\_RUPT= WP***

***,***

***[fonction\*]***

***COEF\_ELAS\_COMP=, [fonction\*]***

***LONG\_CARA =***

***will l\_cara,***

***“LINEAR” ECRO\_COMP\_P\_PIC=/, [DEFECT]***

***/“PARABOLA”, [TXM]***

***ECRO\_TRAC\_P\_PIC=  
/“LINEAR”, [DEFECT]***

***/“EXPONENT”, [TXM]***

)

***BETON\_DOUBLE\_DP makes it possible to define all the characteristics associated with the law with behavior with double criterion of Drücker Prager. In complement of these characteristics, the modulus of elasticity, the Poisson's ratio, and the thermal dilation coefficient, as well as the coefficients of withdrawal endogenous and of withdrawal of desiccation, must be defined under key word ELAS for the coefficients realities, or ELAS\_FO, for the coefficients defined by functions, or tablecloths. All them characteristics of the model, (E, naked, f' C, f' T, Gc, WP) on type [fonction\*] can depend on one or of two variables among the temperature, the hydration and drying. When they depend on temperature, they are functions of the maximum of the temperature reached during the history of loading, which is stored for each point of Gauss, in the form of variable intern. This makes it possible to take into account the irreversible variations of these characteristics to high temperature.***

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### 7.8.2 Operands

***F\_C/F\_T/COEF\_BIAX***

***F\_C=***  
***f' C***

***Resistance in uniaxial pressing f' C.***

***F\_T= f' T***

***Resistance in uniaxial traction f' T.***

***COEF\_BIAX=***

***The report/ratio of resistance in biaxial compression to resistance in uniaxial pressing.***

### 7.8.3 Operands

***ENER\_COMP\_RUPT/ENER\_TRAC\_RUPT/COEF\_ELAS\_COMP***

***ENER\_COMP\_RUPT=***  
***Gc***

***The energy of rupture in Gc compression,***

***ENER\_TRAC\_RUPT= WP***

***The energy of rupture in traction WP.***

***COEF\_ELAS\_COMP=***

***Elastic limit in compression, given by a proportionality factor expressed as a percentage resistance to the peak  $f_c'$  (), in general, about 30% for the standard concretes.***

### 7.8.4 Operands

***LONG\_CARA***

***This operand makes it possible to overload the automatically calculated characteristic length, for each mesh, according to its dimensions (starting from its surface in 2D, its volume in 3D).***

***The automatically calculated characteristic length allows, when the smoothness of the grid evolves/moves from one calculation to another, to preserve stable results by avoiding the phenomena of localization. This length calculated automatically or given by the user, conduit with the value of ultimate work hardening in traction according to the formula (for a linear work hardening post-peak):***

**2 G**

.

**U ()**

**T ()**

=

**lc. ft ()**

*In the particular case of a grid containing of the adjacent meshes whose dimensions are very different, ultimate work hardenings of model **BETON\_DOUBLE\_DP** calculated starting from the length*

*characteristic of the meshes are consequently very different, which can generate problems of convergence or to lead to a not very physical state of stresses. (This characteristic length is calculated starting from the volume of the current mesh). For this reason, one proposes to give possibility with the user of defining an average length which overloads the characteristic length calculated for each mesh. The defect of Code\_Aster is the characteristic length calculated for each mesh.*

*To choose an arbitrary and identical length for all the meshes can also generate difficulties of convergence. The best solution consists in creating a network of which variations of dimensions meshes respect the direction of variation of the stress field, and to use the length characteristic calculated automatically according to the size of the meshes. The overload by **LONG\_CARA** must be to hold for particular cases, when the user cannot freely intervene on the grid.*

*If the user defines the characteristic length in material, it will choose a couple (**WP,***

**2 G**

**. T ()**

**LONG\_CARA)** such as

*the value is worth which it wishes for ultimate work hardening in traction **U.***

**lc. ft ()**

*(The usual value of the deformation associated with ultimate work hardening in traction with an average concrete is of **5.E-4**).*

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### ***7.8.5 Operands***

***COMP\_POST\_PIC/TRAC\_POST\_PIC***

***The parameters making it possible to define the curve of softening in compression and traction are optional, and have default values.***

***ECRO\_COMP\_P\_PIC=***

***/"LINEAR"***

***/***

***"PARABOLA"***

***Form curve post-peak in compression of the text type, which can take the values "LINEAR" and "PARABOLA". The nonlinear curve is then of parabolic type.***

***ECRO\_TRAC\_P\_PIC=***

***/"LINEAR"***

***/***

***"EXPONENT"***

***Form curve post-peak in traction of the text type, which can take the values "LINEAR"***

and "EXPONENT". The nonlinear curve is then of exponential type.

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**7.9**

**Key word factor GRANGER\_FP/GRANGER\_FP\_INDT/V\_GRANGER\_FP**

**Definition of the parameters materials for the viscoelastic model of Granger, modelling creep clean of the concrete. There are 3 relations of behavior: the first GRANGER\_FP does not take in count the phenomenon of ageing, the second GRANGER\_FP\_INDT is identical without effect of the temperature, the third V\_GRANGER\_FP accounts for ageing. Cf [R7.01.01].**

**In 1D and creep the model is written:  $\epsilon(t) = \epsilon_0 + \int_0^t \dot{\epsilon}_c(t-T) dT$**

**$\epsilon(t) = \epsilon_0 + \int_0^t \dot{\epsilon}_c(t-T) dT$**

**$\epsilon(t) = \epsilon_0 + \int_0^t \dot{\epsilon}_c(t-T) dT$**

**0**

**with**

**$T_c$  - (Tref**

**N**

**- )**

**45**

**T**

**- T**

**eq**

**C**

**$J(T, T_c, T, H) = H$**

**$K(T_c) J$**

**C**  
**eq**  
**S (1 - exp-**  
**)**  
**45**

**s=1**  
**S**  
**Tc indicates the time of loading**  
**H C 1**

**-**  
**=**  
**(C), or C is the isothermal curve of desorption**  
**T**  
**U**

**T (T**  
**C**  
**) =**  
**exp -**  
**-**  
**ds**  
**eq**

**1**  
**1**

**R T (S)**  
**293**  
**s=t0**

**.**  
**280 2 + .**  
**01**

**K (tceq) = Tc .02**  
**if one takes into account the phenomenon of ageing,**  
**eq + 1**  
**K (tceq) = 1 if not**  
**Tc**  
**U**

**Tc (T)**  
**exp**

**v**  
**=**  
**-**  
**-**  
**ds**  
**eq**  
**C**  
**1**  
**1**

**R**  
**=**

**T (S) T**  
**ref.**  
**S T**

**0**

**Note:**

**ref.**  
**T**  
**is the temperature of reference, it is chosen by the user using the order**  
**AFFE\_MATERIAU.**

**This behavior can be associated the effects of dilation and thermal withdrawal defined by**  
**operands K\_DESSIC and B\_ENDOGE under key word ELAS\_FO.**

**For GRANGER\_FP\_INDT, the temperature does not intervene. Thus the multiplicative term**  
**T - (Tref -**

**)**  
**45 is removed, just as the dependence of T (T) at the temperature.**

**45**  
**eq**

**7.9.1 Syntax for clean creep**

**/**  
**GRANGER\_FP = \_F (**

***J1***  
=  
***J1***  
,  
***[R]***

***J2***  
=  
***J2***  
,  
***[R]***

***J3***  
=  
***J3***  
,  
***[R]***

***J4***  
=  
***J4***  
,  
***[R]***

***J5***  
=  
***J5***  
,  
***[R]***

***J6***  
=  
***J6***  
,  
***[R]***

***J7***  
=  
***J7***

,  
**[R]**

**J6**  
=  
**J8**

,  
**[R]**

**TAUX\_1**  
=  
**1**

,  
**[R]**

**TAUX\_2**  
=  
**2**

,  
**[R]**

**TAUX\_3**  
=  
**3**

,  
**[R]**

**TAUX\_4**  
=  
**4**

,  
**[R]**

**TAUX\_5**  
=  
**5**

,  
**[R]**



**TAUX\_6**

=

6

,

**[R]**

**TAUX\_7**

=

7

,

**[R]**

**TAUX\_8**

=

8

,

**[R]**

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**QSR\_K**

=

**qsr**

,  
[R]

)

### 7.9.2 Operands for clean creep

*J1*  
=  
*J1*  
...  
...  
. *J8*  
=  
*J8*

*8 coefficients materials of the function of creep, homogeneous at a time.*

*TAUX\_1*  
=  
*1*  
...  
...  
. *TAUX\_8 = 8*

*8 coefficients of “delay” of the function of creep, homogeneous at a time.*

*QSR\_K*  
=  
*Uc/R*

*Constant energy of activation intervening in the time term are equivalent teq modelling the effect of temperature on the kinetics of creep.*

### 7.9.3 Syntax for clean creep independent of the temperature

*Syntax is identical to the case with effect of the temperature, without key word QSR\_K.*

### 7.9.4 Syntax for ageing

*If one uses the relation of behavior which then takes into account the phenomenon of ageing it is necessary to inform moreover:*

***V\_GRANGER\_FP =\_F (***  
***QSR\_VEIL***  
***=***  
***USR***  
***,***  
***[R]***  
***FONC\_V***  
***=***  
***K (tceq)***  
***, [function,***  
***formulate]***  
  
***)***

### ***7.9.5 Operands for ageing***

***QSR\_VEIL = USR***

***Constant energy of activation intervening in the time term of load are equivalent tceq modelling***  
***U***  
***the effect of the temperature on ageing C.***

***R***  
***FONC\_V = K (tceq)***

***Function of ageing***

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### **7.10 Word**

**key**

**NADAI\_B**

***The law of behavior NADAI\_B is a model of behavior of the integral concrete of plastic deformations in compression and a model of cracking in traction. This model allows to represent the behavior of the concrete under cyclic loading, a detailed attention being brought to the management of the openings and closings of the cracks.***

***For behaviour in compression, modeling is developed within the framework of standard elastoplasticity: threshold of reversibility (standard Drücker-Prager), normal plastic flow associated.***

***For behaviour in traction, the model is within the framework of cracking distributed. A threshold of reversibility in traction is defined. The first cracking is detected in a geometrical point given when the constraints exceed the threshold in traction for the first time. The point is then declared fissured, direction of the crack being direction perpendicular to the principal constraint major at this moment. The law of behavior of the concrete in this point becomes an orthotropic law then, them axes of orthotropism being those parallel and perpendicular to the crack (of which the orientation of will change more)***

***The parameters of the law are given starting from a test in uniaxial pressing, resistance in traction of the concrete:  $F$***

***and of the deformation with rupture in traction: rupture***

***Stress-strain curve in compression, one deduces the stress-strain curve plastic in compression.***

**$F'$**

**,**

**$C$**

**$FC$**

**$F'C$**

**$00$**

*, 5 F 'C*  
*peak*  
*rupture*  
*K peak*  
*K rupture*  
*Test of uniaxial pressing*  
*Plastic stress-strain curve*

*Curve stress-strain curve plastic in compression, one deduces:*

*F C:*  
*stress ultimate in compression*  
*:*  
*parameter such as F C defines the surface of initial load in compression*  
*K peak:*  
*plastic deformation with the peak*  
*K rupture: plastic deformation with rupture*

*The user who would not have the tests necessary to provide these data can use them*  
*payments which make it possible to estimate a value of the Young modulus, Poisson's ratio,*  
*limit in traction according to the stress ultimate in compression. For the user who would not like*  
*not to do this work, we recommend values F ', K*

*traction*  
*peak*  
*K*  
*,*  
*,*  
*T*

*rupture*  
*rupture and the factor*  
*of shearing tranverse which is practically inaccessible to measurement.*  
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### **7.10.1 Syntax**

**We indicate  $C_i$  below the correspondence between the key words of behavior  $NADAI\_B$  and them preset parameters  $C_i$  above:**

**//NABAI\_B**

**:**  
 **$\_F$**   
**(**

**$F\_C$**   
**:**  
 **$FC$**

**$F\_T$**   
**:**  
 **$ft$**

**$CRIT\_E\_C$ :  $\theta$**

**$EPS\_P\_C$ :  $epc$**

**$EPS\_R\_C$ :  $erc$**

**$EPSI\_R\_T$ :  $ert$**

**$FAC\_T\_C$ :  $F$**

)

*The Young modulus  $E_0$  and the Poisson's ratio are those provided under the key word factor ELAS.*

### **7.10.2 Operands $F_C/F_T$**

**$F_C$**

:

*FC stress ultimate in compression*

**$F_T$**

:

*ft stress ultimate in traction value recommended 0,1 C*

**F**

### **7.10.3 Operand $CRIT_E_C$**

*CRIT\_E\_C: theta: parameter allowing to define the surface of initial load in compression. Value recommended 0,3*

### **7.10.4 Operands $EPS_P_C/EPS_R_C/EPSI_R_T$**

*EPS\_P\_C: epc: plastic deformation or peak*

*EPS\_R\_C: erc: plastic deformation with rupture. Value recommended 0,0005*

*EPSI\_R\_T: ert: deformation with rupture in traction. Value recommended 0,0005*

### **7.10.5 Operand $FAC_T_C$**

*FAC\_T\_C: F: factor of transfer of shearing. Value recommended 0,4*

## **7.11 Key word factor BAZANT\_FD**

*Model BAZANT\_FD is a viscoelastic model of intrinsic creep of desiccation according to model of Bazant. It is a long-term behavior of the concretes subjected to drying and one mechanical loading simultaneously. The document [R7.01.05] described the corresponding details.*

**Note:**

*It is necessary to inform key word FONC\_DESORP under behavior ELAS\_FO.  
This behavior can be associated the effects of dilation and thermal withdrawal defined by  
operands K\_DESSIC and B\_ENDOGE under key word ELAS\_FO.*

**7.11.1 Syntax**

**BAZANT\_FD = \_F**

(

**LAM\_VISC =, [R]**

)

**7.11.2 Operand**

[ 1-

Pa]

**LAM\_VISC = parameter material in**

.

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**7.12 Word**  
**key**  
**LABORD\_ID**

*This model of nonlinear behavior of the concrete is employed in uniaxial situations under the effect of monotonous and cyclic loadings. The model is described within the framework of formulation thermodynamics of the irreversible processes. It makes it possible to take account of the damage of concrete in traction and compression, separately, manages the opening and refermeture of the cracks, and account of the nonreversible deformation takes.*

*This model was developed to be employed with the multifibre elements of beam [R7.01.07].*

**Note:**

*The taking into account of the effect of a thermal loading is not possible for the moment.*

**7.12.1 Syntax**

/

**LABORD\_ID**  
**= \_F**  
**(**

**Y01**  
**=**  
**Y01**  
**,**  
**[R]**

**Y02**

=

**Y02**

,

**[R]**

**A1**

=

**A1**

,

**[R]**

**A2**

=

**A2**

,

**[R]**

**B1**

=

**B1**

,

**[R]**

**B2**  
=  
**B2**  
,  
**[R]**

**BETA1**  
=  
**1**  
,  
**[R]**

**BETA2**  
=  
**2**  
,  
**[R]**

**SIGF =**

***F***  
,  
***[R]***

);

### ***7.12.2 Operands***

***Y01***  
=  
***Y01***

***Threshold of evolution of the variable of damage under traction***

***Y02***  
=  
***Y02***

***Threshold of evolution of the variable of damage under compression***

***A1 = A1***

***Multiplying parameter describing the kinetics of evolution of the variable of damage under traction***

***A2 = A2***

***Multiplying parameter describing the kinetics of evolution of the variable of damage***

***under compression***

***B1 = B1***

***Parameter of power describing the kinetics of evolution of the variable of damage under traction***

***B2 = B2***

***Parameter of power describing the kinetics of evolution of the variable of damage under compression***

***BETA1 = 1***

***Parameter describing the amplitude of the anelastic deformation under traction***

***BETA2 = 2***

***Parameter describing the amplitude of the anelastic deformation under compression***

***SIGF = F***

***Parameter indicating the constraint of opening and refermeture of crack***

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### **7.13 Key word factor MAZARS/MAZARS\_FO**

*The model of behavior of Mazars is an elastic model of behavior endommageable allowing to describe the softening behavior of the concrete. It distinguishes behaviour in traction and in compression, but uses only one variable of scalar damage (cf [R7.01.08]).*

*The parameters can be a function of the temperature, to use MAZARS\_FO then. Attention, in practical, it is considered that the parameters depend on the maximum temperature seen by material.*

#### **7.13.1 Syntax**

**//MAZARS**

=

**\_F (**

***EPSD0 = d0, [R]***

***AC***  
=  
***Ac***  
,  
***[R]***

***AT***  
=  
***At***  
,  
***[R]***

***BC***  
=  
***Bc***  
,  
***[R]***

***BT***  
=  
***LT***  
,  
***[R]***

**BETA =, [R]**

)

/

**MAZARS**

=

**\_F**

(

**EPSD0 = d0, [function \*\*]**

**AC**

=

**Ac**

,

**[function \*\*]**

**AT**



=  
***At***  
,  
***[function \*\*]***

***BC***  
=  
***Bc***  
,  
***[function \*\*]***

***BT***  
=  
***LT***  
,  
***[function \*\*]***

***BETA =, [R]***

)

***MAZARS (or MAZARS\_FO) makes it possible to define all the characteristics associated with the***

**model with**

**behavior of Mazars. In addition to these characteristics, constant the rubber bands must be defined under key word ELAS for the real coefficients or ELAS\_FO for the coefficients depending temperature.**

### **7.13.2 Operands EPSD0**

**EPSD0 = d0**

**Threshold of damage in deformation (generally  $0.5 \cdot 10^4 < d0 < 1.5 \cdot 10^4$ ).**

### **7.13.3 Operands AC/AT/BC/BT**

**AC = ac**

**Coefficient allowing to fix the shape of the curve post-peak in compression. Introduced one horizontal asymptote which is the axis of for  $ac = 1$  and the horizontal one for passer by by the peak for**

**Ac = 0 (generally  $1 < ac < 1.5$ ).**

**AT = At**

**Coefficient allowing to fix the shape of the curve post-peak in traction. Introduced an asymptote horizontal which is the axis of for  $ac = 1$  and the horizontal one passing by the peak for  $ac = 0$  (generally  $0.7 < At < 1$ ).**

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***BC = Bc***

*Coefficient allowing to fix the shape of the curve post-peak in compression. According to its value can to correspond to a brutal fall of the constraint ( $BC < 104$ ) or a preliminary phase of increase in constraint followed by a more or less fast decrease (generally  $103 < Bc < 2.103$ ).*

***BT = LT***

*Coefficient allowing to fix the shape of the curve post-peak in traction. According to its value can to correspond to a brutal fall of the constraint ( $BC < 104$ ) or a preliminary phase of increase in constraint followed by a more or less fast decrease (generally  $104 < LT < 105$ ).*

#### ***7.13.4 Operand BETA***

***BETA =***

*Parameter of correction for shearing. Value advised 1.06.*

#### ***7.14 Word***

*key*

***BETON\_UMLV\_FP***

*The law of creep UMLV supposes a total decoupling between the spherical components and deviatoric: the deformations induced by the spherical constraints are purely spherical and the deformations induced by the deviatoric constraints are purely deviatoric. In addition, clean deformation of creep is supposed to be proportional to internal relative moisture:*

*Spherical part: S*

*= H F (S*

*) and, left deviatoric: D = H (~*

*F*

*)*

*Where H indicates internal relative moisture.*

*The model of behavior BETON\_UMLV\_FP is a nongrowing old viscoelastic model developed in partnership with the University of Marne-the-Valley to describe the clean creep of concretes. It is particularly adapted to the multiaxial configurations by not presupposing the value Poisson's ratio of creep.*

*The spherical constraints are at the origin of the migration of the water absorptive with the interfaces between*

*hydrates on the level of the macroporosity and absorptive within microporosity in porosity capillary. Diffusion of the inter-lamellate water of the pores of hydrates towards capillary porosity be carried out in an irreversible way. The total spherical deformation of creep is thus written like*

*summon of a reversible part and an irreversible part:*

*fs*

*fs*

*fs*

=

+

{

*R*

{

*I*

*part*

*part*

*reversible*

*irréversib*

*The process of deformation spherical of creep is controlled by the system of coupled equations according to:*

*fs*

*& = 1 [H S*

*- S*

*K fs*

*R*

*R] -*

*fs*

*&*

*I*

*S*

*R*

+

*fs*

*& = 1*

*I*

*[sk fs -  
R  
(sk + S  
R  
ki) fs  
I] - [  
S  
H  
- S  
K fs  
R  
R]*

*S  
I*

*where S  
Kr indicates rigidity connect associated with the skeleton formed by blocks with hydrates on the scale mesoscopic; S*

*R viscosity connect associated with the mechanism with diffusion within porosity capillary;*

*S  
ki indicates rigidity connect intrinsically associated with the hydrates on the scale microscopic and S*

*I viscosity connects associated with the interfoliaceus mechanism of diffusion.*

*I  
(Hooks  
+ appoint the operator of Mac Cauley:  $X + = (X + X)$ )*

*2  
The deviatoric constraints are at the origin of a mechanism of slip (or mechanism of quasi dislocation) of the layers of HSC in nano-porosity. Under deviatoric constraint, creep be carried out with constant volume. In addition, the law of creep UMLV supposes the isotropy of creep*

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*deviatoric. Phénoménologiquement, the mechanism of slip comprises a contribution reversible viscoelastic of the water strongly adsorbed with the layers of HSC and a contribution irreversible viscous of interstitial water:*

*fd*

*fd*

*fd*

**=**

**+**

**{**

**{**

**R**

**{**

**I**

*one*

*contributi*

*N*

*déformatio*

*one*

*contributi*

*water*

*ue*

*déviatoriq*

*water*

*absobée*

*total*

*free*

*The principal component jème of the total deviatoric deformation is governed by the system equations following:*

**D**

**D**

**~**

**J**

***R***  
***Kr***  
**+**  
  
***~ J***  
***D D, J***  
***D D, J***  
***& I***  
**+**  
***= R & + Kr &***

***D***  
***D***

***I***

***I***

***where D***

***Kr indicates rigidity associated with the capacity with water adsorbed to transmit loads (load bearing toilets); D***

***R viscosity associated with the water adsorbed by the layers with hydrates and***

***D***

***I indicates***

***viscosity associated with interstitial water.***

### ***7.14.1 Syntax***

***/BETON\_UMLV\_FP***

***:***

***\_F***

***(***

***K\_RS***

:  
***K\_RS***  
,  
***[R]***

***K\_IS***  
:  
***K\_IS***  
,  
***[R]***

***K\_RD***  
:  
***K\_RD***  
,  
***[R]***

***ETA\_RS***  
:  
***ETA\_RS***  
,  
***[R]***



***ETA\_IS***  
:  
***ETA\_IS***  
,  
***[R]***

***ETA\_RD***  
:  
***ETA\_RD***  
,  
***[R]***

***ETA\_ID***  
:  
***ETA\_ID***  
,  
***[R]***

)

### ***7.14.2 Operand***

***K\_RS: K\_RS***

**S**

***K rigidity connect associated with the skeleton formed by blocks with hydrates on the scale***

**R**

***mesoscopic***

***K\_IS: K\_IS***

**S**

***K rigidity connect intrinsically associated with the hydrates on a microscopic scale***

**I**

***K\_RD: K\_RD***

**D**

***K rigidity associated with the capacity with water adsorbed to transmit loads (load bearing***

**R**

***toilets)***

***ETA\_RS***

**:**

***ETA\_RS***

**S**

***viscosity connects associated with the mechanism with diffusion within capillary porosity***

**R**

***ETA\_IS***

**:**

***ETA\_IS***

**S**

***viscosity connects associated with the mechanism with diffusion interlamellaire***

**I**

***ETA\_RD***

**:**

***ETA\_RD***

**D**

***viscosity associated with the water adsorbed by the layers with hydrates***

**R**

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**ETA\_ID**

**:**

**ETA\_ID**

**D**

**viscosity of interstitial water.**

**I**

**Note:**

**The curve of desorption giving the hygroscopy *H* according to the water *C* concentration must be well informed under key word *ELAS\_FO*.**

**7.15 Key words factor** *BETON\_ECRO\_LINE*

**Definition of a linear curve of work hardening with taking into account of containment in the case specific to the concrete. In order to improve behaviour in compression one defines a threshold of reversibility**

**7.15.1 Syntax**

**/**  
**BETON\_ECRO\_LINE = \_F**

**(D\_SIGM\_EPSI**

**=**

***dsde, [R]***

***SYT***

=

***sigt***

,

***[R]***

***SYC***

=

***sigc***

,

***[R]***

)

### **7.15.2 Operands**

***D\_SIGM\_EPSI = dsde (AND)***

***Slope of the traction diagram.***

***SYT = sigt***

***Maximum constraint in simple traction.***

***SYC = sigm***

***Maximum constraint in simple compression (it does not exist for a Poisson's ratio =0, in this case one does not specify SYC)***

***The Young modulus E is to be specified by key words ELAS or ELAS\_FO.***

### **7.16 Key words factor GLRC**

***Definition of the behavior of the concrete plates written in generalized efforts. GLRC is a model elastoplastic in aggregate variables for orthotropic hulls with possible taking into account of the influence of the membrane effort on the yield stresses in inflection.***

#### **7.16.1 Syntax**

***/GLRC = \_F (  
MEX1  
=  
mex1, [R]***

***MEY1***

=

***mey1, [R]***

***MEX2***

=

***mex2, [R]***

***MEY2***

=

***mey2, [R]***

***CX1 = cx1, [R]***

***CY1 = cy1, [R]***

***CXY1 = cxy1, [R]***

***CX2 = cx2, [R]***

***CY2 = cy2, [R]***

***CXY2 = cxy2, [R]***

)

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***/GLRC\_FO = \_F (MEX1 = mex1, [function ++]***

***MEY1 = mey1, [function ++]***



***MEX2 = mex2, [function ++]***

***MEY2 = mey2, [function ++]***

***CX1 = cx1, [function ++]***

***CY1 = cy1, [function ++]***

***CXY1 = cxy1, [function ++]***

***CX2 = cx2, [function ++]***

***CY2 = cy2, [function ++]***

***CXY2 = cxy2, [function ++]***

)

### ***7.16.2 Operands***

***MEX1 = mex1***

*moment limits elastic in positive inflection in X.*

*MEY1 = mey1*

*moment limits elastic in positive inflection in Y.*

*MEX2 = mex2*

*moment limits elastic in negative inflection in X.*

*MEY2 = mey2*

*moment limits elastic in negative inflection in Y.*

*CX1 = cx1*

*kinematic coefficient of recall in positive inflection.*

*CY1 = cy1*

*kinematic coefficient of recall in positive inflection.*

*CXY1 = cxy1*

*kinematic coefficient of recall in positive inflection.*

*CX2 = cx2*

*kinematic coefficient of recall in negative inflection.*

*CY2 = cy2*

*kinematic coefficient of recall in negative inflection.*

*CXY2 = cxy2*

*kinematic coefficient of recall in negative inflection.*

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**7.17 Word**

**key**

***JOINT\_BA***

*This model of nonlinear behavior of the steel-concrete connection is employed for the fine calculation of concrete structures reinforced where the prediction with the cracks and redistribution with the constraints in the concrete are very important. Available for analyses under the effect of monotonous loadings and cyclic, the model is written within the thermodynamic framework of formulation of the processes irreversible. It makes it possible to take account of the damage of the interface in shearing, in combination with the effects of the friction of the cracks, as well as unrecoverable deformations. document [R7.01.21] described the corresponding details.*

*This model must be employed with the elements "joint" in 2D [R3.06.09]. Steel reinforcements could be modelled with plane elements (QUAD4) or unidimensional (BAR).*

**Note:**

*The taking into account of the effect of a thermal loading is not possible for the moment.*

**7.17.1 Syntax**

/

***JOINT\_BA***

=

***\_F (***

***HPEN =  
HPEN,  
[R]***

***GTT  
=  
GTT  
,  
[R]***

***GAMD0  
=  
0  
,  
[R]***

***AD1  
=  
ad1  
,  
[R]***

***BD1***

=

***bd1***

,

***[R]***

***GAMD2***

=

***2***

,

***[R]***

***AD2***

=

***ad2***

,

***[R]***

***BD2***

=

***bd2***

,

**[R]**

**VIFROT**

=

**vifrot**

,

**[R]**

**F**

=

**alpha**

,

**[R]**

**FC**

=

**C**

,

**[R]**

***EPSTR0***

=

***NR***

,

***[R]***

***ADN***

=

***ADN***

,

***[R]***

***BDN***

=

***bdn***

,

***[R]***

);

### ***7.17.2 Operands***



***HPEN = HPEN***

***Parameter of penetration between surfaces by crushing of the concrete.  
It is checked that  $HPEN > 0.0 E+0$ .***

***GTT = GTT***

***Modulate rigidity of the connection.  
It is checked that  $G$   
GTT  $G$   
.  
concrete  
steel***

***GAMD0 = 0***

***Threshold of perfect adherence or limit of elastic strain.  
It is checked that  $1.E-4$  GAMD0  $1.E-2$ .***

***AD1  
=  
ad1***

***Parameter of evolution of the damage in area 1 (passage of small  
deformations with the great slips).  
It is checked that  $1.E-1$  AD1  $1.E+1$ .***

***BD1  
=  
bd1***

***Parameter of power describing the evolution of the variable of damage in area  
1 (passage of the small deformations to the great slips).  
It is checked that  $BD1$   $1.E-1$ .***

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**GAMD2 = 2**

*Threshold of the great slips.*

*It is checked that 1.E-4 GAMD2 1.E+0.*

**AD2**

=

*ad2*

*Parameter of evolution of the damage in area 2 (maximum resistance of connection and degradation in friction).*

*It is checked that AD2 1.E-6.*

**BD2**

=

*bd2*

*Parameter of power describing the evolution of the variable of damage in area 2 (maximum resistance of the connection and degradation in friction).*

*It is checked that BD2 1.E-1.*

*VIFROT*

*= vifrot*

*Parameter material describing the influence of the friction of the cracks.*

*It is checked that VIFROT 0.0 E+0.*

*F = alpha*

*Parameter material related to kinematic work hardening by friction of the cracks.*

*It is checked that F 0.0 E+0.*

*FC = C*

*Parameter describing the influence of containment on the resistance of the connection.*

*It is checked that FC 0.0 E+0.*

*EPSTRO*

*= NR*

*Threshold of elastic strain on the normal direction before the rupture.*

*It is checked that 1.E-4 EPSTRO 1.E+0.*

*ADN*

*=*

*ADN*

*Parameter of the damage in the normal direction by opening of the crack.*

*It is checked that ADN 1.E-10.*

*BDN*

*=*

*bdn*

*Parameter of power describing the evolution of the variable of damage in normal direction.*

*It is checked that BDN 1.E-1.*

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## **8 Behaviors**

### **Metal-worker-mechanics**

*For the metallurgical behavior (cf [R4.04.01]), two laws of behavior are available: one law characteristic of the metallurgical transformations of steel and a law characteristic of alloys of zirconium.*

*For the mechanical effects and the associated behaviors, the models are common for steel and zirconium (cf [R4.04.02]).*

### **8.1**

#### **Key word factor META\_ACIER**

*Parameters to be informed for the metallurgy of steel.*

#### **8.1.1 Syntax**

/

**META\_ACIER**

=  
***F***  
(

***TRC = nomtrc,***  
***[trc]***

***AR3 = ar3, [R]***

***ALPHA = alpha, [R]***

***MS0 = mso, [R]***

***AC1 = ac1, [R]***

***AC3 = ac3, [R]***

***TAUX\_1***  
**=**  
***T1***  
**,**  
***[R]***

***TAUX\_3***

***=***

***T3***

***,***

***[R]***

***LAMBDA0= 10, [R]***

***QSR\_K = Qapp,***

***[R]***

***D10 = d10, [R]***

**$WSR_K = Wapp,$   
**[R]****

)

### ***8.1.2 Operands for the phase shifts***

***TRC = nomtrc***

***Concept of the trc type produces by operator DEF1\_TRC [U4.43.04] and containing the whole of information provided by diagrams TRC (Transformation into Continuous Cooling) of steel considered.***

***AR3 = ar3***

***Quasi-static temperature of beginning of decomposition of austenite to cooling.***

***ALPHA***

=

***alpha***

***Coefficient of the law of Koistinen-Marburger expressing the quantity of martensite formed in function of the temperature:***

***Z***

= 1 -

((

***exp M - T***

***M***

***S***



).

***MSO = mso***

*Martensitic initial temperature of transformation when this one is total. In this case*  
 *$MS = Ms0$ .*

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*AC1 = ac1*

*Quasi-static temperature of beginning of transformation into austenite with the heating.*

*AC3 = ac3*

*Quasi-static temperature of end of transformation into austenite.*

*TAUX\_1 = T1*

*Value of the function “delay” (cf [R4.04.01]) ((T)) intervening in the model of transformation austenitic at temperature AC1.*

*TAUX\_3 = T3*

*Value of the function “delay” (cf [R4.04.01]) ((T)) intervening in the model of transformation austenitic at temperature AC3.*

*The evolution of the proportion of austenite is then defined by:*

*Z - Z (T)*  
*Z*  
*eq*  
*& =*  
  
*(T)*  
*with: Zeq (T)*

*1*

*Ac1*  
*T*  
*Ac3*

*and (T)*

*T3*  
*T1*  
*Ac1 Ac3*  
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### 8.1.3 Operands for the size of grains

The four operands following involve the calculation of size of grains if they are indicated.

LAMBDA0

=

0

Parameter material intervening in the model of evolution of size of grain below.

$Q_{app}$

= exp

0

$dD$

1 1

1

$RT$

=

-

with

$dt$

$D_{lim}$

$W_{app}$

$D$

=  $D \exp-$

$lim$

10

*RT*

$$QSR_K = Qapp$$

*Parameter energy of activation intervening in the model of evolution of size of grain.*

$$D10 = D10$$

*Parameter material intervening in the model of evolution of size of grain.*

$$WSR_K = Wapp$$

*Parameter energy of activation intervening in the model of evolution of size of grain.*

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8.2

**Key word factor** **META\_ZIRC**

*Parameters to be informed for the metallurgy of the zircaloy (cf [R4.04.01]).*

**8.2.1 Syntax**

**/META\_ZIRC = \_F**

(

**TDEQ = teqd, [R]**

**NR = N, [R]**

**K = K, [R]**

**QSR\_K = qsr**

**, [R]**

***CCT***

=

***CCT***

***, [R]***

***AC = ac, [R]***

***M = m, [R]***

***TDR***

=

***tdr***

***, [R]***

***AR = Ar, [R]***

***Br = Br, [R]***

### ***8.2.2 Operands***

***TDEQ = teqd***

***Initial temperature of transformation to balance***

***: compact phase cold hexagonal***

***: phase hot cubic centered***

***N = N***

***Parameter material relating to the model giving the proportion of according to the temperature, with balance.***

***K = K***

***Parameter material relating to the model giving the proportion of according to the temperature, with balance.***

***CCT = CCT***

***Initial temperature of transformation into to the heating.***

***AC = ac***

***Parameter material intervening in the model of evolution of to the heating.***

***M = m***

***Parameter material intervening in the model of evolution of to the heating.***

***TDR = tdr***

***Initial temperature of transformation into to cooling.***

***AR = Ar***

***Parameter material intervening in the model of evolution of to cooling.***

***Br = Br***

***Parameter material intervening in the model of evolution of to cooling.***

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***8.3***

***Key word factor DURT\_META***

***Definition of the characteristics relating to the calculation of hardness associated with the metallurgy with steels.***

### ***8.3.1 Syntax***

***/***  
***DURT\_META***  
***=***  
***\_F***  
***(***  
***F1\_DURT = HVf1, [R]***

***F2\_DURT = HVf2, [R]***

***F3\_DURT = HVf3, [R]***

***F4\_DURT = HVf4, [R]***



***C\_DURT***  
***= HVa***  
,

***[R]***

)

### ***8.3.2 Operands***

***Hardness is calculated by using a linear law of mixture on the microhardness of the components:***

$$HV = \sum_{I=1}^n z_i \times HV_i$$

***I***

***I***

***I***

***HVi: microhardness of component I***

***zi: proportion of component I***

***F1\_DURT =***

***HVf1 microhardness of the cold phase F1 (ferrite for steel)***

***F2\_DURT =***

***HVf2 microhardness of the cold phase F2 (pearlite for steel)***

***F3\_DURT =***

***HVf3 microhardness of the cold phase F3 (bainite for steel)***

***F4\_DURT =***

***HVf4 microhardness of the cold phase F4 (martensite for steel)***

***C\_DURT***

***=***

***HVf1 microhardness for the hot phase (austenite for steel)***

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***8.4***

***Key words factor ELAS\_META/ELAS\_META\_FO***

***Definition of the elastic characteristics, dilation and elastic limits for modeling of an undergoing material of the metallurgical transformations (see [R4.04.02]). These coefficients can***

***to be are constant compared to temperature ELAS\_META, are to depend on the temperature ELAS\_META\_FO (parameter "TEMP").***

***Certain coefficients depend on the metallurgical structure (parameter "META").***

***For all the relations of behavior relating to materials undergoing of the transformations metallurgical (ELAS\_META, META\_\*\*\*\_\*\*\*), one can treat two types of materials; the first corresponds to steels and second is specific to Zircaloy. Various relations (ELAS\_META, META\_\*\*\*\_\*\*\*) are identical for these two materials (the same phenomena are treated) but it a many involved phases are different. One chooses material desired while activating, in the operator STAT\_NON\_LINE, the key word RELATION\_KIT which is worth "STEEL" or "ZIRC".***

***.***

*steel can comprise (with more) five different metallurgical phases (cold phase 1 = ferrite, cold phase 2 = pearlite, cold phase 3 = bainite, cold phase 4 = martensite and one hot phase = austenite),*

.

*the zircaloy can comprise (with more) three different metallurgical phases (cold phase 1 = pure phase, cold phase 2 = phase mixes and a hot phase = phase.*

*Consequently, for a steel one informs to the maximum 5 elastic limits whereas with Zircaloy one does not inform any to the maximum three.*

#### **8.4.1 Syntax**

*/  
ELAS\_META = \_F  
(  
E  
=  
Young  
,  
[R]*

*NAKED  
=  
naked  
,  
[R]*

*F\_ALPHA =  
F  
,  
[R]*

*C\_ALPHA =*

,  
*[R]*

*PHASE\_REFE =/"HOT", [TXM]*

*/"COLD",*

*EPSF\_EPSC\_TREF =*

,  
*[R]*

***TEMP\_DEF\_ALPHA = T***

,  
***[R]***

***PRECISION***

=  
/  
***, [R]***

/***1.***  
***, [DEFECT]***

***F1\_SY***

=  
***F\_y1***  
,  
***[R]***

***F2\_SY***

=

***F\_y2***

,

***[R]***

***F3\_SY***

=

***F\_y3***

,

***[R]***

***F4\_SY***

=

***F\_y4***

,

***[R]***

***C\_SY = F\_y***

,

***[R]***

***SY\_MELANGE = F,***

**[function]**

**$F1\_S\_VP = F\_c1$**

,  
**[R]**

**$F2\_S\_VP = F\_c2$**

,  
**[R]**

**$F3\_S\_VP = F\_c3$**

,  
**[R]**

**$F4\_S\_VP = F\_c4$**

,  
**[R]**

**$C\_S\_VP$**

=  
*F\_c*  
,  
*[R]*

*S\_VP\_MELANGE*

=  
*F*,  
*[function]*

)  
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*/ ELAS\_META\_FO*  
*=\_F*  
*(*



***E***  
=  
***Young***  
,  
***[function \*\*]***

***NAKED***  
=  
***naked***  
,  
***[function \*\*]***

***F\_ALPHA =***  
***F***  
,  
***[function \*\*]***

***C\_ALPHA =***  
,  
***[function \*\*]***

***PHASE\_REFE =/"HOT", [TXM]***

***/"COLD",***

***EPSF\_EPSC\_TREF =***

***,***  
***[R]***

***TEMP\_DEF\_ALPHA = T***

***,***  
***[R]***

***PRECISION***

***=***  
***/***  
***, [R]***

*/ 1.*  
*, [DEFECT]*

*F1\_SY*  
*=*  
*F\_y1*  
*,*  
*[function \*\*]*

*F2\_SY*  
*=*  
*F\_y2*  
*,*  
*[function \*\*]*

*F3\_SY*  
*=*  
*F\_y3*

,  
[function \*\*]

*F4\_SY*  
=  
*F\_y4*

,  
[function \*\*]

*C\_SY = F\_y*

,  
[function \*\*]

*SY\_MELANGE = F,*  
[function]

*F1\_S\_VP = F\_c1*

,  
[function \*\*]

***F2\_S\_VP = F\_c2***

,  
***[function \*\*]***

***F3\_S\_VP = F\_c3***

,  
***[function \*\*]***

***F4\_S\_VP = F\_c4***

,  
***[function \*\*]***

***C\_S\_VP***

=  
***F\_c***  
,  
***[function \*\*]***

***S\_VP\_MELANGE***

=  
***F,***  
***[function]***

)

### **8.4.2 Operands**

***E = Young***

***Young modulus, identical for all the metallurgical phases.***

***NAKED = naked***

***Poisson's ratio, identical for all the metallurgical phases.***

***F\_ALPHA = F***

***Thermal dilation coefficient average of the cold phases.***

***C\_ALPHA***

***=***

***Thermal dilation coefficient average of the hot phase.***

***PHASE\_REFE =/"HOT"***

***/"COLD"***

***Choice of the metallurgical phase of reference (hot phase or cold phase).***

***Indeed, to define the null thermal deformation, it is necessary to define the temperature of Tref reference***

***(defined in AFFE\_MATERIAU) and the metallurgical phase of reference, so that thermal deformation is considered null in Tref and in the metallurgical state of reference.***

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***EPSF\_EPSC\_TREF =***

***Deformation of the phase not of reference compared to the phase of reference to the temperature ref.***

***T***

***: translated the difference in compactness between the cubic crystallographic structures with faces centered (standard austenitic) and cubic centered (standard ferritic).***

***TEMP\_DEF\_ALPHA = T***

***Temperature compared to which one defines the dilation coefficient. If C\_ALPHA is a function, this operand is obligatory.***

***PRECISION***

***This reality indicates with which precision a temperature T is close to the temperature to reference (cf [§3.1.4]).***

***F1\_SY***

***=***

***F\_sigm\_f***

***Elastic limit of the cold phase 1 for a plastic behavior.***

***F2\_SY***

***=***

***F\_sigm\_f***

***Elastic limit of the cold phase 2 for a plastic behavior.***

***F3\_SY***

$$=$$
$$F\_sigm\_f$$

*Elastic limit of the cold phase 3 for a plastic behavior.*

$$F4\_SY$$
$$=$$
$$F\_sigm\_f$$

*Elastic limit of the cold phase 4 for a plastic behavior.*

$$C\_SY = F\_sigm\_f$$

*Elastic limit of the hot phase for a plastic behavior.*

$$SY\_MELANGE = F$$

*Function used for the law of mixture on the elastic limit of multiphase material for one plastic behavior.*

$$= (1 - F(Z)) + F(Z)$$

y

y

y

$$F1\_S\_VP = F\_sigm\_f$$

*Elastic limit of the cold phase 1 for a viscous behavior.*

$$F2\_S\_VP = F\_sigm\_f$$

*Elastic limit of the cold phase 2 for a viscous behavior.*

$$F3\_S\_VP = F\_sigm\_f$$

*Elastic limit of the cold phase 3 for a viscous behavior.*

$$F4\_S\_VP = F\_sigm\_f$$

*Elastic limit of the cold phase 4 for a viscous behavior.*

$$C\_S\_VP$$
$$=$$
$$F\_sigm\_f$$

*Elastic limit of the hot phase for a viscous behavior.*



***S\_VP\_MELANGE***

***= F***

***Function used for the law of mixture on the elastic limit of multiphase material for one viscous behavior.***

***= (1 - F (Z)) + F (Z)***

***y***

***y***

***y***

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***8.5***

***Key word factor META\_ECRO\_LINE***

***Definition of five modules of work hardening used in the modeling of the phenomenon of work hardening***

***isotropic linear of an undergoing material of the metallurgical phase shifts (see [R4.04.02]).***

***These modules depend on the temperature.***

***8.5.1 Syntax***

***/***  
***META\_ECRO\_LINE = \_F (***

**$F1\_D\_SIGM\_EPSI = dsde, [function **]$**

**$F2\_D\_SIGM\_EPSI = dsde, [function **]$**

**$F3\_D\_SIGM\_EPSI = dsde, [function **]$**

**$F4\_D\_SIGM\_EPSI = dsde, [function **]$**

**$C\_D\_SIGM\_EPSI$**   
**=**  
 **$dsde$**   
**,**  
 **$[function **]$**   
**)**

### **8.5.2 Operands**

**$F1\_D\_SIGM\_EPSI = dsde$**

***Slope of the traction diagram for the cold phase 1.***

$F2\_D\_SIGM\_EPSI = dsde$

*Slope of the traction diagram for the cold phase 2.*

$F3\_D\_SIGM\_EPSI = dsde$

*Slope of the traction diagram for the cold phase 3.*

$F4\_D\_SIGM\_EPSI = dsde$

*Slope of the traction diagram for the cold phase 4.*

$C\_D\_SIGM\_EPSI$

=

$dsde$

*Slope of the traction diagram for the hot phase.*

$dsde$

$sigm$

$E$

$1$

*The Young modulus E is to be specified by key words META\_ELAS or META\_ELAS\_FO.*

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## 8.6

### **Key word factor *META\_TRACTION***

*Definition of five traction diagrams used in the modeling of the phenomenon of work hardening isotropic nonlinear of an undergoing material of the metallurgical phase shifts (see [R4.04.02]). The traction diagrams can possibly depend on the temperature.*

#### **8.6.1 Syntax**

/  
*META\_TRACTION* = *\_F* (

*SIGM\_F1* = *r\_p*, [function \*\*]

*SIGM\_F2* = *r\_p*, [function \*\*]

*SIGM\_F3* = *r\_p*, [function \*\*]

*SIGM\_F4* = *r\_p*, [function \*\*]

*SIGM\_C* = *r\_p*, [function \*\*]

)

##### **8.6.1.1 Operands**

*SIGM\_F1* = *r\_p*

*Isotropic curve work hardening R according to the cumulated plastic deformation p for cold phase 1.*

*SIGM\_F2* = *r\_p*

*Isotropic curve work hardening R according to the cumulated plastic deformation p for cold phase 2.*

*SIGM\_F3* = *r\_p*

*Isotropic curve work hardening R according to the cumulated plastic deformation p for cold phase 3.*

$$SIGM\_F4 = r\_p$$

*Isotropic curve work hardening R according to the cumulated plastic deformation p for cold phase 4.*

$$SIGM\_C$$

=

$$r\_p$$

*Isotropic curve work hardening R according to the cumulated plastic deformation p for hot phase.*

**Note:**

*Attention it is not a question of the curve function of but of the curve R function of p.  
One passes from the one to the other by carrying out following calculations:  $R = -$  elastic limit,  
 $p = (/E)$ .*

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**8.7**

**Key word factor META\_VISC**

*Definition of the viscous parameters of the viscoplastic law of behavior with taking into account of*

*metallurgy (see [R4.04.02]). The viscoplastic model of Norton-Hoff type comprises 5 parameters; parameters traditional,  $N$  of the law of flow in power, yield stress of flow viscous, the parameters  $C$  and  $m$  relating to the restoration of work hardening of viscous origin. These parameters depend on the temperature and the metallurgical structure. The limit elastic parameters are defined in ELAS\_META.*

### **8.7.1 Syntax**

**/ META\_VISC**

**= \_F**

**(**

**F1\_ETA**

**= 1 ,**

**[function \*\*]**

**F2\_ETA**

**= 2 ,**

**[function \*\*]**

**F3\_ETA**

**= 3 ,**

**[function \*\*]**

**F4\_ETA**

**= 4 ,**

**[function \*\*]**

**C\_ETA = 5, [function \*\*]**

**F1\_N = n1, [function \*\*]**

**F2\_N = N2, [function \*\*]**

**F3\_N = n3, [function \*\*]**

**F4\_N = n4, [function \*\*]**

*C\_N*  
=  
*n5*  
,  
[function \*\*]

*F1\_C = C1, [function \*\*]*

*F2\_C = C2, [function \*\*]*

*F3\_C = C3, [function \*\*]*

*F4\_C = C4, [function \*\*]*

*C\_C*  
=  
*C5*  
,  
[function \*\*]

*F1\_M = m1, [function \*\*]*

*F2\_M = m2, [function \*\*]*

*F3\_M = m3, [function \*\*]*

*F4\_M = m4, [function \*\*]*

*C\_M*  
=  
*m5*  
,  
[function \*\*]

)

## **8.7.2 Operands**

***F1\_ETA***

***= 1***

***Parameter of the viscoplastic law of flow, for the cold phase 1.***

***F2\_ETA***

***= 2***

***Parameter of the viscoplastic law of flow, for the cold phase 2.***

***F3\_ETA***

***= 3***

***Parameter of the viscoplastic law of flow, for the cold phase 3.***

***F4\_ETA***

***= 4***

***Parameter of the viscoplastic law of flow, for the cold phase 4***

***C\_ETA = 5***

***Parameter of the viscoplastic law of flow, for the hot phase***

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$$F1\_N = n1$$

*Parameter N of the viscoplastic law of flow, for the cold phase 1.*

$$F2\_N = N2$$

*Parameter N of the viscoplastic law of flow, for the cold phase 2.*

$$F3\_N = n3$$

*Parameter N of the viscoplastic law of flow, for the cold phase 3.*

$$F4\_N = n4$$

*Parameter N of the viscoplastic law of flow, for the cold phase 4*

$$C\_N$$

=

$$n5$$

*Parameter N of the viscoplastic law of flow, for the hot phase*

$$F1\_C = C1$$

*Parameter C relating to the restoration of work hardening of viscous origin, for the cold phase 1.*

$$F2\_C = C2$$

*Parameter C relating to the restoration of work hardening of viscous origin, for the cold phase 2.*

$$F3\_C = C3$$

*Parameter C relating to the restoration of work hardening of viscous origin, for the cold phase 3.*

$$F4\_C = C4$$

*Parameter C relating to the restoration of work hardening of viscous origin, for the cold phase 4*

$$C\_C$$

=

$$C5$$

*Parameter C relating to the restoration of work hardening of viscous origin, for the hot phase*

***F1\_M = m1***

***Parameter m relating to the restoration of work hardening of viscous origin, for the cold phase 1.***

***F2\_M = m2***

***Parameter m relating to the restoration of work hardening of viscous origin, for the cold phase 2.***

***F3\_M = m3***

***Parameter m relating to the restoration of work hardening of viscous origin, for the cold phase 3.***

***F4\_M = m4***

***Parameter m relating to the restoration of work hardening of viscous origin, for the cold phase 4***

***C\_M***

***=***

***m5***

***Parameter m relating to the restoration of work hardening of viscous origin, for the hot phase***

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***8.8***

***Key word factor META\_PT***

*Definition of the characteristics used in the modeling of the plasticity of transformation of one material which undergoes metallurgical phase shifts (see [R4.04.02]).*

*i=*

*3*

*4*

*The model is as follows: Pt =*

*K'*

*II*

*F (Zi) < Zi >*

*2 i=1*

### *8.8.1 Syntax*

*/*

*META\_PT*

*=*

*\_F*

*(*

*F1\_K*

*=*

*KF*

*,*

*[R]*

*F2\_K*

*=*

*Kp*

*,*

*[R]*

***F3\_K***

=

***KB***

,

***[R]***

***F4\_K***

=

***Km***

,

***[R]***

***F1\_D\_F\_META = F' F,***

***[function \*\*]***

***F2\_D\_F\_META = F' p,***

***[function \*\*]***

**$F3\_D\_F\_META = F' B,$**

**[function \*\*]**

**$F4\_D\_F\_META = F' m,$**

**[function \*\*]**

)

### **8.8.2 Operands**

**$F1\_K = KF$**

**$F2\_K = Kp$**

**$F3\_K = KB$**

**$F4\_K = km$**

***Ki constants used in the model of plasticity of transformation, for the different ones cold phases. For steel; phase ferritic, perlitic, bainitic and martensitic.***

**$F1\_D\_F\_META=F' F F2\_D\_F\_META=F' p F3\_D\_F\_META=F' B F4\_D\_F\_META=F' m$**

**Functions**

,

***F used in the model of plasticity of transformation, for the different ones***

***I***

***cold phases. For steel; phase ferritic, perlitic, bainitic and martensitic.***

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**8.9**

**Key word factor *META\_RE***

*Definition of the characteristics used in the modeling of the phenomenon of restoration of work hardening of a material which undergoes metallurgical phase shifts (see [R4.04.02]).*

**8.9.1 Syntax**

/

*META\_RE*

=

*\_F*

(

*C\_F1\_THETA = F*

[R]

*C\_F2\_THETA = p*

[R]

$C_{F3\_THETA} = B$   
[R]

$C_{F4\_THETA} = m$   
[R]

$F1\_C\_THETA = F$   
[R]

$F2\_C\_THETA = p$   
[R]



$F3\_C\_THETA = B$   
[R]

$F4\_C\_THETA = m$   
[R]

### 8.9.2 Operands

$C\_F1\_THETA =$   
 $F C\_F2\_THETA = PC. \_F3\_THETA = B C\_F4\_THETA = m$

*Constants characterizing the rate of work hardening transmitted at the time of the transformation of the phase hot C in cold phase. For steel; transformation of austenite into ferrite, pearlite, bainite and martensite. Thus, = 0 correspond to a total restoration and = 1 with one total transmission of work hardening.*

$F1\_C\_THETA =$   
 $F F2\_C\_THETA = p F3\_C\_THETA = B F4\_C\_THETA = m$

*Constants characterizing the rate of work hardening transmitted at the time of the transformation of the phases cold in hot phase. For steel; transformation of ferrite, the pearlite, bainite and of austenite martensite. Thus, = 0 correspond to a total restoration and = 1 with a total transmission of work hardening.*

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## **9 Behaviors *THERMO-HYDRO-MECANIQUE*S and of grounds**

### **9.1**

#### **Single-ended spanner word *COMP\_THM***

*Allows to select as of the definition of material the mixing rate *THM*.*

*The table below specifies the obligatory key words according to the selected mixing rate.*

***LIQU\_SATU***

***LIQU\_GAZ***

***GAS***

***LIQU\_GAZ\_AT***

***LIQU\_VAPE\_GAZ***

***LIQU\_AD\_GAZ\_VAPE LIQU\_VAPE***

***M***

***THM\_INIT***

***O***

***O***

***O***

***O***

***O***

***O***

***O***

***PRE1 O***

***O***

***O***

*O*

*O*

*O*

*O*

*PRE2*

*O*

*O*

*O*

*PORO O*

*O*

*O*

*O*

*O*

*O*

*O*

*TEMP T*

*O*

*O*

*T*

*O*

*O*

*O*

*PRES\_VAPE*

*O*

*O*

*O*

*THM\_DIFFU*

*O*

*O*

*O*

*O*

*O*

*O*

*O*

*R\_GAZ*

*O*

*O*

*O*

*O*

*O*

*RHO O*

*O*

*O*

*O*

*O*

*O*

*O*

*BIOT\_COEF O*

*O*

*O*

*O O*

*O O*

*PESA\_X O*

*O*

*O*

*O*

*O O*

*O*

*PESA\_Y O*

*O*

*O*

*O*

*O O*

*O*

*PESA\_Z O*

*O*

*O*

*O*

*O O*

*O*

*SATU\_PRES*

*O*

*I*

*O*

*O*

*O*

*O*

*O*

*D\_SATU\_PRES*

*O*

*I*

*O*

*O*

*O*

*O*

*PERM\_LIQU*

*I*

*O*

*I*

*O*

*O*

*O*

*O*

*D\_PERM\_LIQU\_SATU*

*O*

*O*

*O*

*O*

*O*

*PERM\_GAZ*

*O*

*O*

*O*

*O*

*D\_PERM\_SATU\_GAZ*

*O*

*O*

*O*

*O*

*D\_PERM\_PRES\_GAZ*

*O*

*O*

*O*

*O*

*FICKV\_T*

*O*

*O*

*FICKV\_PV*

*FICKV\_PG*

*FICKV\_S*

*D\_FV\_T*

*D\_FV\_PG*

*FICKA\_T*

*O*

*FICKA\_PA*

*FICKA\_PL*

*FICKA\_S*

*D\_FA\_T*

*CP T*

*T*

*T*

*T*

*T*

*T*

*T*

*PERM\_IN/PERM\_END*

*O O*

*O O*

*O*

*O*

*O*

*/PERM\_X*

*PERM\_Y*

*PERM\_Z*

*LAMB\_T T*

*T*

*T*

*T*

*T T*

*T*

*LAMB\_S*

*LAMB\_PHI*

*LAMB\_CT*

*D\_LB\_T*

*D\_LB\_S*

*D\_LB\_PHI*

*THM\_LIQU*

*O*

*O*

*O*

*O*

*O*

*O*

*RHO O*

*O*

*O*

*O*

*O*

*O*

*UN\_SUR\_K O*

*O*



*O O*  
*O O*  
*VISC O*  
*O*  
  
*O*  
*O*  
*O*  
*O*  
*D\_VISC\_TEMP O*  
*O*

*O*  
*O*  
*O*  
*O*  
*ALPHA T*  
*T*

*T*  
*T*  
*T*  
*T*  
*CP T*  
*T*

*T*  
*T*  
*T*  
*T*  
*THM\_GAZ*

*O*  
*O*  
*O*  
*O*  
*O*  
  
*MASS\_MOL*  
*O*  
*O*  
*O O O*  
*VISC*

*O*  
*O*  
*O*  
*O*  
*O*

*D\_VISC\_TEMP*

*O*  
*O*  
*O O*  
*O*

*CP*  
*T*  
*T*  
*T*  
*T*  
*T*

*THM\_VAPE\_GAZ*

*O*  
*O*  
*O*  
*MASS\_MOL*

*O O O*  
*CP*

*O*  
*O*  
*O*  
*VISC*

*O*  
*O*  
*O*  
*D\_VISC\_TEMP*

*O*

*O*

*O*

***THM\_AIR\_DISS***

*O*

*CP*

*O*

***COEF\_HENRY***

*O*

*Legends:*

*O*

*: Obligatory key word*

*T*

*: Obligatory key word in Thermics*

*: Useless key word for this type of mixing rate*

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*Syntax is as follows:*

*COMP\_THM =  
^LIQU\_SATU `,*

*^LIQU\_GAZ `,*

*^GAS `,*

*^LIQU\_GAZ\_ATM `,*

*^LIQU\_VAPE\_GAZ `,*

*^LIQU\_AD\_GAZ\_VAPE `,*

*^LIQU\_VAPE `,*

*^LIQU\_SATU\_GAT `,*

*^LIQU\_NSAT\_GAT `,*

*/*

*`LIQU\_AD\_GAZ\_VAPE `*

*,*

## **9.2**

**Key word factor THM\_INIT**

*For all the ThermoHydroMécaniques behaviors, it makes it possible to describe the initial state of the*

*structure*

(cf [R7.01.11] and [R7.01.14]).

### **9.2.1 Syntax**

***THM\_INIT = \_F***

(

***TEMP***

=

***temp***

,

**[R]**

***PRE1***

= ***pre1***,

**[R]**

***PRE2***

=

***pre2***

,

**[R]**

***PORO***

=

***poro***

,

**[R]**

***PRES\_VAPE***

=

***pvap***

, **[R]**

***DEGR\_SATU***

=

*ds, [R]*

*PRES\_ATMO*

=

*patm*

*, [R]*

)

*For including/understanding these data well, it is necessary to distinguish the unknown factors with the nodes, which we call*

*{ }*

*U ddl and the values defined under key word THM\_INIT which we call pref and T ref.*

*U*

*X*

*U*

*y*

*{ }*

*U ddl = U*

*Z*

*ddl*

*PRE1*

*ddl*

*PRE 2*

*The significance of unknown factors PRE1 and PRE2 varies according to the models. By noting p pressure*

*W*

*of water, p pressure of dissolved air, p*

*p = p + p, p pressure of air*

*AD*

*L pressure of liquid L*

*W*

*AD*

*have*

*dryness pvp the p, steam pressure = p + p total pressure of gas and p = p - p*

*G*

*have*

*vp*

*C*

*G*

*L*

*capillary pressure (also called suction), one has the following significances of unknown factors PRE1 and*

*PRE2:*

*Behavior LIQU\_SATU LIQU\_GAZ\_ATM GAS LIQU\_VAPE\_GAZ LIQU\_GAZ LIQU\_AD\_GA KIT*

*Z\_VAPE*

*PRE1*

*pl*

*- pl*

*pg p = p - p*

*C*

*G*

*L*

*p = p - p*

*C*

*G*

*L p = p - p*

*C*

*G*

*L*

*PRE2*

*pg*

*pg*

*pg*

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*One will be able to refer to [§ 3.3.2.3] of the documentation of order STAT\_NON\_LINE [U4.51.03].*

*One then defines the “total” pressures and the temperature by:*

*p*

*pddl*

*pref*

;

*T*

*Tddl Tref*

=

+

=

+

*Values written by*

*ddl*

*ddl*

*IMPR\_RESU are the nodal unknown factors p*

*and T*

*. In the same way them*

*boundary conditions must be expressed compared to the nodal unknown factors.*



*On the other hand, in fact the pressures and the total air temperature are used in the laws of*

*p  
R  
D  
dp  
behavior*

*=  
T  
L  
L  
=  
-*

*for perfect gases,  
3 dT for the liquid and in  
M*

*K  
L  
L  
L  
relation capillary saturation/pressure.*

*Let us note that the nodal values can be initialized by key word ETAT\_INIT of the order  
STAT\_NON\_LINE.*

*The user must be very careful in the definition of the values of THM\_INIT: indeed, the definition of  
several materials with values different from the quantities defined under THM\_INIT leads to  
discontinuous values initial of the pressure and the temperature, which is not in fact not compatible  
with the general treatment which is made of these quantities. We thus advise with the user  
following step:*

*.  
if at the beginning, there is a uniform field of pressure or of temperature, one returns it directly  
by key word THM\_INIT,*

*.  
if there is a nonuniform field, one enters for example a reference by key word THM\_INIT  
order initial DEFI\_MATERIAU, and values compared to this reference by  
key word ETAT\_INIT of order STAT\_NON\_LINE.*

### **9.2.2 Operand TEMP**

*Temperature of reference ref.*

*T*

*The value of the temperature of reference entered behind key word TEMP\_REF of the order AFFE\_MATERIAU is ignored.*

### **9.2.3 Operand**

**PRE1**

*For the behaviors: LIQU\_SATU, ELAS\_THM and pressure of liquid of reference.*

*For the behavior: GAS pressure of standard gas.*

*For the behavior: LIQU\_GAZ\_ATM pressure of liquid of changed reference of sign.*

*For the behaviors: LIQU\_VAPE\_GAZ, LIQU\_AD\_GAZ\_VAPE and capillary LIQU\_GAZ pressure of reference.*

### **9.2.4 Operand**

**PRE2**

*For the behaviors: LIQU\_VAPE\_GAZ, LIQU\_AD\_GAZ\_VAPE and LIQU\_GAZ and pressure of gas of reference.*

### **9.2.5 Operand**

**PORO**

*Initial porosity.*

### **9.2.6 Operand**

**PRES\_VAPE**

*For the behaviors: LIQU\_VAPE\_GAZ, LIQU\_AD\_GAZ\_VAPE and LIQU\_GAZ and pressure of initial vapor.*

### **9.2.7 Operand**

**DEGR\_SATU**

*For all the unsaturated behaviors: initial degree of saturation.*

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### **9.3**

**Key word factor THM\_LIQU**

*This key word relates to all behaviors THM utilizing a liquid (cf [R7.01.11]).*

#### **9.3.1 Syntax**

**THM\_LIQU = \_F**

(

**RHO**

=

**rho**

,

**[R]**

**UN\_SUR\_K**

=

**usk**

,

**[R]**

**ALPHA**

=

**alp**

,

**[R]**

**CP**

=

**CP**

,

**[R]**

**VISC =**

**VI**

,

**[function**

**\*\*]**

**D\_VISC\_TEMP = dvi,**

**[function \*\*]**

)

### **9.3.2 Operand**

**RHO**

**Density of the liquid for the pressure defined under key word PRE1 of the key word factor THM\_INIT.**

### **9.3.3 Operand**

**UN\_SUR\_K**

**Opposite of the compressibility of the liquid: Kl.**

### **9.3.4 Operand ALPHA**

**Dilation coefficient of the liquid L**

**If pl indicates the pressure of the liquid, L its density and T the temperature, the behavior D**

*dp*

*liquid is:*

*L*

*L*

*=*

*-*

*3 dT*

*K*

*L*

*L*

*L*

### *9.3.5 Operand CP*

*Specific heat with constant pressure of the liquid.*

### *9.3.6 Operand VISC*

*Viscosity of the liquid. Function of the temperature.*

### *9.3.7 Operand*

*D\_VISC\_TEMP*

*Derived from the viscosity of the liquid compared to the temperature. Function of the temperature.*

*The user*

*must ensure coherence with the function associated with VISC.*

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## **9.4**

### **Key word factor *THM\_GAZ***

*This key word factor relates to all behaviors THM utilizing a gas (cf [R7.01.11]). For the behaviors utilizing at the same time a liquid and a gas, and when one takes into account the evaporation of the liquid, the coefficients indicated here relate to dry gas. Properties of vapor are indicated under key word *THM\_VAPE\_GAZ*.*

#### **9.4.1 Syntax**

***THM\_GAZ = \_F (***

***MASS\_MOL***

***=***

***Mgs***

***,***

***[R]***

***CP***

***=***

***CP***

***,***

***[R]***

***VISC =***

***VI***

***,***

***[function***

***\*\*]***

***D\_VISC\_TEMP***

***=***

***dvi***

***,***

***[function***

***\*\*]***

)

### **9.4.2 Operand**

#### **MASS\_MOL**

*Mass molar dry gas. M gs*

*If pgs indicates the pressure of dry gas, gs its density, R the constant of perfect gases and*

*pgs*

*RT*

*T the temperature, the reaction of dry gas is:*

*=*

*.*  
*M*

*gs*

*gs*

### **9.4.3 Operand CP**

*Specific heat with constant pressure of dry gas.*

### **9.4.4 Operand**

#### **VISC**

*Viscosity of dry gas. Function of the temperature.*

### **9.4.5 Operand**

#### **D\_VISC\_TEMP**

*Derived compared to the temperature from viscosity from dry gas. Function of the temperature.*

*The user must ensure coherence with the function associated with VISC.*

## **9.5**

### **Key word factor THM\_VAPE\_GAZ**

*This key word factor relates to all behaviors THM utilizing at the same time a liquid and one gas, and fascinating of account the evaporation of the liquid (cf [R7.01.11]). Coefficients indicated here relate to the vapor.*

### **9.5.1 Syntax**

***THM\_VAPE\_GAZ = \_F***

(

***MASS\_MOL =***

***m***

,

***[R]***

***CP***

=

***CP***

,

***[R]***

***VISC =***

***VI***

,

***[function***

***\*\*]***

***D\_VISC\_TEMP = dvi,***

***[function \*\*]***

)

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### **9.5.2 Operand** **MASS\_MOL**

**Mass molar vapor.  $Mvp$**   
**If  $p$  is  $Mvp$  indicates the pressure of the vapor,  $\rho$  its density,  $R$  the constant of perfect gases**  
 **$p/\rho$**   
 **$RT$**   
**and  $T$  the temperature, the behavior of the vapor is:**  
**=**

**$M$**   
 **$\rho$**   
 **$\rho$**   
**9.5.3 Operand**  
**CP**

**Specific heat with constant pressure of the vapor.**

### **9.5.4 Operand** **VISC**

**Viscosity of the vapor. Function of the temperature.**

### **9.5.5 Operand** **D\_VISC\_TEMP**

**Derived compared to the temperature from viscosity from the vapor. Function of the temperature.**  
**The user must ensure coherence with the function associated with VISC.**

## **9.6** **Key word factor THM\_AIR\_DISS**

**This key word factor relates to fascinating behavior THM THM\_AD\_GAZ\_VAPE of account**

*dissolution of the air in the liquid (cf [R7.01.11]). The coefficients indicated here relate to the air dissolved.*

### **9.6.1 Syntax**

**THM\_AD\_GAZ\_VAPE = \_F**

(

**CP**

=

**CP**

,

**[R]**

**COEF\_HENRY =**

**H**

,

**[function**

**\*\*]**

)

### **9.6.2 Operand**

**CP**

*Specific heat with constant pressure of the dissolved air.*

### **9.6.3 Operand**

**COEF\_HENRY**

*Constant of Henry K, allowing to connect the molar concentration of dissolved air of C (moles/m<sup>3</sup>) with*

**H**

**AD**

*pressure of dry air:*

**p**

*ol*  
*have*  
*C =*

*AD*  
*K H*

#### **9.6.4 Operand** ***D\_VISC\_TEMP***

***Derived compared to the temperature from viscosity from the vapor. Function of the temperature. The user must ensure coherence with the function associated with VISC.***

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**9.7**  
***Key word factor THM\_DIFFU***

***Obligatory for all behaviors THM (cf [R7.01.11]). The user must ensure himself of coherence of the functions and their derivative.***

#### **9.7.1 Syntax**

***THM\_DIFFU = \_F***  
***(***

***R\_GAZ***

=

***rgaz***

,

***[R]***

***RHO***

=

***rho***

,

***[R]***

***CP***

=

***CP***

,

***[R]***

***BIOT\_COEF***

=

***bio***

,

***[R]***

***SATU\_PRES***

=

***sp***

,

***[function]***

***D\_SATU\_PRES***

=

***dsp***

,

***[function]***

***PESA\_X***

=  
*px*  
,

*PESA\_Y*  
=  
*py*  
,

*PESA\_Z*  
=  
*pz*  
,

*PERM\_IN* =  
*perm*  
,

*PERMIN\_X*  
=  
*OX*,

*PERMIN\_Y*  
=  
*OX*,

*PERMIN\_Z*  
=  
*OX*,

*PERM\_LIQU*

=  
*perml,*  
*[function]*

*D\_PERM\_LIQU\_SATU*  
=  
*dperm,*  
*[function]*

*PERM\_GAZ*  
=  
*permg,*  
*[function]*

*D\_PERM\_SATU\_GAZ*  
=  
*dpsg*  
,  
*[function]*

*D\_PERM\_PRES\_GAZ*  
=  
*dppg*  
,  
*[function]*

*FICKV\_T =*  
*fvt*  
,  
*[function]*

*FICKV\_PV =/*  
*fvpv*  
, *[function]*  
*/*  
*1*  
,  
*[DEFECT]*

**FICKV\_PG =/fvpg, [function]**

/

**1**

,  
**[DEFECT]**

**FICKV\_S =/fvs**

,  
**[function]**

/

**1**

,  
**[DEFECT]**

**D\_FV\_T**

=

/

**dfvt**

,  
**[function]**

/

**0**

,  
**[DEFECT]**

**D\_FV\_PG =/dfvpg, [function]**

/

**0**

,  
**[DEFECT]**

**FICKA\_T =**  
**conceited person**

,  
**[function]**

**FICKA\_PA =/fapv, [function]**

/

**1**

,  
**[DEFECT]**

**FICKA\_PL =/fapg, [function]**

/

**1**

,  
**[DEFECT]**

**FICKA\_S =/fas**

**, [function]**

/

**1**

,  
**[DEFECT]**

**D\_FA\_T**

=

/

**dfat**

,  
**[function]**

/

**0**

,  
**[DEFECT]**

**LAMB\_T**

**=/lambt**

**, [function]**

/

**0**

**[DEFECT]**

**LAMB\_S**

**=/lambS**

**, [function]**

/

**1**

,



**[DEFECT]**

**LAMB\_PHI** =/lambp, [function]

/  
1

,  
**[DEFECT]**

**LAMB\_CT** =/lambct

, [function]  
/  
0

,  
**[DEFECT]**

**D\_LB\_S**

=/dlambs  
, [function]  
/  
0

,  
**[DEFECT]**

**D\_LB\_T**

=/dlambt  
, [function]  
/  
0

,  
**[DEFECT]**

**D\_LB\_PHI** =/dlambp

, [function]

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**Key J.P. LEFEBVRE**

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**/**  
**0**  
**,**  
**[DEFECT]**

**SIGMA\_T =**  
**St**  
**,**  
**[function]**

**D\_SIGMA\_T**  
**=**  
**dst**  
**,**  
**[function]**

**PERM\_G\_INTR**  
**=**  
**pgi**  
**,**  
**[function]**

**CHAL\_VAPO**  
**=**  
**cv**  
**,**

**[function  
\*\*]**

**EMMAG  
=  
EM  
,**  
**[R]**

)

### **9.7.2 Operand R\_GAZ**

*Constant of perfect gases.*

### **9.7.3 Operand RHO**

*For the hydraulic behaviors homogenized density.*

**Note:**

*For modelings utilizing it thermal, one uses also the density of solid matter constituents, which one reads under key word RHO of the key word factor ELAS.*

### **9.7.4 Operand CP**

*For the thermal behaviors specific heat with constant constraint of the solid alone.*

### **9.7.5 Operand BIOT\_COEF**

*Coefficient of Biot.*

### **9.7.6 Operand SATU\_PRES**

*For the unsaturated material behaviors (LIQU\_VAPE\_GAZ, LIQU\_AD\_GAZ\_VAPE, LIQU\_GAZ, LIQU\_GAZ\_ATM), isotherm of saturation function of the capillary pressure.*

### **9.7.7 Operand**

## ***D\_SATU\_PRES***

***For the unsaturated material behaviors (LIQU\_VAPE\_GAZ, LIQU\_AD\_GAZ\_VAPE, LIQU\_GAZ, LIQU\_GAZ\_ATM), derived from saturation compared to the pressure.***

### ***9.7.8 Operand***

#### ***PESA\_X***

***Gravity according to X, used only if the modeling chosen in AFFE\_MODELE includes 1 or 2 variable of pressure.***

### ***9.7.9 Operand PESA\_Y***

***Gravity according to y, used only if the modeling chosen in AFFE\_MODELE includes 1 or 2 variable of pressure.***

### ***9.7.10 Operand PESA\_Z***

***Gravity according to Z, used only if the modeling chosen in AFFE\_MODELE includes 1 or 2 variable D pressure.***

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### ***9.7.11 Operand PERM\_IN***

***Intrinsic permeability: function of porosity (in the isotropic case).***

***The permeability to the traditional direction K, whose dimension is that a speed is calculated way***

*following:*

*K K*

*K*

*int*

*rel*

*=*

*G where K*

*L*

$\mu$

*int is the intrinsic permeability, Krel the relative permeability,  $\mu$  viscosity, L density of the liquid and G the acceleration of gravity. Kint is in fact one diagonal tensor, in the isotropic case its three components are equal to the well informed value.*

#### *9.7.12 Operand PERMIN\_X*

*In the orthotropic case, component in X of the intrinsic tensor of permeability. In this case, PERMIN\_Y and PERMIN\_Z are obligatory.*

#### *9.7.13 Operand PERMIN\_Y*

*In the orthotropic case, component in there of the intrinsic tensor of permeability.*

#### *9.7.14 Operand PERMIN\_Z*

*In the orthotropic case, component in Z of the intrinsic tensor of permeability.*

#### *9.7.15 Operand PERM\_LIQU*

*Permeability relating to the liquid: function of saturation.*

#### *9.7.16 Operand D\_PERM\_LIQU\_SATU*

*Derived from the Permeability relating to the liquid compared to saturation: function of saturation.*

#### *9.7.17 Operand PERM\_GAZ*

*Permeability relating to gas: function of the saturation and the gas pressure.*

#### *9.7.18 Operand D\_PERM\_SATU\_GAZ*

*Derived from the permeability to gas compared to saturation: function of the saturation and of gas pressure.*

#### *9.7.19 Operand D\_PERM\_PRES\_GAZ*

*Derived from the permeability to gas compared to the gas pressure: function of the saturation and of*

*gas pressure.*

### **9.7.20 Operand FICKV\_T**

*For behaviors LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE, coefficient of Fick function of temperature for the diffusion of the vapor in the gas mixture. The coefficient of Fick which can be function of saturation, the temperature, the pressure of gas and the steam pressure, one defines it like a product of 4 functions: FICKV\_T, FICKV\_S, FICKV\_PG, FICKV\_VP. In the case of LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE, only FICKV\_T are obligatory.*

### **9.7.21 Operand FICKV\_S**

*For behaviors LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE, coefficient of Fick function of saturation for the diffusion of the vapor in the gas mixture.*

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### **9.7.22 Operand *FICKV\_PG***

*For behaviors LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE, coefficient of Fick function of gas pressure for the diffusion of the vapor in the gas mixture.*

### **9.7.23 Operand *FICKV\_PV***

*For behaviors LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE, coefficient of Fick function of steam pressure for the diffusion of the vapor in the gas mixture.*

### **9.7.24 Operand *D\_FV\_T***

*For behaviors LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE, derived from coefficient *FICKV\_T* compared to the temperature.*

### **9.7.25 Operand *D\_FV\_PG***

*For behaviors LIQU\_VAPE\_GAZ and LIQU\_AD\_GAZ\_VAPE, derived from coefficient *FICKV\_PG* compared to the gas pressure.*

### **9.7.26 Operand *FICKA\_T***

*For the behavior LIQU\_AD\_GAZ\_VAPE, coefficient of Fick function of the temperature for diffusion of the air dissolved in the liquid mixture. The coefficient of Fick which can be a function of saturation, the temperature, the pressure of dissolved air and the pressure of liquid, one defines it as one product of 4 functions*

*: *FICKA\_T*, *FICKA\_S*, *FICKV\_PA*, *FICKV\_PL*. In the case of *LIQU\_AD\_GAZ\_VAPE*, only *FICKA\_T* are obligatory.*

### **9.7.27 Operand FICKA\_S**

*For the behavior LIQU\_AD\_GAZ\_VAPE, coefficient of Fick function of saturation for diffusion of the air dissolved in the liquid mixture.*

### **9.7.28 Operand FICKA\_PA**

*For the behavior LIQU\_AD\_GAZ\_VAPE, coefficient of Fick function of the pressure of dissolved air for the diffusion of the air dissolved in the liquid mixture.*

### **9.7.29 Operand FICKA\_PL**

*For the behavior LIQU\_AD\_GAZ\_VAPE, coefficient of Fick function of the pressure of liquid for the diffusion of the air dissolved in the liquid mixture.*

### **9.7.30 Operand D\_FA\_T**

*For behavior LIQU\_AD\_GAZ\_VAPE, derived from coefficient FICKA\_T compared to temperature.*

### **9.7.31 Operand LAMB\_T**

*For multiplicative behavior THER\_POLY left the thermal conductivity of the mixture depending on the temperature (cf [R7.01.11]).*

*For thermal behavior THER\_HOMO conductivity of the mixture.*

*This operand is obligatory in the thermal case.*

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### **9.7.32 Operand LAMB\_S**

*For multiplicative behavior THER\_POLY left (equal to 1 per defect) conductivity thermics of the mixture depend on saturation (cf [R7.01.11]).*

### **9.7.33 Operand LAMB\_PHI**

*For multiplicative behavior THER\_POLY left (equal to 1 per defect) conductivity thermics of the mixture depend on porosity (cf [R7.01.11]).*

### **9.7.34 Operand LAMB\_CT**

*For behavior THER\_POLY left the thermal conductivity of the constant mixture and additive (cf [R7.01.11]). This constant is equal to zero per defect.*

### **9.7.35 Operand D\_LB\_T**

*For behavior THER\_POLY derived from the part of thermal conductivity of the mixture depending on the temperature compared to the temperature.*

*For behavior THER\_HOMO derived from the thermal conductivity of the mixture compared to temperature.*

### **9.7.36 Operand D\_LB\_S**

*For behavior THER\_POLY derived from the part of thermal conductivity of the mixture depending on saturation.*

### **9.7.37 Operand D\_LB\_PHI**

*For behavior THER\_POLY derived from the part of thermal conductivity of the mixture depending on porosity.*

### **9.7.38 Operand EMMAG**

*Coefficient of storage. This coefficient is taken into account only in the cases of modeling with mechanics.*

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9.8

*Key word factor* **SURF\_ETAT\_SATU (cf [R7.01.14])**

**9.8.1 Syntax**

*SURF\_ETAT\_SATU:*

*\_F (*

*E\_CHAR*

:

*EC. [R]*

*E\_DECHAR*

:

*Edc*

*[R]*

*XN*

:

*xn [R]*

*RF*  
:  
*RF [R]*

*EV\_KB*  
:  
*evkb*  
*[R]*

*EV\_XM*  
:  
*evxm*  
*[R]*

*D\_E\_T*  
:  
*det*  
*[R]*

*ALPHA0*  
:  
*a0 [R]*

*ALPHA1*  
:  
*a1 [R]*

*ALPHA2*

:

*a2 [R]*

*ALPHA3*

:

*a3 [R]*

*ALPHA\_S:*

*have [R]*

*ANG\_FRT:*

*ang*

*[R]*

*COHE:*

*Co [R]*

*RESI\_TRAC*

:

*rtrac [R]*

)

### **9.8.2 Operand** ***E\_CHAR***

*Coefficient of the load module.*  
*Value recommended in unit IF between 50 and 500.*

### **9.8.3 Operand** ***E\_DECHAR***

*Coefficient of the module of unloading.*  
*Value recommended in unit IF between 50 and 500.*

### **9.8.4 Operand** ***EV\_KB***

*Coefficient of the voluminal modulus of deformation.*  
*Value recommended in unit IF between 100 and 1500.*

### **9.8.5 Operand** ***RF***

*Coefficient of the hyperbolic law.*  
*Value recommended in unit IF between 0,5 and 0,95.*

### **9.8.6 Operand** ***XN***

*Exhibitor of the nonlinear law (Dependence of the module to containment).*  
*Value recommended in unit IF between 0 and 1.*

### **9.8.7 Operand** ***EV\_XM***

*Exhibitor of the law of surface of state of the index of the vacuums.*  
*Value recommended in unit IF between 0 and 1.*

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### **9.8.8 Operand**

#### ***D\_E\_T***

*Variation of the module D Young with the temperature.  
Value recommended in unit IF between 1.E-4 and 1.E-5.*

### **9.8.9 Operand**

#### ***ANG\_FRT***

*Angle of friction of the ground.  
Value recommended between 0 and 0,25 degrees.*

### **9.8.10 Operand COHE**

*Cohesion of the ground.  
Value recommended in unit IF between 1 and 10 MPa.*

### **9.8.11 Operand RESI\_TRAC**

*Resistance in traction of the ground.*

### **9.8.12 Operand ALPHA0**

*Constant for the dependence compared to the temperature of the surface of state of the index of the vacuums.*

### **9.8.13 Operand ALPHA1**

*Constant for the dependence compared to the temperature of the surface of state of the index of the vacuums.*

### **9.8.14 Operand ALPHA2**

*Constant for the dependence compared to the temperature of the surface of state of the index of the vacuums.*

### **9.8.15 Operand ALPHA3**

*Constant for the dependence compared to the temperature of the surface of state of the index of the vacuums.*

### **9.8.16 Operand ALPHA\_S**

*Dilation coefficient of the solid matter constituents.*

*Value recommended in unit IF between 3.E-5 and 5.E-5.*

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## **9.9**

**Key word factor SURF\_ETAT\_NSAT (cf [R7.01.14])**

### **9.9.1 Syntax**

*SURF\_ETAT\_NSAT:*

*\_F (*

*E\_CHAR*

:

*EC. [R]*

*E\_DECHAR*

:  
*Edc*  
*[R]*

*XN*

:  
*xn [R]*

*RF*

:  
*RF [R]*

*EV\_KB*

:  
*evkb*  
*[R]*

*EV\_XM*

:  
*evxm*  
*[R]*

*EV\_A:*

*eva*  
*[R]*



*EV\_B:*

*evb*

*[R]*

*EV\_CT*

:

*evct*

*[R]*

*EV\_SIGB:*

*evsb*

*[R]*

*D\_E\_T*

:

*det*

*[R]*

*D\_E\_SUCC*

:

*[R]*

*ANG\_FRT:*

*ang*

*[R]*

*COHE:*

*cohe*

*[R]*

*D\_COEH\_SUCC:*

*DCS [R]*

*ANG\_FRT\_ULT:*

*afu [R]*

*SUCC\_ULTM*

*:*

*known [R]*

*RESI\_TRAC*

*:*

*rt [R]*

*A\_SURF\_SATU:*

*has*

*[R]*

*B\_SURF\_SATU:*

*B*

*[R]*

*C\_SURF\_SATU:*

*C*

*[R]*

*D\_SURF\_SATU:*

*D*

*[R]*

)

### **9.9.2 Operand**

***E\_CHAR***

*Coefficient of the load module.*

*Value recommended in unit IF between 50 and 500.*

### **9.9.3 Operand**

***E\_DECHAR***

*Coefficient of the module of unloading.*

*Value recommended in unit IF between 50 and 500.*

### **9.9.4 Operand**

***RF***

*Coefficient of the hyperbolic law.*

*Value recommended in unit IF between 0,5 and 0,95.*

### **9.9.5 Operand**

***XN***

*Exhibitor of the nonlinear law (Dependence of the module to containment).*

*Value recommended in unit IF between 0 and 1.*

### **9.9.6 Operand *EV\_KB***

*Coefficient of the voluminal modulus of deformation.  
Value recommended in unit IF between 100 and 1500.  
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### **9.9.7 Operand**

***EV\_XM***

*Exhibitor of the law of surface of state of the index of the vacuums.*

*Value recommended in unit IF between 0 and 1.*

### **9.9.8 Operand**

***EV\_A***

*Coefficient has surface D index of the vacuums.*

### **9.9.9 Operand *EV\_B***

*Coefficient B of surface D index of the vacuums.*

### **9.9.10 Operand *EV\_CT***

*Coefficient C of surface D index of the vacuums.*

### **9.9.11 Operand *EV\_SIGB***

*Coefficient sigma of surface D index of the vacuums.*

### **9.9.12 Operand D\_E\_T**

*Variation of the module D Young with the temperature.  
Value recommended in unit IF between 1.E-4 and 1.E-5.*

### **9.9.13 Operand D\_E\_SUCC**

*Variation of the module D Young with suction.*

### **9.9.14 Operand ANG\_FRT**

*Angle of friction of the ground.  
Value recommended between 0 and 0,25 degrees.*

### **9.9.15 Operand ANG\_FRT\_ULT**

*Ultimate angle of friction.*

### **9.9.16 Operand COHE**

*Cohesion of the ground.  
Value recommended in unit IF between 1 and 10 MPa.*

### **9.9.17 Operand D\_COEH\_SUCC**

*Variation of cohesion with suction.*

### **9.9.18 Operand RESI\_TRAC**

*Resistance in traction of the ground.*

### **9.9.19 Operand SUCC\_ULTM**

*Ultimate suction.*

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### **9.9.20 Operand A\_SURF\_SATU**

*Coefficient has surface of state of saturation.*

### **9.9.21 Operand B\_SURF\_SATU**

*Coefficient B of the surface of state of saturation.*

### **9.9.22 Operand C\_SURF\_SATU**

*Coefficient C of the surface of state of saturation.*

### **9.9.23 Operand D\_SURF\_SATU**

*Coefficient D of the surface of state of saturation.*

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## **9.10 Key word factor CAM\_CLAY\_THM (cf [R7.01.14])**

### **9.10.1 Syntax**

*CAM\_CLAY\_THM: \_F (*

*NAKED*

*:*

*naked [R]*

*LAMBDA*

*:*

*lambda*

*[R]*

*KAPA:*

*kapa*

*[R]*

*M:*

*m*

*[R]*

*PRES\_CRIT*

*:*

*PC [R]*

*GAMA:*

*gama*

*[R]*

*A0\_PC*

:

*a0 [R]*

*A1\_PC*

:

*a1 [R]*

*A2\_PC*

:

*a2 [R]*

*ALPHA0\_PC*

:

*a10*  
*[R]*

*ALPHA1\_PC*

:

*a11*  
*[R]*

*ALPHA2\_PC*

:

*a12*  
*[R]*

*ALPHA3\_PC*

:

*a13*  
*[R]*



**ALPHA\_S:**

*als*

*[R]*

)

### **9.10.2 Operand NAKED**

*Poisson's ratio.*

### **9.10.3 Operand LAMBDA**

*Slope of the right-hand side of loading.*

*Value recommended in unit IF between 0.1 and 0.4.*

### **9.10.4 Operand KAPA**

*Slope of the right-hand side of unloading.*

*Value recommended in unit IF between 0.01 and 1.*

### **9.10.5 Operand PRES\_CRIT**

*Effective critical pressure.*

### **9.10.6 Operand M**

*Slope of the critical line of state.*

*Value recommended in unit IF between 0.8 and 0.9.*

### **9.10.7 Operand GAMA**

*Ecs 1*

*Ecs being the index of the vacuums for 1 MPa of containment.*

*The value recommended for Ecs in unit IF is between 1 and 3.*

### **9.10.8 Operand A0\_PC**

*Coefficient of definition of the constraint of preconsolidation PC of the surface of load.*

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### **9.10.9 Operand A1\_PC**

*Coefficient of definition of the constraint of preconsolidation PC of the surface of load.*

### **9.10.10 Operand A2\_PC**

*Coefficient of definition of the constraint of preconsolidation PC of the surface of load.*

### **9.10.11 Operand ALPHA0\_PC**

*Coefficient of definition of the constraint of preconsolidation PC of the surface of load.*

### **9.10.12 Operand ALPHA1\_PC**

*Coefficient of definition of the constraint of preconsolidation PC of the surface of load.*

### **9.10.13 Operand ALPHA2\_PC**

*Coefficient of definition of the constraint of preconsolidation PC of the surface of load.*

### **9.10.14 Operand ALPHA3\_PC**

*Coefficient of definition of the constraint of preconsolidation PC of the surface of load.*

### **9.10.15 Operand ALPHA\_S**

*Dilation coefficient of the solid matter constituents.*

*Value recommended in unit IF between 3.e-5 and 5.e-5.*

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## **9.11 Word**

**key**

**CAM\_CLAY**

*The Camwood-Clay model is an elastoplastic model used in soil mechanics and is especially adapted to argillaceous materials. The model presented here is called modified Camwood-Clay.*

*document [R7.01.14] described the corresponding equations. This model can be used independently of behaviors THM. The elastic characteristics must be defined under key word ELAS.*

### **9.11.1 Syntax**

**CAM\_CLAY = \_F**

(

**LAMBDA**

=

*lambda*

,  
[R]

*KAPA*  
=  
*kapa*  
,  
[R]

*M*  
=  
*m*  
,  
[R]

*PORO*  
=  
*poro*  
,  
[R]

*PRES\_CRIT*  
=  
*prescr*  
, [R]

*Pa*  
=  
*Pa*  
,  
[R]

)

### **9.11.2 Operands LAMBDA**

*Coefficient of compressibility (plastic slope in a hydrostatic test of compression).*

### **9.11.3 Operands KAPA**

*Elastic coefficient of swelling (elastic slope in a hydrostatic test of compression).*

### **9.11.4 Operands M**

*Critical line slope of state.*

### **9.11.5 Operands PORO**

*Initial porosity. If CAM\_CLAY is used under RELATION\_KIT, key word PORO indicated under CAM\_CLAY and under THM\_INIT must be the same one.*

### **9.11.6 Operands PRES\_CRIT**

*The critical pressure equalizes with half of the pressure of consolidation.*

### **9.11.7 Operands Pa**

*Initial pressure corresponding to initial porosity generally equal to the atmospheric pressure.*

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### **9.12 Key word factor CJS**

*The law (Cambou, Jaffani, Sidoroff) is a law of behavior for the grounds. It comprises three mechanisms, one corresponds to nonlinear elasticity, another corresponds to a plasticization for isotropic states of stresses, and the third mechanism corresponds to a dependent plasticization in a state of stress déviatoire. The document [R7.01.13] described with precision the equations corresponding.*

*The elastic characteristics must be defined under key word ELAS.*

*Law CJS covers three possible forms (CJS1, CJS2 and CJS3), according to whether one authorizes or not the activation of the nonlinear mechanisms.*

*Table Ci below gives the mechanisms activated for three levels CJS1, CJS2 and CJS3:*

***Elastic mechanism isotropic plastic Mechanism***

***Plastic mechanism***

***déviatoire***

***CJS1***

*linear*

*not activated*

*activated, perfect plasticity*

***CJS2***

*nonlinear*

*activated*

*activated, isotropic work hardening*

***CJS3***

*nonlinear*

*activated*

*activated, kinematic work hardening*

**Note:**

*By adopting the correspondence of the parameters for the limiting states, it is possible to use behavior CJS1 to model a law of Mohr Coulomb in soil mechanics.*

**9.12.1 Syntax**

*CJS = \_F (*

*BETA\_CJS = beta,*  
*[R]*

*RM*  
*=*  
*rm*  
*,*  
*[R]*

*N\_CJS =*  
*N*  
*,*  
*[R]*

*KP*  
*=*  
*kp*  
*,*  
*[R]*

*RC*  
*=*

*rc*  
,  
*[R]*

*A\_CJS =*  
*has*  
,  
*[R]*

*B\_CJS =*  
*B*  
,  
*[R]*

*C\_CJS =*  
*C*  
,  
*[R]*

*GAMMA\_CJS*  
*=*  
*G*  
,  
*[R]*

*MU\_CJS*  
*=*  
*driven*  
,  
*[R]*

*PCO*  
*=*  
*pco*



,  
[R]

*Pa*  
=  
*Pa*  
,  
[R]

*Q\_INIT*  
=  
*Q*  
,  
[R]

*R\_INIT*  
=  
*R*  
,  
[R]

)  
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*The various coefficients are to be informed or not according to the level which one wants to use, in accordance with table Ci below (F for optional, O for obligatory and nothing for without object).*

*Symbol*

*Q\_init*

*R\_init*

*N*

*Kp*

*Rc*

*With*

*Key word*

*Q\_INIT R\_INIT N\_CJS*

*KP GAMMA\_CJS BETA\_CJS RC*

*A\_CJS*

*CJS1 F O O*

*CJS2 F F O*

*O O O O O*

*CJS3 F O*

*O O O O*

*Symbol*

*B*

*Rm*

$\mu$

*pco*

*C*

*Pa*

*Key word*

*B\_CJS RM M\_CJS*

*PCO C\_CJS PA*  
*CJS1 O*  
*O*  
*CJS2 O*  
*O*  
*CJS3 O O O O O*  
*O*

*We draw the attention of the user to the fact that, for the same material, the same coefficient can take different values according to the level used. The level used is never indicated, it is indicated by the fact that certain coefficients are indicated or not.*

*In addition, key word ELAS must be obligatorily indicated when one uses law CJS (under one of its three levels). The definition of the Young modulus and the Poisson's ratio make it possible to calculate the coefficients  $K_{eo}$  and  $G_o$ .*

### **9.12.2 Operand BETA\_CJS**

*For levels CJS1, CJS2 CJS3.*

*Parameter. Control the plastic variation of volume in the mechanism déviatoire.*

### **9.12.3 Operand RM**

*For levels CJS1, CJS2 CJS3.*

*Maximum value of opening of the field of reversibility déviatoire.*

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### **9.12.4 Operand N\_CJS**

*For levels CJS2 CJS3.*

*Control the dependence of the modulus of elasticity with the average constraint.*

*I + Q*  
*N*

*I + Q*  
*N*

*K = K E*  
*1*

*init*

*1*

*init*

*O*

*G = G*

*3 P*

*O*

*has*

*3 Pa*

### **9.12.5 Operand KP**

*For levels CJS2 CJS3.*

*Modulate plastic compressibility.*

*Q*  
*N*

*&Q = K p &q = K p*

*Iso*

*O*

*&q*

*Iso*

*Pa*

### **9.12.6 Operand RC**

*For levels CJS2 CJS3*

*Value criticizes variable R:*

*dp*

*S*

*ij*

*S &ij*

*E*

*&dp = -*

*II*

*v*

*-*

*C*

*I*

*S*

*S*

*II*

*II*

*R I*

*Sc*

*C*

*II = -*

*I*

*(*

*H S)*

### ***9.12.7 Operand A\_CJS***

*For levels CJS2.*

*Control the isotropic work hardening of the mechanism déviatoire;*

*WITH R R*

*R*

*m*

*= R +*

*With R*

*m*

### **9.12.8 Operand R\_INIT**

*For levels CJS2.*

*Initial value of variable R. At the first computing time, if the initial value of R is null, is that one did not define an initial state of the internal variables by key word ETAT\_INIT of STAT\_NON\_LINE,*

*either that this initial state or no one, one will take as initial value that definite by key word R\_INIT of DEFI\_MATERIAU.*

### **9.12.9 Operand B\_CJS**

*For levels CJS3.*

*Control the kinematic work hardening of the mechanism déviatoire;*

*D*

*- .*

*1 5*

*1*

*F*

*I*

*&X = - &d*

*Dev.*

*IX*

*1*

*ij*

*B*

*X - 1*

*ij*

*3 P*

*ij*

*has*

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### **9.12.10 Operand C\_CJS**

*For levels CJS3.*

*Control the evolution of the pressure criticizes  $p = p$*

(  
*exp - C*

*C*

*Co*

*v).*

### **9.12.11 Operand PCO**

*For levels CJS3.*

*initial critical pressure  $p = p$*

(  
*exp - C*

*C*

*Co*

*v).*

### **9.12.12 Operand GAMMA\_CJS**

*For levels CJS1 CJS2 CJS3.*

*Control the form of the criterion:*

*1/6*

(

*det**1/6* $S) = (1 + Co ($  $S^3 S)$  $(S)$  $H$  $= 1 +$ *54**s3**II*

### **9.12.13 Operand MU\_CJS**

*For levels CJS3.*

*Control the value of rupture of variable R.*

 $3 p$  $R = R$  $C$  $R$  $C + \mu \ln$ *II*

### **9.12.14 Operand Pa**

*For levels CJS1 CJS2 CJS3.*

*atmospheric pressure. Must be given negative.*

### **9.12.15 Operand Q\_INIT**

*For levels CJS1 CJS2 CJS3.*

*Numerical parameter allowing to make acceptable a null state of stress. Can also be used to define a cohesion, at least for level CJS1. The formula will be used:*

 $Q$  $C$  $init = -3 \cotan.$ 

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### **9.13 Key word factor LAIGLE**

*The law of LAIGLE [R7.01.15] is a rheological model of behavior for the modeling of rocks. Those are characterized by the three following parameters:*

.

*“has” which defines the influence of the component of dilatancy in the behavior in large deformations. This parameter depends on the level of deterioration of the rock,*

.

*“S” which defines the cohesion of the medium. It is thus representative of the damage of rock,*

.

*“m” is a function of the mineralogical nature of the rock, and is associated a return of experiment important.*

*The elastic characteristics must be definite soue key word ELAS.*

#### **9.13.1 Syntax**

*LAIGLE =\_F (*

*GAMMA\_ULT*

=

*gamma\_ult,*

[R]

*GAMMA\_E =*

*gamma\_e,*

[R]

*M\_ULT*

=

*m\_ult*

,

[R]

*M\_E*

=

*m\_e*

,

[R]

*A\_E*

=

*a\_e*

,

[R]

*M\_PIC*

=

*m\_pic,*

[R]

*A\_PIC*

=

*a\_pic,*

[R]

*ETA*

=

*eta*

,

[R]

*SIGMA\_C* =

*sigma\_c,*

[R]

*GAMMA*

=

*gamma,*

[R]

*KSI*

=

*ksi*

,

[R]

*GAMMA\_CJS*  
=  
*gamma\_cjs*, [R]

*SIGMA\_P1*  
=  
*sigma\_p1*,  
[R]

*Pa*  
=  
*Pa*  
,

[R]

)

### **9.13.2 Operand GAMMA\_ULT**

*Parameter ult: Plastic deformation déviatoire corresponding to the stage.*

### **9.13.3 Operand GAMMA\_E**

*Parameter E: Plastic deformation déviatoire corresponding to the complete disappearance of cohesion.*

### **9.13.4 Operand M\_ULT**

*Parameter mult: Value of m of the ultimate criterion reached ult.*

### **9.13.5 Operand M\_E**

*Parameter me: Value of m of the intermediate criterion reached in E.*

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### **9.13.6 Operand A\_E**

Parameter *E*

*a*: Value of *A* of the intermediate criterion reached in *E*.

### **9.13.7 Operand M\_PIC**

Parameter *mpic*: Value of *m* of the criterion of peak reached with the peak of constraint.

### **9.13.8 Operand A\_PIC**

Parameter *has peak*: Value of the exhibitor *has* with the peak of constraint.

### **9.13.9 ETA operand**

Parameter: Exhibitor controlling work hardening.

### **9.13.10 Operand SIGMA\_C**

Parameter *C*: Resistance in simple compression.

### **9.13.11 Operands GAMMA and KSI**

Parameters *and*: Parameters regulating dilatancy.

*A condition to respect is that the report/ratio remains lower than 1. In the case of hard stones very*

*resistant, subjected to constraints of containment relatively low, the variation of*

*dilatancy sin (according to the state of the constraints - to see [R7.01.15]) can tend towards, which justify this condition.*

### **9.13.12 Operand GAMMA\_CJS**

*Parameter cjs: Parameter of form of the surface of load in the déviatoire plan.*

### **9.13.13 Operand SIGMA\_P1**

*Parameter 1*

*p: Intersection of the intermediate criterion and the criterion of peak.*

### **9.13.14 Operand Pa**

*Atmospheric pressure. Must be given positive.*

**Note:**

*Parameters M\_E, A\_E, A\_PIC, SIGMA\_P1, SIGMA\_C and MPIC are dependent the ones peak has*

*ae*

*others by the relation:*

*C*

*p1*

*E*

*m =*

*mpic*

*+*

*1*

*. This dependence is checked with the centre*

*p1*

*C*

*code.*

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*U4.43.01-II Page**: 123/148***9.14 Key word factor DRUCKER\_PRAGER**

*The law of DRUCKER\_PRAGER [R7.01.16] is a model of behavior for the mechanics of grounds, it is defined by the relation:*

$$+ I - R(p) 0$$

*eq**1**where*

*is a function of the diverter of the effective constraints,*

*eq*

$$I = Tr$$

*1*

*() is the trace of the effective constraints,*

*is a coefficient of dependence in pressure,*

*R(p) is a function of the cumulated plastic deformation.*

*In the linear case, the function R is given by:*

$$0 < p < p$$

$$R(p) = H p +$$

*ult**y*

$$p p$$

$$R(p) = H p +$$

*ult*

*ult*

*y*

*In the parabolic case,  $R(p) = F$   
where the function  $F(p)$  is given by*

*:*  
*y*  
*(p)*

*2*

*$0 < p <$*

*p*

*p*

*F p*

*1*

*1*

*ult*

*( )*

*y ult*

*=*

*--*

*p*

*y*

*ult*

*p p*

*F p*

*ult*

*( ) = yult*

*y*



### 9.14.1 Syntax

*DRUCKER\_PRAGER* = *\_F*

(

*WORK HARDENING* = /

*`LINEAR`*

,

*^PARABOLIC`*,

*ALPHA*

=

*alpha*,

*[R]*

*P\_ULTM*

=

*p\_ult*

,

*[R]*

*SY*

=

*sy*

,

*[R]*

$H = H,$   
 $[R]$

$SY\_ULTM = sy\_ult, [R]$

)

### **9.14.2 Operand WORK HARDENING**

*Allows to define the type of desired work hardening.*

### **9.14.3 Operand ALPHA**

*Indicate the coefficient of dependence in pressure. It is pointed out that the operand ALPHA is connected to*

$\cdot$   
 $2 \sin ( )$

*the angle of friction by the relation: =*

$\cdot$   
 $3 - \sin ( )$

### **9.14.4 Operand P\_ULTM**

*Indicate the ultimate cumulated plastic deformation.*

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### **9.14.5 Operand SY**

*Indicate the plastic constraint. This operand is related to the combination of the binding fraction  $6C \cos ()$*

*C with the angle of friction in the following way:  $SY =$*

*.*

*$3 - \sin ()$*

### **9.14.6 Operand H**

*Indicate the module of work hardening,  $H < 0$  if the law is lenitive. This operand is obligatory for work hardening of a linear type (operand `WORK HARDENING = `LINEAR ``).*

### **9.14.7 Operand SY\_ULTM**

*Indicate the ultimate constraint. This operand is obligatory for work hardening of a parabolic type (operand `WORK HARDENING = `PARABOLIC ``).*

## **9.15 Key word BARCELONA factor**

*The model of Barcelona describes the elastoplastic behavior of the unsaturated grounds coupled with hydraulic behavior (cf [R7.01.14] for more detail). This model is reduced to the model Cam\_Clay in the saturated case. Two criteria intervene: a mechanical criterion of plasticity (that of Cam\_Clay) and a hydrous criterion controlled by suction (or capillary pressure). It cannot be used that within the framework of behaviors THHM and HHM. Characteristics necessary to model must be given under this key word and key words `CAM_CLAY` and `ELAS`. It is thus obligatory to inform the parameters of key words `CAM_CLAY` and `ELAS`.*

### **9.15.1 Syntax**

**`BARCELONA = _F`**

**`(`**

***R***  
=  
***R***  
,  
***[R]***

***BETA***  
=  
***beta***  
,  
***[R]***

***KC***  
=  
***kc***  
,  
***[R]***

***PC0\_INIT = Pc0 (0)***  
, ***[R]***

***KAPAS***  
=

***Kappas***

,  
***[R]***

***LAMBDAS =***  
***Lambdas,***  
***[R]***

***ALPHAB***  
***=***  
***alphab, [R]***

)

### ***9.15.2 Operands R, BETA***

***Adimensional coefficients intervening in the expression: (p = 0 1***

***exp (-) +***

***c)***

***() [(R)***

***p***

***R***

***C***

***]***

### ***9.15.3 Operand KC***

***Adimensional parameter controlling the increase in cohesion with suction (pressure capillary).***

### ***9.15.4 Operand PCO\_INIT***

***Initial threshold of the capillary pressure (homogeneous with constraints).***

### **9.15.5 Operand KAPAS**

*Adimensional coefficient of rigidity associated the change of suction in the elastic range.*

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### **9.15.6 Operand LAMBDA**

*Coefficient of compressibility related to a variation of suction in the plastic range. (adimensional).*

### **9.15.7 Operand ALPHAB**

*Coefficient of correction of the normality of the plastic flow [R7.01.17].*

*Optional and adimensional corrective term allowing to better take into account results experimental. By defect, it is calculated by Code\_Aster according to the slope of the right-hand side of state critical, of the coefficient of swelling and the coefficient of compressibility.*

### **9.16 Key word factor HOEK\_BROWN**

*Law of behavior in rock mechanics of the law type of modified HOEK-BROWN (cf. [R7.01.18])*

*Mechanical characteristics elastic E, NAKED, and ALPHA must be defined in parallel under key word ELAS.*

### **9.16.1 Syntax**

***HOEK\_BROWN = \_F (***

***GAMMA\_RUP***

***=***

***grup***

***,***

***[R]***

***GAMMA\_RES***

***=***

***likings***

***,***

***[R]***

***S\_END***

***=***

***send***

***,***

***[R]***

***S\_RUP***

=

*srup*

,

**[R]**

***M\_END***

=

*mend*

,

**[R]**

***M\_RUP***

=

*mrup,*

**[R]**

***BETA***

=

*beta*

,

**[R]**

***ALPHAHB = alphahb, [R]***



***PHI\_RUP =***  
***prup,***  
***[R]***

***PHI\_RES =***  
***near***  
***,***  
***[R]***

***PHI\_END = phiend, [R]***

)

### ***9.16.2 Operand GAMMA\_RUP***

***Value of the parameter of work hardening to the rupture of material.***

### ***9.16.3 Operand GAMMA\_RES***

***Value of the parameter of work hardening at the beginning of residual resistance.***

### ***9.16.4 Opérande \_S\_END***

***Value of the product  $S * SIGMA_c ** 2$  attack with the initiation of damage.***

### ***9.16.5 Operand S\_RUP***

***Value of the product  $S * SIGMA_c ** 2$  attack in GAMMA\_RUP.***

### **9.16.6 Operand M\_END**

*Value of the  $M \cdot \text{SIGMA}_c$  product reached with the initiation of damage.*

### **9.16.7 Operand M\_RUP**

*Value of the  $M \cdot \text{SIGMA}_c$  product reached in GAMMA\_RUP.*

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### **9.16.8 Operand BETA**

*Parameter characterizing the behavior post-rupture of material.*

### **9.16.9 Operand ALPHAB**

*Parameter characterizing the behavior post-rupture of material.*

### **9.16.10 Operand PHI\_RUP**

*Value of the angle of friction reached in GAMMA\_RUP.*

### **9.16.11 Operand PHI\_RES**

*Value of the angle of friction reached in GAMMA\_RES.*

### **9.16.12 Operand PHI\_END**

*Value of the angle of friction to the initiation of damage (taken null by defect).*

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### **10 Behaviors specific to the elements 1D**

#### **10.1 Key words factor *VMIS\_POUTRE/VMIS\_POUTRE\_FO***

**Parameters defining the total criterion of plasticity intervening in the elastoplastic behavior elements of beam (Modelings *POU\_D\_E, POU\_D\_T, POU\_D\_TG*). (See [R5.03.30]).**

**The criterion of plasticity is defined by:**

$$G(T, qp, p) = F(T, qp)$$

,

,

,

$$) - R(p) \theta$$

with

2

$N^2$

$M \times$

$$F(T, qp)$$

,

$$) = NR$$

+ A

$p$

2

$p$

2

$p$

2  
y (y).  $M + A$   
y  
Z (Z).  $M$   
+

NR  
Z  
M2  
p  
px

*R (p) can be calculated starting from ECRO\_FLEJOU or ECRO\_LINE.*

*With regard to the inflection, functions A*

*p*  
*p*  
*y (y) and Az (Z) allow the progressive passage of*  
*I there y*

*Iz y*  
*moment of beginning of plasticization of the section (in general, Mey =*  
*and M*

*=*  
*) with*  
*Z*  
*ez*  
*max*  
*y<sub>max</sub>*  
*moment limits M*

*= M*  
*py*  
*ey (M*  
*= M*  
*pz*  
*ez). These moments are to be introduced directly by*  
*the user, they are not calculated by the code according to the elastic limit and of*

*y*  
*geometry of the section. The value of depends on the form of the section: traditional values*  
*are:*

*.*  
*1.5 for a rectangular section*  
*4*

*for a hollow circular section*

*16*

*3 for a full circular section.*

***Functions A***

*p*

*p*

*y (y) and Az (Z) are defined by the preceding characteristic moments, and them numerical parameters*

*y*

*y*

*Z Z:*

*(p y*

*y)*

*y*

*+*

*M2*

*M2*

*py*

*ey*

*With*

*p*

*y (y) = (*

*p y*

*y) + y*

*With*

*p*

*Z (Z) = .....*

*The normal effort limits is characterized by NR = S*

*p*

*y. The limiting torque is M = C*

*px*

*y.*

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**Key** *J.P. LEFEBVRE*

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**10.1.1 Syntax**

**/VMIS\_POUTRE**

**/VMIS\_POUTRE\_FO = \_F (**

**NP**

**=Np**

**,**  
**[R] or [function \*\*]**

**MEY**

**=Mey**

**,**  
**[R] or [function \*\*]**

***MPY***  
=  
***Mpy***  
,  
***[R] or [function \*\*]***

***CAY***  
=  
***ay***  
,  
***[R] or [function \*\*]***

***CBY***  
=  
***by***  
,  
***[R] or [function \*\*]***



**MEZ**

=

**Mez**

,  
**[R] or [function \*\*]**

**MPZ**

=

**Mpz**

,  
**[R] or [function \*\*]**

**CAZ**

=

**az**

,  
**[R] or [function \*\*]**

**CBZ**

=  
*bz*  
,  
*[R] or [function \*\*]*

*MPX*  
=  
*Mpx*  
,  
*[R] or [function \*\*]*

)

## *10.2 Key word factor ECRO\_FLEJOU*

*Definition of the curve of work hardening R (p):*

*E.E*

*p*  
*with H =*

*H. p*

*E - E*  
*R (p) = S = S*

*p*  
+  
*p*  
*L*  
*y*  
*l*

*E.H*

*p*

*that is to say E =*

*l +*

*p*  
*E + H*

*U*  
*Respec is thus needed for the third time E < E*

*p*  
-  
*U*  
*y*  
=  
*U*  
*E p*

*This curve has the advantage of presenting a horizontal asymptote equal to (cf [R5.03.30]).*

*U*

### *10.2.1 Syntax*

*ECRO\_FLEJOU = \_F (EP = ep,*

**[R]**

***SY = sy,***

**[R]**

***KNOWN = known,***

**[R]**

***PUISS = alpha***

**,  
[R]**

)  
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### **10.3 Key word factor ECRO\_ASYM\_LINE (cf [R5.03.09])**

***It makes it possible to model a behavior with linear isotropic work hardening, but with limits of elasticity and different modules of work hardening in traction and compression. This is used by the model of behavior 1D VMIS\_ASYM\_LINE, usable for elements of bar.***

***Elastic behaviour in traction and compression is the same one: even Young modulus.***

***There are two fields of isotropic work hardening defined by RT and RC. The two fields are independent one of the other. We adopt an index T for traction and C for compression.***

**YT**

***Effort limits in traction. In absolute value.***

**YC**

***Effort limits in compression. In absolute value.***

**Pt**

***Plastic deformation cumulated in traction. Algebraic value.***

**PC**

***Plastic deformation cumulated in compression. Value***

*algebraic.*

*ETT*

*Slope of work hardening in traction.*

*Etc*

*Slope D`work hardening in compression.*

*The equations of the model of behavior are:*

.

678

$\sigma = \sigma - -$

1

-  $\sigma_{th}$

$\sigma = \sigma$

$\sigma$

+

$C$

$\sigma T$

$\sigma = \sigma$

$C$

$\sigma C$

$\sigma = \sigma$

$T$

$\sigma T$

-  $R p 0$

$T ($

$T)$

- -  $R p 0$

$C ($

$C)$

*with*

$\dot{\epsilon}_p$   
 $= 0$  if  $\dot{\epsilon} - R_p < 0$   
 $C$   
 $C$  (  
 $C$ )

$\dot{\epsilon}_p$   
 $0$  if  $\dot{\epsilon} = R_p$   
 $C$   
 $C$  (  
 $C$ )

$\dot{\epsilon}_p = 0$  if  $\dot{\epsilon} - R_p < 0$   
 $T$   
 $T$  (  
 $T$ )

$\dot{\epsilon}_p 0$  if  $\dot{\epsilon} = R_p$   
 $T$   
 $T$  (  
 $T$ )

where:

$\dot{\epsilon}_p$  & PC: speed of plastic deformation in compression,

$\dot{\epsilon}_p$  & Pt: speed of plastic deformation in traction

HT: thermal deformation of origin:  $HT = (T - ref.$

$T)$ . is defined under ELAS.

It is noticed that one cannot have simultaneously plasticization in traction and compression: that is to say

$\dot{\epsilon}_p C = 0$ , either  $\dot{\epsilon}_p T = 0$ , or both is null.

### 10.3.1 Syntax

$ECRO\_ASYM\_LINE = \_F (DT\_SIGM\_EPSI$   
 $= RT,$

***SY\_T = yT,***

***DC\_SIGM\_EPSI = RC,***

***SY\_C = yC,***

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***11 Behaviors***

***private individuals***

***11.1 Key word factor LEMAITRE\_IRRA***



***Characteristics (specific to the irradiation) of the creep of the pencils or fuel assemblies (behavior LEMAITRE\_IRRA of STAT\_NON\_LINE).***

***The elastic characteristics must be defined under key word ELAS or ELAS\_FO.***

***The uniaxial form of the law of growth is:***

$$S(T) = (At + b) T$$

***G***  
***. D***

***0***

***T***

***where is the neutron flux and D the fluence, recovered in STAT\_NON\_LINE by the key word***

***0***  
***IRRA of VARI\_COMM. T is in °C.***

***If one adopts a modeling 1D (the behavior is then applied to an element of beam in the axial direction, cf [R5.03.09]), this uniaxial form is used just as it is.***

***On the other hand, for modelings 2D and 3D, the law of growth is written (cf [R5.03.08]):***

***S***

$$G(T) = (At + b) T$$

***.***

***0***

***D***

***0***

***G***

***1 0 0***

***with:***

***0***

**= 0 0 0**

**G**

**0 0 0**

**1R**

*One must then define using operand ANGLE\_REP of the MASSIVE key word of the operator AFFE\_CARA\_ELEM local axes corresponding to the R1 reference mark (see [U4.42.01]). This operand awaits 3 nautical angles of which one uses only the 2 first (the third can thus be unspecified).*

*The parameters of growths are provided behind key words GRAN\_A, GRAN\_B and GRAN\_S. One informs four key words QSR\_K, BETA, PHI\_ZERO, L (the other parameters of creep are identical to those of behavior LEMAITRE) and behaviour in creep is then according to:*

**N**

**Q**

**1**

**-**

**eq**

**R (T +T0)**

**&p =**

**+ L E**

**(T =**

**•**

**0**

**)**

**1 /**

**p m K**

**273,15 C**

**0**

*where is the neutron flow calculated starting from the fluence recovered in STAT\_NON\_LINE by operand IRRA of key word VARI\_COMM (see [R5.03.08] or [R5.03.09] according to modeling). T is in °C.*

*If it is wished that the behavior not depend on the fluence, but comprises nevertheless the term in exp (- Q/RT), it is possible, only for modelings 2D and 3D, to use key word LEMAITRE\_IRRA in STAT\_NON\_LINE by informing key word LEMAITRE\_IRRA in DEFI\_MATERIAU. It is then necessary imperatively to affect UN\_SUR\_K, A, B, S with zero and PHI\_ZERO with one. Under these conditions, it is not necessary to define a field of fluence.*

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*11.1.1 Syntax*

*LEMAITRE\_IRRA*

*= \_F*

*(*

**NR**  
**=**  
**N,**  
**[R]**

**UN\_SUR\_K**  
**= 1/K**  
**, [R]**

**UN\_SUR\_M**  
**=/1/m**  
**, [R]**  
**/**  
**0.**  
**,**  
**[DEFECT]**  
**QSR\_K =/Q/R**  
**, [R]**  
**/**  
**0.**  
**,**  
**[DEFECT]**

**BETA =/, [R]**  
/  
**0.**  
,  
**[DEFECT]**

**PHI\_ZERO =/0,**  
**[R]**  
/  
**0.**  
,  
**[DEFECT]**

**L =/L, [R]**  
/  
**0.**  
,  
**[DEFECT]**

**GRAN\_A**  
**=/has, [R]**  
**/**  
**0.**  
**,**  
**[DEFECT]**

**GRAN\_B**  
**=/B, [R]**  
**/**  
**0.**  
**,**  
**[DEFECT]**

**GRAN\_S**  
**=/S, [R]**  
**/**  
**0.**  
**,**  
**[DEFECT]**

)

## 11.2 Key word factor *LMARC\_IRRA*

*Élasto-viscoplastic model developed with the LMA-RC to describe the viscoplastic behavior orthotropic of the tubes of sheaths of the fuel pin [R5.03.10], supplemented by the parameters of growth provided behind key words GRAN\_A, GRAN\_B and GRAN\_S.*

*Briefly, the relations of behavior are:*

3

*F* $= \sim - X - R =$  $(\sim - X) T M (\sim - X)$ 

0

2

*N**F* $3M (\sim$  $- X)$ 

2

 $\sim -$  $\& v$  $p = \&v$  $= \&v$ 

=

 $v p T$  $I v p$ 

~

 $\&v$  $(\&)$ *X* $M - \&$  $= \sin H$ 

2

-

 $\&0$ *X*

3

***K***

***m***

***2***

***v p***

***1***

***X***

***X***

***X& = p***

***Y (v)***

***()***

***NR &***

***- Q***

***(X X)***

***&***

***3***

***v - R sinh***

***m***

***NR R***

***X0***

***X***

***()***



2

*vp*

1

2

2

2

*vp*

2

*XI*

(*v*)

( )

( )

*p*

*Y*

*I*

*NR &*

*Q(X*

*X*

)

( )

*&v*

*X*

*p*

*Y(v)*

( )

=

-

-

*NR &*

*QX*

*v*

3

=

-

23

*&*

3

*with: Y ()*

*Y (THERE Y*

*0*

*) eb*

*T*

*v*

*v*

*=*

*+*

*-*

*X =*

*X NR X*

*2*

*Note:*

*~*

*represent the diverter of the constraints and ~*

*- X the equivalent within the meaning of Hill.*

*The matrices M, NR, R and Q make it possible to describe the anisotropy of behavior viscoplastic.*

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*11.2.1 Syntax*

/  
***LMARC*** = = ***\_F (R\_0***  
=  
***R0***  
,  
***[R]***

***DE\_0 =***  
***eps0, [R]***

***NR***  
=  
***N, [R]***

**$K$**   
**=**  
 **$K, [R]$**

**$Y_0$**   
**=**  
 **$y_0$**   
**, [R]**

**$Y_I$**   
**=**  
 **$y_{inf},$**   
**[R]**

***B***  
=  
***B***  
***, [R]***

***A\_0***  
=  
***X0,***  
***[R]***

***RM***  
=  
***rm,***  
***[R]***

***M***  
=  
***m***  
***, [R]***

***P***  
=  
***p***  
***, [R]***

***P1***  
=  
***p1,***  
***[R]***

***P2***  
=  
***p2,***  
***[R]***

***M11***  
=  
***M11,***  
***[R]***

***M22***  
=  
***M22,***  
***[R]***

***M33***  
=  
***M33,***  
***[R]***

***M66***  
=  
***M66,***  
***[R]***

***N11***  
=  
***N11,***  
***[R]***



***N22***  
=  
***M22,***  
***[R]***

***N33***  
=  
***N33,***  
***[R]***

***N66***  
=  
***N66,***  
***[R]***

***Q11***  
=  
***Q11,***  
***[R]***

***Q22***  
=  
***Q22,***  
***[R]***

***Q33***  
=  
***Q33,***  
***[R]***

***Q66***

=  
**Q66,**  
**[R]**

**R11**  
=  
**R11,**  
**[R]**

**R22**  
=  
**R22,**  
**[R]**

**R33**  
=

**R33,**  
**[R]**

**R66**  
**=**  
**R66,**  
**[R]**

**GRAN\_A**  
**=/has,**  
**[R]**  
**/**  
**0.**  
**,**  
**[DEFECT]**

**GRAN\_B**  
=**B**,  
**[R]**  
/  
**0**.  
,  
**[DEFECT]**

**GRAN\_S**  
=**S**,  
**[R]**  
/  
**0**.  
,  
**[DEFECT]**

)

### ***11.3 Key word factor DIS\_GRICRA***

***This key word makes it possible to define the parameters associated with the nonlinear behavior with the connection enters the grid and the pencil in a fuel assembly modelled by a discrete element (cf [R5.03.17]). The behavior usable in orders STAT\_NON\_LINE and DYNA\_NON\_LINE starting from these parameters is DIS\_GRICRA:***

.

***behavior being pressed on a discrete element with 2 nodes (modeling DIS\_TR) with***

*degrees of freedom in translation and rotation*

*contact with friction of Coulomb for the degrees of translation, modelled by a model elastoplastic*

*nonlinear law of behaviour in rotation based on geometrical considerations and physics (cf [R5.03.17])*

*A certain number of parameters additional, available for this behavior but which do not appear in this document, are clarified in [V6.04.131].*

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*11.3.1 Syntax*

*DIS\_GRICRA =*

*\_F (*

*% Behavior "DIS\_GRICRA"*

*KN\_BOS =/kn\_bossette,*

*[R]*

*KT\_BOS =/kt\_bossette, [R]*

*KN\_RES =/kn\_ressort,*

**[R]**

***KT\_RES =/kt\_ressort, [R]***

***COUL\_BOS  
=/mu\_bossette, [R]***

***COUL\_RES  
=  
/  
mu\_ressort,  
[R]***

***ECRO\_BOS  
=/gamma\_bossette, [R]***

***ECRO\_RES  
=/gamma\_ressort, [R]***

***FORC\_SER  
=/forc\_serrage,  
[R]***

***DIST\_BOS  
=/distance\_bossette, [R]***

)

### ***11.3.2 Operands***

***The connection grid-pencil of the fuel assemblies consists of a system of bosses and of springs (cf [R5.03.17]), for which one must specify the following parameters:***

***KN\_BOS = kn\_bossette***

***Normal rigidity of the bosses (in N/m).***

***KT\_BOS = kt\_bossette***

***Tangential rigidity of the bosses (in N/m).***

***KN\_RES = kn\_ressort***

***Normal rigidity of the springs (in N/m).***

***KT\_RES = kt\_ressort***

***Tangential rigidity of the springs (in N/m).***

***COUL\_BOS = mu\_bossette***

***Coefficient of Coulomb for the friction of the bosses.***

***COUL\_RES = mu\_ressort***

***Coefficient of Coulomb for the friction of the springs.***

***ECRO\_BOS = gamma\_bossette***

***Parameter of work hardening allowing to treat the friction of the bosses (in N/m).***

***This parameter does not have a physical direction, and is introduced only to help the convergence of calculation***

***when there is slip (idem perfect plasticity).***

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***ECRO\_RES = gamma\_ressort***

***Parameter of work hardening allowing to treat the friction of the springs (in N/m)  
This parameter does not have a physical direction, and is introduced only to help the convergence of calculation  
when there is slip (idem perfect plasticity).***

***FORC\_SER = forc\_serrage***

***Force tightening (positive) initial pencil in the grid (equal to the force applied to the springs)  
(in NR).***

***DIST\_BOS = distance\_bossette***

***Outdistance between the bosses (in m).  
This parameter must be readjusted if one uses only one discrete to model several connections  
grid-pencil, and thus does not correspond necessarily to the true distance between the bosses  
measured on the grids of the assembly.***

#### ***11.4 Key word factor GATT\_MONERIE***

***Thermomechanical law of behavior of fuel “GATT-Monerie” in order to simulate tests  
of indentation. This law of behavior is an isotropic élasto-viscoplastic law without work hardening  
whose specificities are:***

- the potential of dissipation is the sum of two potentials of the Norton type (without threshold),***
- the fuel having a residual porosity likely to evolve/move in compression  
(thickening), this potential depends, in addition to the equivalent constraint, of the constraint  
hydrostatic.***

***The two internal variables of this model are the plastiquecumulée deformation and the fraction  
voluminal of porosity.***

##### ***11.4.1 Syntax***

***GATT\_MONERIE***

***= \_F  
(***

**D\_GRAIN =**  
/  
**d\_grain,**  
**[R]**  
**PORO\_INIT**  
**=/poro\_init**  
**, [R]**  
**EPSI\_01 =/eps1,**  
**[R]**  
/  
**2.7252E-10,**  
**[DEFECT]**  
**EPSI\_02 =/eps2,**  
**[R]**  
/  
**9.1440E-41**  
  
**[DEFECT]**

**with**  
**D\_GRAIN**

**: cut combustible grain**  
**PORO\_INIT: initial porosity**  
**EPSI\_01: coefficient speed of forced low deformation**  
**EPSI\_02: coefficient speed of forced strong deformation**

**The elastic characteristics must be indicated under key word ELAS.**

### **11.5 Key word factor DIS\_CONTACT**

**This key word makes it possible to define the parameters associated with the nonlinear behaviors with contact or**

**shock with friction associated with the discrete elements (cf [R5.03.17]). Behaviors usable in orders STAT\_NON\_LINE and DYNA\_NON\_LINE starting from these parameters are:**

**.  
DIS\_CONTACT: behavior being pressed on a discrete element with 2 nodes (modelings DIS\_T and DIS\_TR):**

**1) contact with friction of Coulomb for the degrees of translation,  
2) relation of behavior of the elastoplastic type for the degrees of rotation**

**.  
DIS\_CHOC: shock with friction of Coulomb being pressed on a discrete element with 1 or 2 nodes (modelings DIS\_T or DIS\_TR being pressed on meshes POI1 or SEG2).**

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***11.5.1 Syntax***

***DIS\_CONTACT =***

***\_F (***

***% Behavior "DIS\_CHOC"***

***RIGI\_NOR =***

***KN,***

***[R]***

***DIST\_1*** =/*dist1*,  
**[R]**  
/  
0,  
**[DEFECT]**

***DIST\_2*** =/*dist2*,  
**[R]**  
/  
0,  
**[DEFECT]**

***RIGI\_TAN*** =/*Kt*,  
**[R]**  
/  
0,  
**[DEFECT]**

***AMOR\_NOR*** =/*Cn*,  
**[R]**  
/  
0,  
**[DEFECT]**

**AMOR\_TAN** =/Ct,  
**[R]**  
/  
0,  
**[DEFECT]**

**COULOMB**  
=/driven,  
**[R]**  
/  
0,  
**[DEFECT]**

**PLAY**  
=  
/  
**d0,**  
**[R]**  
/  
0,  
**[DEFECT]**

**% Behavior "DIS\_CONTACT"**

**COULOMB**

**=/driven,**

**[R]**

**/**

**0,**

**[DEFECT]**

**KT\_ULTM**

**=/ktu**

**, [R]**

**/**

**0,**

**[DEFECT]**

**EFFO\_N\_INIT =**

**Finished**

**,**

**[R]**

**/RIGI\_N\_FO = Fn, (T)**

**[fonction+]**

***/RIGI\_N\_IRRA=FF, (fluence) [function]***

***/RELA\_MZ***

***= f\_mz,  
[function]***

***/  
ANGLE\_1***

***=  
a1,  
[function]***

***ANGLE\_2***

***=  
a2,  
[function]***

***ANGLE\_3***

***=  
a3,  
[function]***

***ANGLE\_4***

***=  
a4,  
[function]***

***MOMENT\_1 =***

***m1,***

**[function]**

**MOMENT\_2 =**  
**m2,**  
**[function]**

**MOMENT\_3 =**  
**m3,**  
**[function]**

**MOMENT\_4 =**  
**m4,**  
**[function]**

**C\_PRAGER\_MZ =/Cpr**  
**, [R]**  
**/**  
**0,**  
**[DEFECT]**

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**11.5.2 Operands**

**Behavior “DIS\_CONTACT”:**

**Behavior concerning the degrees of freedom of translation**

*COULOMB = driven*

*Value of the coefficient of friction.*

*EFFO\_N\_INIT = Finished*

*Initial normal effort in the spring (in general negative, so that there is contact at the initial moment).*

*KT\_ULTM = ktu*

*Slope of regularization which simulates a nonperfect slip.*

*RIGI\_N\_FO = Fn (T)*

*Multiplying function (depend on time) of rigidity, in general decreasing with time, to simulate the effect of the irradiation on the rigidity of the spring.*

*RIGI\_N\_IRRA = FF (fluence)*

*Multiplying function (depend on the fluence) of rigidity, in general decreasing with fluence, to simulate the effect of the irradiation on the rigidity of the spring. To define this function, it is necessary*

*to use order DEFI\_FONCTION and to take for example as NOM\_PARA, “INST”: for the moment the fluence does not form part of the possible NOM\_PARA.*

**Behavior concerning the degrees of freedom of rotation**

*RELA\_MZ = f\_mz*

*Curve (moment) according to DR. (degree of rotation)*

$ANGLE\_1 = a1, MOMENT\_1 = m1,$   
 $ANGLE\_2 = a2, MOMENT\_2 = m2,$   
 $ANGLE\_3 = a3, MOMENT\_3 = m3,$   
 $ANGLE\_4 = a4, MOMENT\_4 = m4,$

*Definition of the curve moment-angle of the characteristic in rotation of the connection grid-pencil, 2 parameters moment and angle depend on the temperature and the fluence.*

$C\_PRAGER\_MZ = cpr$

*Constant of Prager which makes it possible to define mixed work hardening.*

***Behavior “DIS\_CHOC”:***

$COULOMB = driven$

*Value of the coefficient of friction*

$RIGI\_NOR = kN$

*Value of the normal rigidity of shock. If RIGI\_NOR is present it is this value which is taken in count. If it is not present, the discrete elements to which one affects this material must have their stiffness defined in addition (for example using order AFFE\_CARA\_ELEM with key words DISCRETE or RIGI\_PARASOL).*

$RIGI\_TAN = Kt$

*Value of the tangential rigidity of shock*

$AMOR\_NOR = Cn$

*Value of the normal damping of shock*

$AMOR\_TAN = Ct$

*Value of the tangential damping of shock*

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*DIST\_1 = dist1*

*Outdistance characteristic of matter surrounding the first node of shock*

*DIST\_2 = dist2*

*Outdistance characteristic of matter surrounding the second node of shock (shock between two structures mobiles)*

*PLAY = d0*

*Outdistance between the node of shock and an obstacle not modelled (case of a shock between a structure mobile and an indeformable and motionless obstacle).*

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## **11.6 Key word factor ASSE\_CORN: behaviour of an assembly bolted**

### **11.6.1 Syntax**

/  
ASSE\_CORN

=  
\_F

(

NU\_1 = nul  
[R]

MU\_1 = nul  
[R]

*DXU\_1*

=

*dxu1*

[R]

*DRYU\_1*

=

*dryu1*

[R]

*C\_1*

=

*c1*

[R]

*NU\_2 = nu2*

*[R]*

*MU\_2 = mu2*

*[R]*

*DXU\_2*

*=*

*dxu2*

*[R]*

*DRYU\_2*

*=*

*dryu2*

*[R]*

*C\_2*  
=  
*c2*  
*[R]*

*KY*  
=  
*ky*  
*[R]*

*KZ*  
=  
*kz*  
*[R]*

*KRX*

=  
*krx*  
[R]

*KRZ*  
=  
*krz*  
[R]

*R\_P0 =/*  
*rp0*  
[R]

*/1.E-4*



)

## **11.6.2 Operands**

*On the following figure, the plan represents the plan of the assembly. The axis of the bolts is perpendicular in this plan. The reader will refer to [U4.42.01] AFFE\_CARA\_ELEM for orientation of reference mark RL defining the plan of the assembly.*

*y  
X  
RL  
Z*

*Traces of the bolts*

*within assembly*

*The relation of behaviour of the assembly is:*

*.  
non-linear in translation according to X and rotation around Y.*

*.  
linear according to the other degrees of freedom: DY, DZ, DRX, DRZ*

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***Behaviours in traction along axis X and rotation around axis Y.***

**NR**

**My**

**NU\_2**

**MU\_2**

**C\_2\*NU\_2**

**C\_2\*MU\_2**

**NU\_1**

**MU\_1**

**C\_1\*NU\_1**

**C\_1\*MU\_1**

**DX**

**DRY**

**DXU\_1**

**DXU\_2**

**DRYU\_1**

**DRYU\_2**

***The behavior of the connection is considered linear in the other directions:***

**KY**

***: stiffness in translation following Y***

**KZ**

***: stiffness in translation according to Z***

**KRX**

***: stiffness in rotation around X***

**KRZ**

***: stiffness in rotation around Z***

**R\_P0: Slope in the beginning or of discharge**

***11.7 Key word factor ARMS: behavior of a conductor arrangement***

***air***

***The arm of each armament of broken phase, represented by a discrete element, has one non-linear behavior in force-displacement consisted the difference between displacement***

*maximum dlp of the end of the armament in the plastic phase and limiting elastic displacement dle.*

### *11.7.1 Syntax*

*/ ARM = \_F  
(KYE  
= kye  
, [R]*

*DLE  
= dle  
, [R]*

*KYP  
= kyp  
, [R]*

*DLP  
= dlp  
, [R]*

**KYG**

= *kyg*

, [R]

)

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**11.7.2 Operand**

**KYE = kye**

*Elastic slope until a limiting effort.*

**DLE = dle**

*Displacement limits elastic strain.*

**KYP = kyp**

***Plastic slope until limiting displacement DLP.***

***DLP = dlp***

***Displacement limits plastic deformation 0.***

***KYG = kyg***

***Slope of discharge.***

***F***

***KYP***

***KYE***

***KYG***

***DLE***

***D***

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***12 Behavior***

***fluid***

***12.1 Key word FLUID factor***

***I***

## ***FLUID***

***Definitions of the constant characteristics of fluid.***

### ***12.1.1 Syntax***

***/ FLUID = \_F***

***(RHO***

***= rho***

***,***

***[R]***

***/CELE\_R***

***=***

***celr,***

***[R]***

***/CELE\_C***

***=***

***celc,***

***[C]***

)

### ***12.1.2 Operands***

***RHO***  
***= rho***

***Density of the fluid. No the checking.***

***/CELE\_R***  
***= celr***

***Celerity of propagation acoustic waves in the fluid environment (standard reality).  
No the checking of about size.***

***/***  
***CELE\_C***  
***=***  
***celc***

***Celerity of propagation acoustic waves in the fluid environment (standard complex  
in particular for a porous environment). No the checking of about size.***

***For a modeling in PHENOMENON: ACCOUSTICS (order AFFE\_MODELE [U4.41.01]) only  
the definition of celerity using key word CELE\_C is valid.***

***The definition using key word CELE\_R led to a stop in error.***

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### ***13 Data Materials associated with postprocessings***

#### ***13.1 Key word factor TIRES***

***One will be able to refer to [R7.04.01].***

##### ***13.1.1 Syntax***

***TIRE = \_F (***

***/WOHLER***

***=***

***f\_wohl***

***,***

***[function]***

***/***

***A\_BASQUIN***

***=***

***has***

***,***

***[R]***



***/BETA\_BASQUIN***

***=***

***,***

***[R]***

***/***

***A0***

***=***

***a0***

***,***

***[R]***

***/***

***A1***

***=***

***a1***

***,***

***[R]***

***/***

***A2***

***=***

***a2***

,  
**[R]**

/  
**A3**  
=  
**a3**

,  
**[R]**

/  
**SL**  
=  
**SL**  
,  
**[R]**

**MANSON\_COFFIN**

=  
**f\_mans**

,  
**[function]**

***E\_REFE***

=

***EC.***

,

***[R]***

***D0***

=

***d0***

,

***[R]***

***TAU0 = 0***

,

***[R]***

)

### ***13.1.2 Operand WOHLER***

***This operand makes it possible to introduce the curve of Wöhler of material in a form discretized not by point. This function gives the number of cycles to the Nrupt rupture according to the half-amplitude***

***of constraint***

.

2

***The curve of Wöhler is a function for which the user chooses the mode of interpolation:***

.

**LOG LOG: interpolation logarithmic curve on the number of cycles to the rupture and on half-amplitude of the constraint (formula of Basquin per pieces),**

**FLAX FLAX: linear interpolation on the number of cycles to the rupture and on the half amplitude constraint (this interpolation is disadvised because the curve of Wöhler is not absolutely not linear in this reference mark),**

**FLAX LOG: interpolation into linear on the half-amplitude of constraint, and logarithmic curve on the number of cycles to the rupture, which corresponds to the expression given by Wöhler.**

**The user must also choose the type of prolongation of the function on the right and on the left.**

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**13.1.3 Operands A\_BASQUIN/BETA\_BASQUIN**

**A\_BASQUIN**

**= has**

**BETA\_BASQUIN =**

**These operands make it possible to introduce the curve of Wöhler of material in the analytical form of BASQUIN [R7.04.01].**

**D = A Salt**

**where**

*With and are two constants of material,*

*Salt = forced alternate of the cycle =*

*,*  
*2*

*and D elementary damage.*

*Note:*

*Attention, in software POSTDAM, one gives constant A and for D = it who is not homogeneous with the 2 other mathematical expressions of the curve of Wöhler.*

### *13.1.4 Operands A0/A1/A2/A3/SL*

*A0 = a0*

*A1 = a1*

*A2 = a2*

*A3 = a3*

*SL = SL*

*These operands make it possible to define in analytical form the curve of Wöhler in “current zone” [R7.04.01].*

*1 EC.*

*Salt = forced alternate =*

*2nd*

*X = log (Salt)*

*10*

*2*

*3*

*NR*

*a0+a1x+a2x +a3x*

*rupt = 10*

*1/NR if Salt Sl*

*D = .0 if not*

*This list of operands makes it possible to introduce the various parameters of this analytical form.*

*a0, a1, a2 and a3 constant of material,*

*SI limits endurance of material.*

*The Young modulus E is introduced into DEFI\_MATERIAU (key word factor ELAS operand E).*

*The value of EC., Young modulus associated with the curve with tiredness with material is also introduced*

*in DEFI\_MATERIAU under the key word factor TIRES, operand E\_REFE.*

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### *13.1.5 Operand MANSON\_COFFIN*

*MANSON\_COFFIN = f\_mans*

*This operand makes it possible to introduce the curve of Manson-Whetstone sheath of material in a form*

*discretized point by point. This function gives the number of cycles to the rupture according to*

*half-amplitude of deformations*

*.*  
*2*

### *13.1.6 Operand E\_REFE*

*E\_REFE = EC.*

*This operand makes it possible to specify the value of the Young modulus associated with the curve*

*with tiredness with material. This value allows amongst other things, to define the curve of Wöhler in “current zone” [R7.04.01].*

### **13.1.7 D0 operand**

**D0 = d0**

*Allows to specify the value of the limit of endurance in alternate pure traction and compression. This value is used in the calculation of the criteria of Crossland and Dang Van Papadopoulos [R7.04.01] by the ordering of POST\_FATIGUE [U4.83.01].*

### **13.1.8 Operand TAU0**

**TAU0**

=  
0

*Allows to specify the value of the limit of endurance in alternate pure shearing. This value is used in the calculation of the criteria of Crossland and Dang Van Papadopoulos [R7.04.01] by order POST\_FATIGUE [U4.83.01].*

### **13.2 Key word factor DOMMA\_LEMAITRE**

**DOMMA\_LEMAITRE = \_F (**

**S**  
=  
**S,**  
**[function \*\*]**

**EPSP\_SEUIL = Pd, [function \*\*]**

*EXP\_S*  
=  
*Pd*,  
*[R]*  
/  
*1.0*,  
*[DEFECT]*

)

*Under this key word factor are gathered all the characteristics material necessary to calculation of the damage of Lemaitre and the law of Lemaitre-Sermage.*

### ***13.2.1 Operand S***

*S = S*

*S is a parameter material necessary to the calculation of the damage of Lemaitre. S must be one function of the parameter TEMP.*

### ***13.2.2 Operand EPSP\_SEUIL***

*EPSP\_SEUIL = Pd*

*Allows to specify the value of the threshold of damage Pd, necessary to the calculation of the damage of Lemaitre.*

### ***13.2.3 Operand EXP\_S***

*XP\_S = exp*

*Allows to define the law of Lemaitre-Sermage, the default value (1.0) corresponds to the calculation of*



*damage of Lemaitre*  
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*13.3 Key word factor CISA\_PLAN\_CRIT*

*CISA\_PLAN\_CRIT = \_F (*

*MATAKE\_A = has,*

*[R]*

*MATAKE\_B = B, [R]*

***ENDU\_FT = endu\_ft,***

***[R]***

)

***Under this key word factor are gathered all the characteristics material necessary to implementation of the criteria with critical plans.***

### ***13.3.1 Operand MATAKE\_A***

***MATAKE\_A = has,***

***Allows to specify the value of the coefficient without dimension has, present in the criterion of MATAKE, cf [R7.04.01] and [U4.83.02].***

### ***13.3.2 Operand MATAKE\_B***

***MATAKE\_B = B,***

***Allows to specify the value of the coefficient B, present in the criterion of MATAKE, cf [R7.04.01] and [U4.83.02].***

### ***13.3.3 Operand ENDU\_FT***

***ENDU\_FT = endu\_ft,***

***Allows to specify the value of the report/ratio of the limits of endurance in inflection and alternating torsion, cf [R7.04.01] and [U4.83.02]. This value must be higher or equal to one and lower or equal***

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**13.4 Key word factor WEIBULL/WEIBULL\_FO**

**Definition of the coefficients of the model of Weibull [R7.02.06].**

**Briefly, the probability of cumulated rupture of rupture  $Pr$  of a structure is written, in the case of one monotonous loading:**

**$m$**

**$V$**

**$p$**

**$P$**

**$I$**

**$I \exp$**

**$R = -$**

**-**

$V$   
 $V$   
 $U$   
 $0$   
 $p$

where the summation carries on the plasticized  $V_p$  meshes (i.e cumulated plastic deformation higher than a value chosen arbitrarily  $PS$ ) and  $m, V, U, 0$  are the parameters of the model of Weibull.

In the case of an unspecified way of loading:

$m$   
 $P(T) \propto \exp$

$R$   
 $= -$   
 $-$

$U$

with:  
 $m$

$m$   
 $V$   
 $\sim$

$= \max \{(U)$   
 $I$   
 $\}$   
 $\{$

,  
 $u < t, p \& (U)$

>}  
0  
V  
V  
0

*&p indicating the rate of cumulated plastic deformation.*

*Lastly, if the constraint of cleavage depends on temperature (WEIBULL\_FO):*

*m*  
*0*

*P (T)*

*l exp*

*R*  
*= -*  
*-*

*,*

*0*

*U*

*0*  
*0*

*indicating the constraint of Weibull defined conventionally for U given:*

*m*  
*m*  
*0. (U)*  
*0*  
*U*  
*I*  
*V*

*= max*

*{*  
*,*

$u < t, p \& (U) > \}$

$0$

$V$

$V$

$U ((U))$

$0$

*(U) indicating the temperature in the element V.*

### *13.4.1 Syntax*

*I WEIBULL =*

*\_F (*

*M = m, [R]*

*SIGM\_REFE*

*=*

*U*

*,*

*[R]*

*VOLU\_REFE*

*=*

*V0*

*,*

*[R]*

***SEUIL\_EPSP\_CUMU =/PS, [R]***

***/***

***10-6,***

***[DEFECT]***

***)***

***I WEIBULL\_FO = \_F (***

***M = m, [R]***

***SIGM\_REFE***

***=***

***U,***

***[function]***

***SIGM\_CNV***

***=***

***0u, [R]***

***VOLU\_REFE***

=

***V0***

,

***[R]***

***SEUIL\_EPSP\_CUMU =/PS,***

***[R]***

/

***10-6,***

***[DEFECT]***

)

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### **13.4.2 Operands**

***M = m, SIGM\_REFE: U, SIGM\_CNV: 0u, VOLU\_REFE: V0***

***Parameters associated with the model with Weibull.***

***SEUIL\_EPSP\_CUMU = PS***

***Cumulated plastic deformation.***

### **13.5 Key words factor RCCM/RCCM\_FO**

***Definition of the sizes necessary to the use of the methods simplified defined in payment RCC-M [R7.04.03]. These sizes are constant or function of the parameter “TEMP”.***

#### **13.5.1 Syntax**

***//RCCM = \_F***

***(SY\_02 = *sigm*, [R])***

***SM***  
=  
***sigm***  
,  
**[R]**

***KNOWN***  
=  
***sigm***  
,  
**[R]**

***SC***  
=  
***sigm***  
,  
**[R]**

***HS***  
=  
***sigm***  
,  
**[R]**

***N\_KE = H, [R]***

***M\_KE = m, [R]***

)

***/RCCM\_FO = \_F (SY\_02 = *sigm*, [function]***

***SM***

=

***sigm***

,

***[function]***

***KNOWN***  
=  
***sigm***  
,  
***[function]***

***S = sigm, [function]***

***N\_KE = H, [function]***

***M\_KE = m, [function]***

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**13.5.2 Operand SY\_02**

*Limit elastic with 0,2% of plastic deformation at the temperature of calculation. This operand can to vary according to the temperature.*

**13.5.3 Operand SM**

*Acceptable constraint equivalent of material to the temperature of calculation. This operand can vary in function of the temperature.*

**13.5.4 Operand KNOWN**

*Tensile strength of material at the temperature of calculation. This operand can vary in function temperature.*

**13.5.5 Operand SC**

*Working stress of material at the ambient temperature, cf RCCM.*

**13.5.6 Operand HS**

*Working stress of material at the maximum temperature, cf RCCM.*

**13.5.7 Operand S**

*Working stress of material. This operand varies according to the temperature, cf RCCM.*

### **13.5.8 Operand $N_{KE\_RCCM}/M_{KE\_RCCM}$**

$$N_{KE\_RCCM} = N$$

$$M_{KE\_RCCM} = m$$

*These operands make it possible to define the values of  $N$  and  $m$  two constants of material.*

*These characteristics are necessary for the calculation of the elastoplastic coefficient of concentration  $K_e$ , which is defined by the RCC-M as being the relationship between the amplitude of real deformation and the amplitude of deformation determined by the elastic analysis.*

$$K = 1$$

*if*

*S*

*E*

*3 m*

$$K = 1 + (1 - N)$$

*E*

*(/S*

*3 m -)*

*1 ( (*

*N m -)*

*1) if*

*S*

*3*

*<< m*

*3 S*

*m*

*m*

$$K = 1 N$$

*if*

*m*

*3 S*

*E*

*m*

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**Date:**

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**Author (S):**

**C. DURAND, A.M. DONORE Key**

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**Organization (S): EDF-R & D /AMA**

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**Macro-order INCLUDE\_MATERIAU**

**1 Goal**

**To recover the characteristics of a material in the Catalogue Materials Aster.**

**This macro-order makes it possible to define a material via DEFINI\_MATERIAU, of which characteristics**

*physics is taken or evaluated according to the temperature in a data base.*

*The name of the concept material produced and usable in the continuation of the command file is specified by*

*key word **NOM\_MATER**.*

*For the executions on the internal waiter of calculation EDF, the catalogues materials are located in /aster/v7/sta7/materiau repertory. In the sources published, only a catalogue is given to titrate example: **A42\_REF\_A.NOMI**.*

*In ASTK, the access path to the catalogues materials is skeletal in the menu Options/Arguments/rep\_mat.*

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## **2 Syntax**

**INCLUDE\_MATERIAU**

(

**NOM\_AFNOR**

=

**nomafnor,**

**[K8]**



***TYPE\_MODELE***

***="/ref.",***

***/***

***"BY"***

***,***

***ALTERNATIVE***

***=***

***/***

***"A"***

***,***

***/"B",***

***/"It,***

***/"Of,***

***/"E",***

***/"F",***

***/"G",***

***/"H",***

***/"I",***

***/"L,***

***/"K",***

***/"It,***

***/"Me,***

***/"***

***/"O",***

***/"P",***

***/"Q",***

***/"R",***

***/"***

***/"You,***

***/"U",***

***/"V",***

***/"W",***

***/"X",***

***/"Y",***

***/"Z",***

**TYPE\_VALE**

=

/

**“NOMI”**

,

**/“MAXIMUM”**,

**/“MINI”**,

**NOM\_MATER**

=

**to subdue,**

**[K8]**

**EXTRACTION =**

**(\_F**

**(**

**COMPOR**

=

**compor,**

**[K16]**

**TEMP\_EVAL**

=

**temp, [R8]**

**))**

**UNITE\_LONGUEUR =/“Me**

**,**

**[DEFECT]**

/

“MM”,

**INFORMATION =/**

**1**

,  
**[DEFECT]**

/ 2

,

)

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### 3 *Catalogue Matériaux Aster*

*Code\_Aster has a Catalogue Materials whose objectives are:*

- to provide the users, the data materials necessary to the realization of studies numerical,*
- to ensure the perennality of information,*
- to guarantee the reliability and the coherence of the data available,*
- and to facilitate and automate the access to the data.*

*In Code\_Aster, the material is defined by a whole of characteristics necessary to the setting in work of a law of behavior, which is introduced by the general order **DEFI\_MATERIAU**.*

*In the Catalogue Materials, the material is indexed by its designation in standard AFNOR.*

*The Catalogue Materials distinguishes two types of materials according to the type of study:*

*• the “material of reference” for generic studies. It corresponds to a whole of products manufactured according to the same well defined specification. It is characterized by values median, minimal and maximum typical of the population concerned. It is it material which it is advised to use if one does not have a perfect description of material to be modelled,*

*• the “particular material” for specific studies. It corresponds to a product well identified or with a concept of material given. This material is characterized by values specific of its properties, together with extreme values related to the heterogeneity of material and/or with uncertainty on the values. This material is finely documented so to avoid its systematic use without precaution.*

*In addition, one can index various materials (of reference or private individual) corresponding to even designation AFNOR. The RCC-M distinguishes, for the same designation AFNOR, them characteristics material following the technical specification of reference, the type of product (forged, rolled-iron product, tube, sheet,...) and dimensions of the component. In order to take account of this dimension additional, in the Catalogue Materials, one associates each material a letter of the alphabet.*

*To summarize, in the Catalogue Materials the materials are indexed by a chain of*

*characters which is composed of the concatenation:*

- *designation in standard AFNOR,*
- *word ref. (if material of reference) or BY (if particular material),*
- *of a letter of the alphabet.*

*For example: 18MND5\_REF\_A*

*The Catalogue Materials is presented in two distinct forms:*

- *a form “files” usable by Code\_Aster by order INCLUDE\_MATERIAU.  
It is a whole of files having for name the character string previously  
described (for example 18MND5\_REF\_A) and for extension one of the character strings  
following: NOMI (for the median values), MINIS (for the minimal values) and MAXIMUM  
(for the maximum values),*

- *a form “cards”, where the user can consult the characteristics materials in form  
tables and to obtain the origin of the characteristics. This shape of the catalogue is accessible  
on the site of Code\_Aster: [www.code-aster.org](http://www.code-aster.org) under the mitre “Use”. Each card  
material is the subject of an independent validation by department MMC.*

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#### **4 Operands**

**NOM\_AFNOR/TYPE\_MODELE/ALTERNATIVE/  
TYPE\_VALE**

*These operands make it possible to choose material to be used and thus to define its name according to the rule presented in [§3].*

**NOM\_AFNOR**

=

**nomafnor**

**[K8]**

*Allows to specify the designation of material in standard AFNOR (for example: 18MND5).*

**TYPE\_MODELE =/**

**“Ref.”,**

**/**

**“BY”,**

*Allows to specify if they are the characteristics of material of reference or those of particular material which one wishes to use.*

**ALTERNATIVE**

=

**/**

**“A”,**

**.....**

**/**

**“Z”,**

*Allows to specify the alternative of the material which one wishes to use (the characteristics are in general different according to the thickness or the diameter and this for the same designation in standard AFNOR). The paragraph of description of material of the card material allows to know the alternative interesting the user.*

**TYPE\_VALE**

=

**/**

**“NOMI”,**

**/“MAXIMUM”,**

*/“MINI”,*

*Allows to specify if one wants to use the median values, minimal or maximum.*

**5 Operand**  
**NOM\_MATER**

**NOM\_MATER**

**=**

*to subdue*  
**[K8]**

*Allows the user to specify the name which will be affected with the MATER concept used in Aster. The user can thus carry out several INCLUDE\_MATERIAU in the same Aster calculation, with condition of giving different names of MATER concept to each call to INCLUDE\_MATERIAU.*

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**6 Word**  
**key**  
**EXTRACTION**

*The values of characteristics material contained in the Catalogue Materials are generally*

*tables of values depending on the temperature. So one did not inform in the Catalogue Materials that certain key words control ratios **DEFI\_MATERIAU**: those for which operands are defined by functions (for example: **ELAS\_FO**, **THER\_NL**,...). On the other hand, words key factors for which the operands are defined by realities (for example: **ELAS**,...) are not not well informed in the various files composing the form "files" of the Catalogue Materials. One can however generate these key words in order **DEFI\_MATERIAU** by the key word **EXTRACTION** by specifying the behavior which one wishes to generate and by specifying the value of temperature to which one wishes to extract the values from the function.*

## **6.1 Operand**

### **COMPOR**

#### **COMPOR**

=

*compor*

**[K16]**

*Behavior to be created in order **DEFI\_MATERIAU** (for example **ELAS** from **ELAS\_FO** for a given temperature) (must correspond to a key word factor of **DEFI\_MATERIAU**).*

## **6.2 Operand**

### **TEMP\_EVAL**

#### **TEMP\_EVAL**

=

*temp*

**[R8]**

*Temperature to which, one wishes to extract the values from the characteristics materials. By example, one creates in order **DEFI\_MATERIAU** the operand  $E = E$  under the key word  $0$  factor **ELAS** by extracting the value with  $T$  from the operand  $E = E(T)$  definite under the key word  $0$  factor **ELAS\_FO**. To be able to carry out such an operation, it is necessary of course, that the word key **ELAS\_FO** is defined in the file associated with selected material. The interpolation, if need is, is linear, except if it is not authorized.*

## **7 Operand**

### **UNITE\_LONGUEUR**



**UNITE\_LONGUEUR =/“Me**

,  
**[DEFECT]**

/

**“MM”**

,

*Allows to use the data of the catalogue material with the millimetre like unit of length.*

*The values indicated in the catalogue material are and remain in meters. If the user specifies UNITE\_LONGUEUR = “MM” in the order INCLUDE\_MATERIAU, that means that the user wishes to handle units of length in millimetres, and orders it INCLUDE\_MATERIAU carries out the transformation of the units.*

**8 Operand**

**INFORMATION**

**INFORMATION**

=

/

1,

**[DEFECT]**

/

2,

1

*no impression of the contents of the file included,*

2

*impression of the contents of the file included, in the file “MESSAGE”.*

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**9 Example**

**of use**

**.**

**Command file**

**BEGINNING ()**

**....**

**....**

**.....**

**....**

**INCLUDE\_MATERIAU**

**(NOM\_AFNOR = "18MND5", TYPE\_MODELE = "ref.",**

**ALTERNATIVE = "A"**

**, TYPE\_VALE**

**= "NOMI",**

**NOM\_MATER**

**=**

**"MAT3"**

**,**

**INFORMATION**

**=**

**2**

)

*chmat3 = AFFE\_MATERIAU (GRID = my,*

*AFFE=\_F (GROUP\_MA= (“STRIA1”. , “SQUA”), MATER=MAT3, TEMP\_REF =20.))*

....

....

....

....

*END ()*

.

*File material associated with /aster/v7/STA7/materiau/18MND5\_REF\_A.NOMI*

#

*# LAMBDA according to the temperature*

#

*A0 = DEFI\_FONCTION (*

*NOM\_PARA*

*=*

*“TEMP”*

*,*

*PROL\_DROITE*

*=*

*“EXCLUDED”*

*,*

*PROL\_GAUCHE*

*=*

*“EXCLUDED”*

*,*

*VALE*

*=*

*(*

*20.*

*,*

*37.7*

*,*

*50.*

*, 38.6,*

..  
..

..  
..

**600.,**  
**33.0**  
,  
**650.,**  
**31.8**

))

....  
....  
.....  
....

#  
*# ALPHA according to the temperature*

#  
**A4 = DEFI\_FONCTION (**  
**NOM\_PARA**  
**=**  
**“TEMP”**

,  
**PROL\_DROITE**  
**=**  
**“EXCLUDED”**

,  
**PROL\_GAUCHE**  
**=**  
**“EXCLUDED”**

,

**VALE**

=

(

**20.**

**, 11.22E-6, 50.**

**, 11.45E-6,**

..

..

..

..

**400.,**

**13.72E-6**

,

**450.,**

**14.02E-6,**

))

....

....

.....

....

**chechmate = DEFI\_MATERIAU (**

**THER\_NL = \_F (**

**#**

**SUBST**

**THER**

**RHO\_CP**

=

***A1***

,

***#***

***EVAL***

***Z1***

***LAMBDA***

=

***A0***

,

***#***

***EVAL***

***Z0***

)

***ELAS\_FO =\_F (***

***#***

***SUBST***

***ELAS***

***E***

=

***A2***

***#***

***EVAL***

***Z2***

***NAKED***

=

***A3***

***#***

***EVAL***

***Z3***

***ALPHA***

=

***A4***

***#***

***EVAL***

***Z4***

***TEMP\_DEF\_ALPHA***

=

**20.**

#

**SUPPR**

)

)

**RETURN ()**

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**Date:**

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**Author (S):**

**J. Key PELLETT**

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**Organization (S): EDF-R & D /AMA**

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***Operator AFFE\_MATERIAU***

***1 Goal***

***To assign materials to geometrical zones of a grid.***

***Product a structure of data of the cham\_mater type.***

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***J. Key PELLET***



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**2 Syntax**

**chm [cham\_mater] = AFFE\_MATERIAU**

(  
**GRID = my**  
,  
/  
**[grid]**  
/  
**[skeleton]**

**MODEL = Mo, [model]**

**# assignment of the name of material and the temperature of reference:**

**AFFE**  
=  
**(\_F (**

*/ALL =  
“YES”,  
/  
NET*

*= lma  
,  
[l\_maille]  
/  
GROUP\_MA  
= lgma  
,  
[l\_gr\_maille]*

*MATER  
=/chechmate  
,  
[to subdue]*

*/  
l\_mat,  
[l\_mater]*

***TEMP\_REF***

= / 0.

, ***[DEFECT]***

/

***tref***

,

***[R]***

***SECH\_REF = sref,***

***[R]***

),),

***# assignment of the variables of orders:***

***AFFE\_VARC***

= ( ***\_F*** (

/ ***ALL*** =

***“YES”, [DEFECT]***

/

/

**NET**

= *lma*

, [*l\_maille*]

/

**GROUP\_MA**

= *lgma*,

[*l\_gr\_maille*]

**NOM\_VARC**

=/“**IRRA**”,

/

“**CORR**”,

/

“**NEUTI**”,

/

**“NEUT2”,**

/

**CHAMP\_GD = chvarc**  
**[field]**

/

**EVOL**  
**= evovarc [evol\_sdaster]**

**NOM\_CHAM = nosymb, [TXM]**

***VALE\_REF = vref, [R]***

***),),***

***)***

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### **3 General information**

*This order is used to affect the material characteristics on the finite elements of the model (even if in fact the meshes of the grid are really affected). These characteristics material are defined by the materials which one affects on the meshes (key word **MATER**). Each material contains a certain number of parameters (Young modulus, density,...). These parameters can be related to certain variables. We will call these variables of “variable of order”.*

*Currently, the variables of order used (in mechanics) are the temperature, the hydration, drying, phases metallurgical, irradiation, corrosion,... But only affected variables via order **AFFE\_MATERIAU** for the moment the irradiation (**IRRA**) and corrosion (**CORR**) are.*

### **4 Operands**

#### **4.1**

#### **GRID**

**GRID** = my,

*Name of the grid (or the skeleton) which one wants to affect by material characteristics.*

**Note:**

*The operation of assignment is the same one for the meshes of a skeleton as for the meshes of one grid. In the continuation of the document, one will always say grid to simplify.*

*When one affects materials on the meshes of a skeleton, it is that one wants to calculate*

*constraints (for example) on the meshes of postprocessing (coarser).*

## ***4.2 Place of assignment***

### ***AFFE***

*Key word factor which makes it possible to affect various materials on “pieces” of the grid.*

*/ALL = “YES”,*

*This key word makes it possible to affect on all the meshes of the grid.*

*/GROUP\_MA = l<sub>gma</sub>,*

*This key word makes it possible to affect on a list of groups of meshes of the grid.*

*/  
NET  
=  
l<sub>ma</sub>,*

*This key word makes it possible to affect on a list of meshes of the grid.*

*With each group of meshes, (key word GROUP\_MA) or each list of meshes (key word NETS), or with all the grid (key word ALL) is affected a material chechmate, which is a concept product by one of operators DEFINI\_MATERIAU [U4.43.01] or DEFINI\_COQU\_MULT [U4.42.03].*

*Let us recall that order DEFINI\_MATERIAU [U4.43.01] makes it possible to define the parameters of relations of behavior to be used for a mechanical, thermal, acoustic analysis. order DEFINI\_COQU\_MULT [U4.42.03] allows to define a homogenized material representative of a laminated material multi-layer.*

*If a mesh appears explicitly (or implicitly) in several occurrences of the key word factor AFFE, the rule of overload is applied: it is the last assignment which precedes [U2.01.08].*

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## 4.3

***Quantities to be affected***

### ***4.3.1 Notice concerning calculations of breaking process***

***In general, the material characteristics must be known finite elements modelling “matter”: “voluminal” elements (or of structure). The finite elements of “skin” are there for to apply boundary conditions and do not have to know the material properties of the matter subjacent. An exception exists for the calculation of option CALC\_K\_G of the operators . For these calculations, the finite elements modelling the lips of the crack must be affected by same material as the “voluminal” elements subjacent.***

### ***4.3.2 Operand***

***MATER***

***MATER = chechmate,***

***Name of the material which one wants to affect.***

***In the case general, each mesh is affected only by one material. Sometimes, it is necessary to indicate a material list when the nonlinear mechanical behavior is obtained by order DEFI\_COMPOR [U4.43.06].***

### ***4.3.3 Operand***

***TEMP\_REF***

***TEMP\_REF = Tref,***

***The temperature of Tref reference introduced behind key word TEMP\_REF is the temperature for which it does not have there thermal deformation (cf [R4.08.01]).***

*If the thermal dilation coefficient (of which the value is introduced into the order HT*

*DEFI\_MATERIAU [U4.43.01]) does not depend on the temperature:*

*(T) = (T - ref.  
T).*

*If the thermal dilation coefficient depends on the temperature the mathematical expression allowing the calculation of the thermal deformation differs according to the specification from thermal dilation coefficient in order DEFI\_MATERIAU:*

*.  
the values of the thermal dilation coefficient (introduced into DEFI\_MATERIAU) have summer determined by tests of dilatometry carried out at the Tref temperature. In this case, key word TEMP\_DEF\_ALPHA should not be specified in the order DEFI\_MATERIAU and the thermal deformation are calculated by the expression:*

*HT (T) = (T) (  
HT  
T - ref.  
T) and (ref.  
T) = 0*

*where (T) is well informed under the key word ALPHA (or ALPHA\_\*) in DEFI\_MATERIAU.*

*.  
the values of the thermal dilation coefficient are determined by tests of dilatometry which took place at a Tdef temperature different from the temperature from Tref reference. It is then necessary to carry out a change of reference mark in the calculation of the deformation thermics [R4.08.01].*

*HT (T) = HT (T) - HT  
m  
m (ref.  
T)*

*where thm is the thermal deformation measured (definite compared to the temperature Tdef),*

*HT is the thermal deformation calculated (definite compared to the temperature Tref).*

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*The Tdef temperature is indicated under key word TEMP\_DEF\_ALPHA in DEFI\_MATERIAU, and values of the dilation coefficient (definite compared to Tdef temperature) are indicated under the key word ALPHA or (ALPHA\_\*) in DEFI\_MATERIAU.*

#### **4.3.4 Operand**

**SECH\_REF**

**SECH\_REF: c0 [R]**

*c0 represents the water content initial of the concrete. The user must provide this number when it does one mechanical calculation (MECA\_STATIQUE or STAT\_NON\_LINE) with a loading of the type SECH\_CALCULEE.*

*c0 must be given in the same units as the “drying” of SECH\_CALCULEE (for example in L/m3). This unit must be coherent with parameter DEFI\_MATERIAU/ELAS\_FO/K\_DESSIC.*

*With this water content initial, the withdrawal of desiccation is null since:  
 $EPS_{rd} = K_{DESSIC} (C0 - C)$ .*

#### **4.4 Word**

**key**

**AFFE\_VARC**

*This key word factor makes it possible to affect fields of variables of order on the meshes of grid. An event of the key word is used to affect a variable of order. For the moment, both variables of order usable in this order (IRRA and CORR) have each one only one*

*component (IRRA and COOR) but it is envisaged for example that a deformation (6 components EPXX, EPYY,...) can be a variable of order.*

#### **4.4.1 Operand**

**NOM\_VARC**

**NOM\_VARC = nomvarc,**

*Name of the variable of order which one wants to affect (IRRA or CORR).*

#### **4.4.2 Operands**

**TOUT=' OUI', GROUP\_MA=lgma, MAILLE=lmail**

*These key words make it possible to indicate the zone to be affected.*

#### **4.4.3 Operand**

**CHAMP\_GD=chvarc**

*This key word makes it possible to associate the variable of order nomvarc the field chvarc. This field is a field of realities (not of functions). It is thus independent of time and will be used throughout transitory calculations.*

*If the values of the variable of order are dependent on time, it is necessary to use key word EVOL (see below).*

*In the field chvarc, the program will seek a of the same component name than nomvarc.*

#### **4.4.4 Operands**

**EVOL=evovarc and NOM\_CHAM=nomsym**

*These key words make it possible to associate the variable of order nomvarc the transient evovarc. key word NOM\_CHAM makes it possible to indicate the reference symbol of the fields of SD\_résultat to be used.*

*By defect, the code chooses NOM\_CHAM=' IRRA' for NOM\_VARC=' IRRA' and NOM\_CHAM=' CORR' for*

*NOM\_VARC=' CORR'. The fields are fields of realities (not functions). In these fields, it program will seek a of the same component name than nomvarc.*

#### **4.4.5 Operand**

**VALE\_REF=vref**

*This key word makes it possible to define a value of “reference” for the variable of order nomvarc. By example, when drying is treated like a variable of order in the key word AFFE\_VARC, key word VALE\_REF will replace key word current SECH\_REF. 2 current variables (IRRA and CORR) do not have a value of reference.*

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**Titrate:**

**Operator AFFE\_MATERIAU**

**Date:**

**31/01/06**

**Author (S):**

**J. Key PELLET**

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**5 Examples**

**Example 1**

**chmat = AFFE\_MATERIAU (GRID = my, AFFE = (**

**\_F (ALL = "YES", MATER = steel),**

**\_F (MAILLE= ("ma1", "ma2", "ma3"), MATER=alu,  
TEMP\_REF=20.),),**

**)**

**On the whole of the grid (except the meshes: ma1, ma2, ma3) are affected the material of name steel with the temperature of reference per defect: 0.**

**On the meshes ma1, ma2, ma3 are affected the material aluminum with the temperature of reference 20.**

**Example 2**

*Assignment on all the grid of the material CHECHMATE whose certain parameters are related to irradiation. The temporal evolution of the irradiation is given via the SD result EVOL = FLUENC.*

```
CHMAT = AFFE_MATERIAU (GRID = MA,
AFFE = _F (TOUT=' OUI', MATER = CHECHMATE,),
AFFE_VARC=_F (NOM_VARC=' IRRA', EVOL =FLUENC,),
)
```

**Example 3**

*Use of the variable of order “NEUT1” to simulate a dependence of the coefficients materials according to the Young modulus.*

*In this example (resulting from the case test ssnv130c), one wants to illustrate the possibility of using a field of*

*Young modulus whom one supposes known (CHYOUNG). For example, this field is read in a file (LIRE\_CHAMP) or it is the result of a calculation. One then will define a material for which Young modulus (key word E) is the function “identity” of variable “NEUT1” and the field is affected CHYOUNG like variable of order “NEUT1”.*

```
CHYOUNG=...
```

```
NU_F=DEFI_CONSTANTE (VALE=0.3)
```

```
E_F = DEFI_FONCTION (NOM_PARA=' NEUT1', VALE= (- 1.E-9, - 1.E-9, 1.E+9,1.E+9));
```

```
MA=DEFI_MATERIAU (ELAS_FO=_F (E=E_F, NU=NU_F),,);
```

```
CM=AFFE_MATERIAU (MAILLAGE=M,
```

```
AFFE=_F (TOUT= “YES”, MATER= MA),
```

```
AFFE_VARC=_F (NOM_VARC=' NEUT1', CHAMP_GD=CHYOUNG),
```

```
)
```

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**19/01/05**

**Author (S):**

**V. CANO Key**

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**Organization (S): EDF-R & D /AMA**

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**Document: U4.43.04**

**Operator DEFI\_TRC**

**1 Goal**

**To define a diagram TRC (Transformations into Continuous Cooling) of reference for metallurgical calculations.**

**The diagram trc thus defined is necessary to the characterization of a law of behavior metallurgical with cooling in operator DEFI\_MATERIAU (key word factor META\_ACIER).**

*For the definition of the metallurgical data and the modeling which is made by it, one will refer to document [R4.04.01].*

*Product a structure of data of the trc type.*

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## ***2 Syntax***

***name [trc] = DEFI\_TRC***

***(HIST\_EXP = \_F***

***(***

***VALE = lval,***

***[l\_R]***



)

*TEMP\_MS = \_F*

(

*THRESHOLD*

=

*zS*

,

*[R]*

*AKM*

=

*akm*

,

*[R]*

***BKM***

=

***bkm***

,

***[R]***

***TPLM =***

***Vc, [R]***

)

***GRAIN\_AUST = \_F (DREF =***

***C, [R]***

***With =***  
***has***  
***,***  
***[R]***

)

)

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### **3 Operands**

#### **3.1 Word**

**key**

**HIST\_EXP**

**HIST\_EXP**

**=**

**An occurrence of the key word factor HIST\_EXP makes it possible to define the ferrite evolutions, pearlite and bainite associated with a thermal history with cooling and conditions with austenitization data.**

#### **3.1.1 Operand**

**VALE**

**VALE = lval**

**List values defining the austenitization, the thermal history (T T) and ferrite evolutions, pearlite and bainite.**

**The first value is the value of derived from the function (T T) (i.e. the speed of cooling) when T is worth 700°C.**

**The second value is the size of grain (i.e. their diameter) resulting from the conditions of austenitization associated with the TRC.**

**The 6 following values define the thermal history between AR3 and TMF (temperature of beginning of decomposition of austenite in “quasi-static” cooling and temperature of end of martensitic transformation respectively). These values are the respective coefficients of students'rag processions of degree 0 to 5 such as the polynomial of a nature 5 thus built either the interpolation enters**

**AR3 and TMF within the meaning of least squares of the function (F)**

**T deduced from the thermal history and such as:**

(  
*F*)  
 $T = \ln (T (T))$

*If the experimental thermal history to define is a function closely connected of time (i.e. where the speed of cooling is constant) one will inform these six values like all equal to zero.*

*The following values (necessarily by group of 4) define the respective proportions of ferrite, pearlite and bainite present at a temperature given for the thermal history experimental defined by the first 8 values.*

*The ferritic, perlitic and bainitic transformations associated a thermal history are defined by the whole of the final proportions of each phase (final Z1, final Z2, Z3 final) and corresponding temperatures, for each transformation with:*

- *the temperature to which the transformation begins,*
- *the temperature to which 1% of new phase are formed,*
- *the temperature to which Zfinal 1% of new phase is formed,*
- *the temperature to which the transformation is finished (with Zfinal of formed phase).*

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*The whole of the “points” (Z, Z, Z,)*

*T*

*1*

*2*

*3*

*defining an experimental history presents itself  
thus as follows:*

*coefficients of the polynomial*

*P5 representing F (T)*

*such as F (T) = ln (T (T))*

*T (T) for T (T) = 700°C*

*U*

*Cut grain associated to the TRC*

*N*

*D*

*with*

*HIST\_EXP = \_F*

*(VALE =*

*(*

*R*

*espo*

*-8.784D-03, 1.100D-06, 8.563D+00, -2.760D-02,*

*1.220D-04, -2.955D-07, 3.402D-10, -1.517D-13,*

*horn*

*P*

*0.000D+00, 0.000D+00, 0.000D+00,*

*8.360D+02,*

*X*

*0.000D+00, 0.000D+00, 0.000D+00,*

*7.897D+02,*

*–*  
*E*

*1.000D-02, 0.000D+00, 0.000D+00,*

*7.860D+02,*

*ST*

*7.039D-01, 0.000D+00, 0.000D+00,*

*6.568D+02,*

*temperature of*

**7.270D-01, 1.000D-02, 0.000D+00,  
6.525D+02,  
beginning of  
E  
U  
R  
HI  
7.370D-01, 2.728D-02, 0.000D+00,  
6.488D+02,  
transformation  
7.370D-01, 1.840D-01, 0.000D+00,  
6.150D+02,  
ferritic  
é fact  
7.370D-01, 1.940D-01, 0.000D+00,  
6.107D+02,  
7.370D-01, 1.940D-01, 0.000D+00,  
5.218D+02,  
O  
T  
Cl  
E  
7.370D-01, 1.940D-01, 1.000D-02,  
4.900D+02,  
m  
7.370D-01, 1.940D-01, 5.900D-02,  
4.120D+02,  
E  
ntal  
7.370D-01, 1.940D-01, 6.900D-02,  
3.802D+02  
R  
I  
m  
, )  
pé  
U  
R  
R  
E  
NCE of  
beginning of transformation**

*temperature corresponding*

*O*

*I*

*R*

*E*

*ex*

*perlite and proportion*

*to formed bainite 1% and*

*N*

*E*

*occ*

*St*

*of ferrite formed with this*

*proportion of ferrite*

*U*

*hi*

*temperature*

*and pearlite formed with this*

*temperature*

### *3.2 Word*

*key*

*TEMP\_MS*

*TEMP\_MS*

*This key word factor makes it possible to define the law of evolution of temperature ms according to quantities of ferrite, pearlite and bainite already formed according to the law:*

*Ms = Ms0*

*if*

*Z + Z + Z*

*1*

*2*

*3 THRESHOLD*

*Ms = Ms0 + AKM (Z + Z + Z*

*1*

*2*

*3) + BKM*

*if*

*Z + Z + Z*

*1*



2

### 3 > **THRESHOLD**

where  $Ms_0$  is the “traditional” temperature of martensitic beginning of transformation when this one (it is total is defined under the key word factor **META\_ACIER** of **DEFI\_MATERIAU**).

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#### 3.2.1 Operand

##### **THRESHOLD**

##### **THRESHOLD**

= zS,

**Z**

*is the quantity of austenite transformed into on this side which  $ms$  is*

**S**

*invariant.*

#### 3.2.2 Operand

##### **AKM**

**AKM**

= akm,

*akm is the factor of proportionality between the reduction in temperature  $ms$  and quantity of transformed austenite ( $Z + Z + Z$  1 2 3 ).*

### **3.2.3 Operand BKM**

**BKM**  
**=  $bkm$ ,**

*bkm is the ordinate at the origin of the equation closely connected connecting the reduction in  $ms$  to quantity of transformed austenite.*

### **3.2.4 Operand TPLM**

**TPLM**  
**=**  
 **$V_c$ ,**

*$V_c$  is the speed of cooling with  $700^\circ\text{C}$  of the experimental history more slow, which makes it possible to form a little martensite.*

*These four key words define the values of the sizes THRESHOLD, AKM, BKM intervening in law of evolution of  $ms$  that one supposes independent of the size of grain.*

## **3.3 Word**

**key**  
**GRAIN\_AUST**

*Allows to define the influence of the size of grain on the metallurgical transformations in cooling defined by the diagram  $trc$ .*

### **3.3.1 Operand DREF**

**DREF =**  
 **$C$ ,**

*$C$  is the size of grain (i.e. its diameter) associated the diagram defined under the key word factor HIST\_EXP.*

### **3.3.2 Operand**

**With**

**With =**

**has**

**,**

*A is a parameter material which makes it possible to characterize the effect of the size of grain on diagram TRC of a steel (cf [R4.04.01]).*

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*Operator* **DEFI\_TEXTURE**

*Date:*

20/12/04

*Author (S):*

**J.M. PROIX**, Key S. TAHERI

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*Organization (S):* EDF-R & D /AMA

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***Document: U4.43.05***

***Operator*** **DEFI\_TEXTURE**

## ***1 Goal***

***To define, for a material CFC, crystallographic orientations and their system of slip.***

***This operator creates a concept of the `tabl_texture` type which is necessary to the characterization of one***

***law of polycrystalline behavior (`POLY_CFC`) in operator `DEFI_MATERIAU`.***

***For the definition of the metallurgical data and the modeling which is made by it, one will refer to document [R5.03.13].***

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***Titrate:***

***Operator `DEFI_TEXTURE`***

***Date:***

***20/12/04***

***Author (S):***

***J.M. PROIX, Key S. TAHERI***

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## ***2 Syntax***

***name [`tabl_texture`] = `DEFI_TEXTURE` (***

***`SYST_GLISSEMENT`***

***= (***

***`_F` (***

***`NR` = (`xN1`, `xN1`, `xN1`, `xN2`, `xN2`, `xN2`, ..., `xN4`, `xN4`, `xN4`, `xN4`), [`l_R`]***

*L* = (*xL1*, *xL2*,... *xL12*), [*l\_R*]  
)  
*\_F* (  
*NR* = (*yN1*, *yN1*, *yN1*, *yN2*, *yN2*, *yN2*,..., *yN4*, *yN4*, *yN4*, *yN4*), [*l\_R*]

*L* = (*yL1*, *yL2*,... *yL12*), [*l\_R*]  
)  
*\_F* (  
*NR* = (*zN1*, *zN1*, *zN1*, *zN2*, *zN2*, *zN2*,..., *zN4*, *zN4*, *zN4*, *zN4*), [*l\_R*]

*L* = (*zL1*, *zL2*,... *zL12*), [*l\_R*]  
)

*PLAN* = (  
*\_F* (  
*ANGL\_NAUT*

*ANGL\_NAUT*

=  
(  
*a11*,  
*a12*,  
*a13*),

[*l\_R*]

*PROPORTION* = *val1*

[*R*]  
)  
*\_F*  
(.....),  
*\_F* (  
*ANGL\_NAUT*

*ANGL\_NAUT*

=  
(

*a14,*  
*a2u,*  
*a3u),*  
*[l\_R]*

*PROPORTION = valn*

*[R]*  
*),),*

*TITRATE*  
*:*  
*`definition*  
*of*

*texture'*  
*[KN]*

)  
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*3 Operands*



### **3.1 Word**

*key*

**PLAN**

**PLAN**

:

*An occurrence of the key word **PLANE** factor makes it possible to lay down a crystallographic orientation in  
to leave the data:*

.

*of the three nautical angles laying down the orientation of the crystal compared to the reference mark total,*

.

*and of the proportion of the crystals of this orientation.*

#### **3.1.1 Operand**

**ANGL\_NAUT**

**ANGL\_NAUT: a1i, a2i, a3i**

*Defines the three nautical angles compared to the total reference mark for the ième orientation crystallographic. This is to be as many repeated once as of orientations present.*

*The maximum number of orientation is fixed at 40 in the source.*

#### **3.1.2 Operand**

**PROPORTION**

**PROPORTION: vali**

*The proportion of the crystals defines, of which orientation laid down above, compared to the whole of*

*crystals. This is to be repeated of as many time as of orientations present. The sum of well informed proportions must be equal to 1.*

### **3.2 Word**

*key*

**SYST\_GLISSEMENT**

**SYST\_GLISSEMENT**

:

*The key word factor **SYST\_GLISSEMENT** makes it possible to define the whole of the plans and the directions*

*of slip.*

***Currently, only the structures of the Cubiques type to Centered Faces are possible. That mean, that SYST\_GLISSEMENT must necessarily define four slip surfaces and three directions of slip for each one of these plans.***

*In fact, one directly defines the whole of all the directions of slip (thus 12 on the whole in the case CFC) and, for each directions of slip, one defines (by his normal vector) it slip surface which is associated for him (either 12 also in case CFC).*

*The complete syntax of SYST\_GLISSEMENT is thus necessarily, for a structure CFC:*

*SYST\_GLISSEMENT =*

*(*

*NR = (1. , 1. , 1. , 1. , 1. , 1. , -1. , -1. , -1. , -1. , -1. , -1.),*

*L = (- 1. , 0. , -1. , -1. , 0. , 1. , 0. , 1. , 1. , -1. , 1. , 0.)*

*)*

*(*

*NR = (1. , 1. , 1. , -1. , -1. , -1. , 1. , 1. , 1. , -1. , -1. , -1.),*

*L = (0. , -1. , 1. , 0. , 1. , 1. , -1. , 1. , 0. , 1. , 0. , 1.)*

*)*

*(*

*NR = (1. , 1. , 1. , 1. , 1. , 1. , 1. , 1. , 1. , 1. , 1. , 1.),*

$L = (1, 1, 0, 1, 1, 0, 1, 0, 1, 0, 1, 1)$

)

*One specifies however below the general standard of the operands NR and L.*

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### **3.2.1 Operand**

#### **NR**

$NR = (xN1, xN1, xN1, xN2, xN2, xN2, \dots, xN4, xN4, xN4, xN4)$

*Values:  $xN1, \dots, xN4$ , are projections on axis OX of the crystal, of the normal vectors with all slip surfaces. The values  $yNi$  and  $zNi$  answer a similar definition for projections on axes OY and OZ of the crystal. The figure below shows a slip surface with the associated normal and the 3 associated directions of slip for CFC.*

$xL2, yL2, zL2$

Z

$xL1, yL1, zL1$

$xL3, yL3, zL3$

$B$

*normal in the ABC plan (*

$xN1, yN1, zN1)$

*With*

$y$

$C$

$X$

### **3.2.2 Operand**

**$L$**

$L = (xL1, xL2, \dots, xL12)$

*Values:  $xL1, \dots, xL12$ , is projections on axis  $OX$  of the crystal of the 12 directions of slips for the 4 slip surfaces. The first 3 values being projections of the 3 directions of slips of the foreground defined by  $xN1, yN1$  and  $zN1$  under  $NR$ . The values  $yLi$  and  $zLi$  answer a similar definition for projections on axes  $OY$  and  $OZ$  of the crystal.*

### **3.3 Word**

**key**

**TITRATE**

**TITRATE**

*Titrate that the user wants to see appearing in the structure of data  $tabl\_texture$ .*

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*Organization (S): EDF-R & D /AMA*

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***Document: U4.43.06***

***Operator DEFI\_COMPOR***

## **1 Goal**

**To define the behavior of a monocrystal or a polycrystal, while allowing the user to choose them components of the single-crystal law of behavior. One gives, according to this definition, only its name of the crystallographic structure, knowing that directions of the systems of slip of each family of systems of slip are defined once for all in the source. behavior is defined in an external way with STAT\_NON\_LINE.**

**The structure of produced data contains names of systems of slip, associated names material parameters, for each behavior of monocrystal. Names of the systems of slip refer to internal objects with the code specifying for each one the orientations of slip surfaces.**

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## **2 Syntax**

**Comp1 [compor] = DEFI\_COMPOR (**

**/MONOCRYSTAL**

=  
(  
\_F (  
  
**MATER=**  
**mat1,**  
**[to subdue]**  
  
**FLOW =/“ECRO\_VISC1”**  
**/“ECOUC\_VISC2”**  
**/“ECOUC\_VISC3”**  
  
**ECRO\_ISOT=/**  
**“ECRO\_ISOT1”**  
**/**  
**“ECRO\_ISOT2”**  
  
**ECRO\_CINE=/**  
**“ECRO\_CINE1”**  
  
**“ECRO\_CINE2”**  
  
**ELAS=**  
  
**/“ELAS”**  
**“ELAS\_ORTH”**  
**FAMI\_SYST\_GLIS =/“BASAL”,**  
**/“PRISMATIC”,**  
**/“OCTAHEDRAL”,**  
**/“PYRAMIDAL1”,**  
**/“PYRAMIDAL2”,**  
**/“CUBIQUE1”,**  
**/“CUBIQUE2”,**  
**/“STIRRING”,**  
**/“JOINT\_GRAIN”**  
**/“RL”,**  
**/“UNIAXIAL”**  
)  
/  
**POLYCRYSTAL**

=

(  
\_F (

**MONOCRYSTAL**

=

**comp1,**  
**[compor]**

**FRAC\_VOL**

=

**fvol, [R]**

**ANGL\_REP**

=

**(has, B, c)**  
**[l\_R]**  
**)**

**LOCALIZATION =**

**/"BZ",**  
**/"BETA",**

**DL**

=

**dl,**  
**[R]**



**DA**  
=  
**da,**  
**[R]**  
)

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***J.M. PROIX, T. KANIT Key***  
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***3 Operands***

***3.1 Word***  
***key***  
***MONOCRYSTAL***

*An occurrence of the key word factor MONOCRYSTAL makes it possible to define a law of behavior elastoviscoplastic single-crystal. This is to be repeated once as many as one has laws of behavior single-crystal different [R5.03.11].*

### **3.1.1 Operand MATER**

*The name of the SD material defines used for the monocrystal. This operand makes it possible to check that parameters associated with the behaviors chosen under the key words FLOW, ECRO\_ISOT, ECRO\_CINE and ELAS exist well in material.*

### **3.1.2 Operand FLOW**

*The viscoplastic type of flow used in the definition of the law of behavior defines MONOCRYSTAL. This is to be chosen among: ECOU\_VISC1, ECOU\_VISC2, ECOU\_VISC3.*

### **3.1.3 Operand ECRO\_ISOT**

*The isotropic type of work hardening used in the definition of the law of behavior defines MONOCRYSTAL. This is to be chosen among: ECRO\_ISOT1 or ECRO\_ISOT2.*

### **3.1.4 Operand ECRO\_CINE**

*The kinematic type of work hardening used in the definition of the law of behavior defines MONOCRYSTAL. This is to be chosen among: ECRO\_CINE1 or ECRO\_CINE2.*

### **3.1.5 Operand ELAS**

*The type of the elastic behavior used in the definition of the law of behavior defines MONOCRYSTAL. This is to be chosen among: ELAS or ELAS\_ORTH.*

### **3.1.6 Operand FAMI\_SYST\_G LIS**

*The surname of the systems of slip defines on which one defined the law of behavior MONOCRYSTAL. Orientations of the normals in the slip surfaces and of directions of slip are calculated automatically by the code starting from the name of family.*

*This one is to be chosen among: BASAL, PRISMATIC, OCTAHEDRAL, PYRAMIDAL1, PYRAMIDAL2,*

## ***CUBIQUE1, CUBIQUE2, STIRRING, JOINT\_GRAIN, RL.***

### ***3.2 Word***

***key***

***POLYCRYSTAL***

***An occurrence of the key word factor POLYCRYSTAL makes it possible to define a phase of the behavior***

***polycrystalline, starting from the data of a single-crystal behavior, voluminal fraction of this phase, and of the orientation of this phase. This is to be repeated once as many as one has different single-crystal phases. Moreover, one rule of localization, commune to all them phases, is defined by the key word LOCALIZATION [R5.03.11].***

#### ***3.2.1 Operand***

***MONOCRYSTAL***

***The name of the SD compor defining defines the monocrystal.***

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#### ***3.2.2 Operand***

***FRAC\_VOL***

***The voluminal fraction of the phase in progress defines. The sum of the whole of the values of fvol must be equal to 1.***

#### ***3.2.3 Operand***

## ***ANGL\_REP***

*Defines the 3 nautical angles (provided in degrees) which make it possible to direct the monocrystal corresponding to the phase defined by the current occurrence of POLYCRYSTAL. For more specified on the nautical angles, to consult the documentation of AFFE\_CARA\_ELEM [U4.42.01].*

### ***3.3 Key word***

#### ***LOCALIZATION***

*The name of the rule of localization used for the polycrystal defines.*

#### ***3.3.1 Operands***

##### ***DL and DA***

*If the rule of localization is "BETA", two real parameters should be provided: dl and da.*

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### ***3.4 Examples***

*The following example corresponds to a traditional use of MONOCRYSTAL. It results from the test SSNV171B:*

***ACIER=DEFI\_MATERIAU (ELAS=\_F (E=145200.0,***

***NU=0.3,)***

***ECOUC\_VISC2=\_F (N=10.0,***

```

K=40.0,
C=1.0,
D=36.68,
A=10.0,),
ECRO_ISOT2=_F (R_0=75.5,
Q1=9.77,
B1=19.34,
H=0.5,
Q2=-33.27,
B2=5.345,),
ECRO_CINE1=_F (D=36.68,));

```

```

COMPORT=DEFI_COMPOR (MONOCRISTAL= (_F (MATER=ACIER,
ECOULEMENT=' ECOU_VISC2',
ECRO_ISOT=' ECRO_ISOT2',
ECRO_CINE=' ECRO_CINE1',
ELAS=' ELAS',
FAMI_SYST_G LIS=' OCTAEDRIQUE',),),);

```

The following example, implementing POLYCRYSTAL, results from test SSNV125:

```

MATPOLY=DEFI_MATERIAU (ELAS=_F (E=192500.0,
NU=0.3,),
ECOULEMENT=_F (N=10.0,
K=40.0,
C=6333.0,
D=36.68,
A=72.21,),
ECRO_ISOT2=_F (R_0=75.5,
Q1=9.77,
B1=19.34,
H=2.54,
Q2=-33.27,
B2=5.345,),
ECRO_CINE1=_F (D=36.68,));

```

```

MONO1=DEFI_COMPOR (MONOCRISTAL=_F (MATER=MATPOLY,
ECOULEMENT=' ECOU_VISC2',
ECRO_ISOT=' ECRO_ISOT2',
ECRO_CINE=' ECRO_CINE1',
ELAS=' ELAS',
FAMI_SYST_G LIS=' OCTAEDRIQUE',),);

```

```

POLY1=DEFI_COMPOR (POLYCRISTAL= (_F (MONOCRISTAL=MONO1,

```

*FRAC\_VOL=0.025,*  
*ANGL\_REP= (- 149.676, 15.61819, 154.676),),*  
*\_F (MONOCRISTAL=MONO1,*  
*FRAC\_VOL=0.025,*  
*ANGL\_REP= (- 481.729, 35.46958, 188.729),),),*  
*LOCALISATION=' BETA',*  
*DL=321.5,*  
*DA=0.216,);*  
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***Operators AFFE\_CHAR\_MECA and***

***AFFE\_CHAR\_MECA\_F***



## ***1 Goal***

***To affect loadings and boundary conditions on a mechanical model.***

.  
***For AFFE\_CHAR\_MECA, the values affected do not depend on any parameter and are defined by actual values.***

.  
***For AFFE\_CHAR\_MECA\_F, the values affected are related to one or more parameters as a whole {INST, X, Y, Z}.***

***These functions must be in particular defined beforehand by the call to one of operators:***

.  
***DEFI\_CONSTANTE [U4.31.01],***

.  
***DEFI\_NAPPE [U4.31.03],***

.  
***DEFI\_FONCTION [U4.31.02],***

.  
***CALC\_FONC\_INTERP [U4.32.01].***

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*2 Syntax*

*general*

*CH [char\_meca] = AFFE\_CHAR\_MECA*

(

*MODEL*

= *Mo*,

*[model]*

/

*VERI\_NORM =*

/

*“YES”*,

*[DEFECT]*



/  
“NOT”,

/ **LIAISON\_XFEM= “YES”**

/  
**TEMP\_CALCULEE=**  
*temple,*

/  
**[evol\_ther]**

/  
**[cham\_no\_TEMP\_R]**

/  
**[carte\_TEMP\_R]**

/  
**[carte\_TEMP\_F]**

/  
**HYDR\_CALCULEE=**  
*hydr,*  
**[evol\_ther]**

/  
**SECH\_CALCULEE=**  
*sech,*

/  
**[evol\_ther]**

/  
**[cham\_no\_TEMP\_R]**

/  
**[carte\_TEMP\_R]**

/  
**[carte\_TEMP\_F]**

/  
**EPSA\_CALCULEE=**  
*epan*  
*[evol\_noli]*

**/EVOL\_CHAR**

= *evch*  
*[evol\_char]*

**/PESANTEUR=**

*(G, ap, LP, CP)*

*[l\_R]*

**/ROTATION=**

*(Omega, rear, Br, Cr)*

*[l\_R]*

**/DDL\_IMPO= \_F**

*(see key word DDL\_IMPO*

*[§*

*4.12])*

**/ FACE\_IMPO= \_F**  
*(see key word FACE\_IMPO*  
*[§*  
*4.13])*

**/ LIAISON\_DDL= \_F**  
*(see key word LIAISON\_DDL*  
*[§ 4.14])*

**/ LIAISON\_OBLIQUE= \_F** *(see key word LIAISON\_OBLIQUE [§ 4.15])*

**/ LIAISON\_GROUP= \_F** *(see key word LIAISON\_GROUP [§*  
*4.16])*

**/ LIAISON\_MAIL= \_F** *(see*  
*key word LIAISON\_MAIL [§*  
*4.17])*

**/ LIAISON\_CYCL= \_F** *(see*  
*key word LIAISON\_CYCL [§*  
*4.18])*

**/**  
**CONTACT= \_F**

*(see  
key word CONTACT  
[§  
4.19])*

*/ FORCE\_NODALE=\_F (see  
key word FORCE\_NODALE [§  
4.20])*

*/ LIAISON\_SOLIDE=\_F (see key word LIAISON\_SOLIDE [§ 4.21])*

*/ LIAISON\_ELEM=\_F (see  
key word LIAISON\_ELEM [§  
4.22])*

*/ LIAISON\_UNIF=\_F (see  
key word LIAISON\_UNIF [§  
4.23])*

*/ LIAISON\_CHAMNO=\_F (see key word LIAISON\_CHAMNO [§ 4.24])*

*/ VECT\_ASSE=\_F  
  
(see key word VECT\_ASSE*

[§  
4.25])

*continuous medium*

*/ FORCE\_FACE=\_F*  
(see key word *FORCE\_FACE* [§  
4.26])

*/ FORCE\_ARETE=\_F*  
(see key word *FORCE\_ARETE*  
[§ 4.27])

*/ FORCE\_CONTOUR=\_F* (see key word *FORCE\_CONTOUR* [§  
4.28])

*/ FORCE\_INTERNE=\_F* (see key word *FORCE\_INTERNE* [§  
4.29])

*/*  
*PRES\_REP=\_F*  
(see  
key word *PRES\_REP*  
[§  
4.30])

*/ EFFE\_FOND=\_F*  
(see key word *EFFE\_FOND*

[§  
4.31])

*/ EPSI\_INIT = \_F*

*(see key word EPSI\_INIT*

[§  
4.32])

*beam hull*

*/ FORCE\_POUTRE = \_F (see  
key word FORCE\_POUTRE [§  
4.33])*

*/ DDL\_POUTRE = \_F  
(see key word DDL\_POUTRE [§  
4.34])*

*/ FORCE\_TUYAU = \_F  
(see key word FORCE\_TUYAU  
[§ 4.35])*

*/ FORCE\_COQUE = \_F  
(see key word FORCE\_COQUE  
[§ 4.36])*

*/ LIAISON\_COQUE = \_F (see key word LIAISON\_COQUE [§  
4.37])*

***concrete***

***/ RELA\_CINE\_BP=\_F (see  
key word RELA\_CINE\_BP [§  
4.38])***

***électroméca***

***/ FORCE\_ELEC=\_F  
(see key word FORCE\_ELEC [§  
4.39])***

***/ INTE\_ELEC=\_F***

***(see key word INTE\_ELEC  
[§  
4.40])***

***accoustics***

***/ IMPE\_FACE=\_F***

***(see key word IMPE\_FACE  
[§  
4.41])***

***/ VITE\_FACE=\_F***

***(see key word VITE\_FACE  
[§  
4.42])***

***/ ONDE\_FLUI=\_F***

*(see key word ONDE\_FLUI*

*[\$*

*4.43])*

*/ ONDE\_PLANE=\_F*

*(see key word ONDE\_PLANE [\$*

*4.44])*

*thermo-hydrau*

*/ FLUX\_THM\_REP=\_F (see*

*key word FLUX\_THM\_REP [\$*

*4.45])*

*méth. Harlequin*

*/ HARLEQUIN =\_F (see*

*key word*

*HARLEQUIN*

*[\$*

*4.46])*

*fluid forces of fall of bunches*

*/ GRAPPE\_FLUIDE =\_F (see key word GRAPPE\_FLUIDE [\$ 4.47])*

**INFORMATION**

**=**

**/**

**1**

**,  
[DEFECT]**

**/ 2**



,  
)  
;  
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**CH [char\_meca] = AFFE\_CHAR\_MECA\_F**

**(MODELE= Mo,**  
**[model]**

/  
**DDL\_IMPO=\_F**  
**(see**  
**key word DDL\_IMPO**  
**[\$**  
**4.10])**

**/ FACE\_IMPO=\_F**

**(see key word FACE\_IMPO**

[§  
4.11])

*/LIAISON\_DDL=\_F*  
(see key word *LIAISON\_DDL*  
[§ 4.12])

*/LIAISON\_OBLIQUE=\_F* (see key word *LIAISON\_OBLIQUE* [§ 4.13])

*/LIAISON\_GROUP=\_F* (see key word *LIAISON\_GROUP* [§  
4.14])

*/*  
*CONTACT=\_F*  
(see  
key word *CONTACT*  
[§  
4.16])

*/FORCE\_NODALE=\_F* (see key word *FORCE\_NODALE* [§  
4.17])

*/LIAISON\_SOLIDE=\_F* (see key word *LIAISON\_SOLIDE* [§ 4.18])

**/ LIAISON\_UNIF=\_F** (*see*  
*key word LIAISON\_UNIF* [§  
4.20])  
*continuous medium*

**/ FORCE\_FACE=\_F**  
(*see key word FORCE\_FACE* [§  
4.23])

**/ FORCE\_ARETE=\_F**  
(*see key word FORCE\_ARETE*  
[§ 4.24])

**/ FORCE\_CONTOUR=\_F** (*see key word FORCE\_CONTOUR* [§  
4.25])

**/ FORCE\_INTERNE=\_F** (*see key word FORCE\_INTERNE* [§  
4.26])

**/**  
**PRES\_REP=\_F**  
(*see*  
*key word*  
**PRES\_REP**  
[§  
4.27])

***/ EPSI\_INIT=\_F***

*(see key word EPSI\_INIT*

*[\$*

*4.29])*

*beam hull*

***/ FORCE\_POUTRE=\_F***

*(see key word FORCE\_POUTRE [\$*

*4.30])*

***/ FORCE\_TUYAU=\_F***

*(see key word FORCE\_TUYAU*

*[\$ 4.31])*

***/ FORCE\_COQUE=\_F***

*(see key word FORCE\_COQUE*

*[\$ 4.32])*

***/ LIAISON\_COQUE=\_F (see key word LIAISON\_COQUE [\$***

*4.33])*

*accoustics*

***/ IMPE\_FACE=\_F***

*(see key word IMPE\_FACE*

*[\$*

*4.37])*

***/ VITE\_FACE= \_F***

***(see key word VITE\_FACE***

***[\$***  
***4.38]***

***/ ONDE\_PLANE= \_F***

***(see key word ONDE\_PLANE [\$***  
***4.39]***

***/ FLUX\_THM\_REP= \_F (see***  
***key word FLUX\_THM\_REP [\$***  
***4.41]***

***/***  
***VERI\_NORM =***  
***/***  
***“YES”,***  
***[DEFECT]***

***/***  
***“NOT”,***  
***)***

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**Version**

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**Operators** *AFFE\_CHAR\_MECA* and *AFFE\_CHAR\_MECA\_F*

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### **3 General information**

**Possible error messages related to order** *AFFE\_CHAR\_MECA*

**It happens sometimes that a mechanical ordering of calculation** (*MECA\_STATIQUE*, *STAT\_NON\_LINE*,...)

**stop in fatal error during the calculation of the second elementary members due to the loadings defined in the** *AFFE\_CHAR\_MECA\_xx* **orders. When the code stops during these calculations elementary, important information of the error message is the name of the option of calculation asked by the code.**

**The name of this option is in general unknown to the user and it is thus difficult for him to include/ understand the message.**

**In the table below, one gives in with respect to the names of the options of calculation, the name of order and key word factor which make it possible to activate this option.**

**Elementary option of calculation**

**Order**

**Key word factor**

***CHAR\_MECA\_EPSI\_F* *AFFE\_CHAR\_MECA\_F***

***EPSI\_INIT***

***CHAR\_MECA\_EPSI\_R* *AFFE\_CHAR\_MECA***

***EPSI\_INIT***

***CHAR\_MECA\_FF1D1D* *AFFE\_CHAR\_MECA\_F***

***FORCE\_POUTRE***

***CHAR\_MECA\_FF1D2D* *AFFE\_CHAR\_MECA\_F***

**FORCE\_CONTOUR**  
**CHAR\_MECA\_FF1D3D AFFE\_CHAR\_MECA\_F**  
**FORCE\_ARETE**  
**CHAR\_MECA\_FF2D2D AFFE\_CHAR\_MECA\_F**  
**FORCE\_INTERNE**  
**CHAR\_MECA\_FF2D3D AFFE\_CHAR\_MECA\_F**  
**FORCE\_FACE**  
**CHAR\_MECA\_FF3D3D AFFE\_CHAR\_MECA\_F**  
**FORCE\_INTERNE**  
**CHAR\_MECA\_FFC02D AFFE\_CHAR\_MECA\_F**  
**FORCE\_COQUE**  
**CHAR\_MECA\_FFC03D AFFE\_CHAR\_MECA\_F**  
**FORCE\_COQUE**  
**CHAR\_MECA\_FLUX\_F AFFE\_CHAR\_MECA\_F**  
**FLUX\_THM\_REP**  
**CHAR\_MECA\_FLUX\_R AFFE\_CHAR\_MECA**  
**FLUX\_THM\_REP**  
**CHAR\_MECA\_FORC\_F AFFE\_CHAR\_MECA\_F**  
**FORCE\_NODALE**  
**CHAR\_MECA\_FORC\_R AFFE\_CHAR\_MECA**  
**FORCE\_NODALE**  
**CHAR\_MECA\_FR1D1D AFFE\_CHAR\_MECA**  
**FORCE\_POUTRE**  
**CHAR\_MECA\_FR1D2D AFFE\_CHAR\_MECA\_F**  
**FORCE\_CONTOUR**  
**CHAR\_MECA\_FR1D3D AFFE\_CHAR\_MECA**  
**FORCE\_ARETE**  
**CHAR\_MECA\_FR2D2D AFFE\_CHAR\_MECA**  
**FORCE\_INTERNE**  
**CHAR\_MECA\_FR2D3D AFFE\_CHAR\_MECA**  
**FORCE\_FACE**  
**CHAR\_MECA\_FR3D3D AFFE\_CHAR\_MECA**  
**FORCE\_INTERNE**  
**CHAR\_MECA\_FRC02D AFFE\_CHAR\_MECA**  
**FORCE\_COQUE**  
**CHAR\_MECA\_FRC03D AFFE\_CHAR\_MECA**  
**FORCE\_COQUE**  
**CHAR\_MECA\_FRELEC AFFE\_CHAR\_MECA**  
**FORCE\_ELEC**  
**CHAR\_MECA\_PESA\_R AFFE\_CHAR\_MECA**  
**GRAVITY**  
**CHAR\_MECA\_PRES\_F AFFE\_CHAR\_MECA\_F**  
**PRES\_REP**

**CHAR\_MECA\_PRES\_RAFFE\_CHAR\_MECA  
PRES\_REP  
CHAR\_MECA\_ROTA\_RAFFE\_CHAR\_MECA\_F  
ROTATION**

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## **4 Operands**

### **4.1**

#### **General information on the operands**

##### **4.1.1 Two categories of operands**

*The operands under a key word factor are of two forms:*

.

*operands specifying the geometrical entities on which are affected them loadings (key words GROUP\_NO, GROUP\_MA, etc...). The arguments of these operands are identical for the two operators,*

.

*operands specifying the affected values (DX, DY, etc...). Significance of these operands is the same one for the two operators. The arguments of these operands are all the real type for operator AFFE\_CHAR\_MECA and of the function type (created in particular by one of operators DEFI\_FONCTION, DEFI\_NAPPE or DEFI\_CONSTANTE) for operator AFFE\_CHAR\_MECA\_F.*

*This is true near with an exception: the argument of COEF\_MULT for the key word factor LIAISON\_DDL in AFFE\_CHAR\_MECA\_F is obligatorily of real type.*

*We will thus not distinguish in this document, except mention express of the opposite, both operators AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F.*

##### **4.1.2 Designation of the topological entities of assignment of the loadings**

*In a general way, the entities on which values must be affected are defined:*

*.  
by node and in this case:*

*- is  
by  
the operand  
GROUP\_NO allowing to introduce a list of groups of nodes:  
let us note that in certain cases a group of node must contain one node,  
-  
maybe by the operand NODE allowing to introduce a list of nodes.*

*.  
by mesh and in this case:*

*- is  
by  
GROUP\_MA allowing to introduce a list of groups of meshes,  
- is  
by  
NET allowing to introduce a list of meshes.*

#### *4.1.3 Regulate of overload*

*To define the field of assignment most simply possible, the rule of overload is used defined in the document " Règles of overload " [U1.03.00]:  
it is the last assignment which precedes.*

#### *4.1.4 Structural elements, continuous mediums*

*For the assignment of the loadings distributed on the elements with average layer (plate - hull) or with  
average fibre (beam, cable, bar) the key words factors are distinct from those used for  
continuous mediums.*

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***4.1.5 Normals and tangents with the meshes***

***Normals:***

***.***

***SEG2 or SEG3 in 2D (coordinated defined by COOR\_2D in the file of grid in format Aster). Normal N is such as (N, T) form a direct reference mark, T being carried by segment directed by the first two nodes of the segment.***

***2***

***T***

***1***

***N***

***.***

***QUAD4,..., QUAD9, TRIA3, TRIA6 in 3D (coordinated defined by COOR\_3D in the file of grid to the format Aster). The orientation of normal N is that corresponding to the direction direct of the description of the mesh.***

***N***

***N***

***3***

***4***

***3***

***1***

***2***

***1***

***2***

***Tangents:***

*Can be specified only if the mesh is of type SEG2 or SEG3 in 2D. The tangent is that defined by the segment directed by its first two nodes.*

*2  
1  
T*

*If DNOR (or DTAN) are specified, the normal (or the tangent) on a node is the average of normals or of the tangents of the meshes which have this joint node (except for the elements quadratic curves where the normal is correctly calculated in any point)*

*N  
N  
N*

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*4.2 Operand  
MODEL*

*MODELE= Mo,*

**Concept produced by operator AFFE\_MODELE where the types of affected finite elements are defined on the grid.**

#### **4.3 Operand VERI\_NORM**

```
/ VERI_NORM=/“YES”  
[DEFECT]  
/  
“NOT”
```

**Checking of the orientation of the normals to the surface in 3D and linear meshes in 2D. If a normal is not outgoing, there is emission of an error message.**

#### **4.4 Operand LIAISON\_XFEM (AFFE\_CHAR\_MECA only)**

```
/ LIAISON_XFEM=  
“YES”,
```

**During a calculation with method X-FEM [R7.02.12], it is necessary to create a load additional to cancel some ddl's nouveau riches. It is thus necessary imperatively to indicate LIAISON\_XFEM=' OUI' in this specific charge for any calculation X-FEM, as on the following example:**

```
chxfem  
= AFFE_CHAR_MECA (MODEL  
= model,  
LIAISON_XFEM = “YES”,  
)
```

#### **4.5 Operand TEMP\_CALCULEE (AFFE\_CHAR\_MECA only)**

```
/ TEMP_CALCULEE= temple,
```

**Concept produced by a linear thermal calculation or not linear (THER\_LINEAIRE [U4.54.01], THER\_NON\_LINE [U4.54.02]) or created starting from values of temperatures affected by order CREA\_CHAMP [U4.72.04] key word AFFE or starting from order CREA\_RESU [U4.44.12]. If the concept temple is of cham\_no\_TEMP\_R type then the thermal loading will be supposed to be constant in time. If it is of type evol\_ther, the possible prolongations to the terminals of transitory calculation will be supposed to be constant.**

#### **4.6 Operand**

**HYDR\_CALCULEE (AFFE\_CHAR\_MECA only)**

**/ HYDR\_CALCULEE**

**=**

**hydr,**

**Concept produced by a nonlinear thermal calculation (THER\_NON\_LINE [U4.54.02]) gathering fields of hydration and temperature in a concept of the evol\_ther type.**

#### **4.7 Operand**

**SECH\_CALCULEE (AFFE\_CHAR\_MECA only)**

**/ SECH\_CALCULEE**

**=**

**sech,**

**Concept produced by a nonlinear thermal calculation (THER\_NON\_LINE [U4.54.02]) gathering fields of drying.**

**This concept can be either of evol\_ther type, or of cham\_no\_TEMP\_R type (if the loading is constant in time), that is to say of carte\_temp\_R type (if the loading is constant spaces some and in time), that is to say of carte\_temp\_F type (loading function of space).**

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#### **4.8 Operand**

**EPSA\_CALCULEE (AFFE\_CHAR\_MECA only)**

**/EPSA\_CALCULEE**

=

*epsa,*

*Anelastic deformations resulting from external software (Cyrano3 Code for example) and converted into result of the evol\_noli type by order LIRE\_RESU [U7.02.01] option “EPSA\_ELNO”. This loading is taken into account by STAT\_NON\_LINE [U4.51.03].*

#### **4.9 Operand**

**EVOL\_CHAR (AFFE\_CHAR\_MECA only)**

**/EVOL\_CHAR**

= *evch,*

*Evolutionary loadings in the time of the type “evol\_char” [U5.01.17] produced by LIRE\_RESU [U7.02.01] and containing fields of pressure, densities of voluminal force in 2D or 3D and densities of surface force in 2D or 3D.*

#### **4.10 Operand**

**GRAVITY (AFFE\_CHAR\_MECA only)**

**/GRAVITY = (G, ap, LP, CP),**

*Acceleration and direction of gravity. The loading which results from it is form:*

*where*

*is the total Cartesian reference mark.*

*is the definite density like characteristic of material (see operators DEFI\_MATERIAU [U4.43.01] and AFFE\_MATERIAU [U4.43.03]).*

#### **4.11 Operand**

**ROTATION (AFFE\_CHAR\_MECA only)**

**/ROTATION**

= (*, rear, Br, Cr*),

*Number of revolutions and direction of the vector rotation which leads to:*

*The loading which results from it is: (OM) where is the origin of the co-ordinates and a point running of the structure with definite density like characteristic of material (see operators DEFI\_MATERIAU [U4.43.01] and AFFE\_MATERIAU [U4.43.03]).*

***CENTER = (X, y, Z),***

***If the center is not the origin, one can specify his co-ordinates (X, y, Z).***

***Important remark:***

***One can vary in time the number of revolutions by breaking up the rotation in way multiplicative between space loading and evolution in time***

***, then in***

***multiplying the LOAD by a multiplying function (key word FONC\_MULT) in calculation transient (DYNA\_TRAN\_MODAL, DYNA\_LINE\_TRAN, DYNA\_NON\_LINE). However, it is appropriate to pay attention: the loading [(OM)] being proportional squared number of revolutions,***

***, it is necessary to affect the square of the evolution in time,***

***, behind FONC\_MULT.***

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***4.12 Key word***

***DDL\_IMPO***

***4.12.1 Drank***

***Key word factor usable to impose, with nodes introduced by one (at least) of the key words:***

***ALL, NODE, GROUP\_NO, MESH, GROUP\_MA, one or more values of displacement (or of certain associated sizes).***



*According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_MECA) or via a concept function (AFFE\_CHAR\_MECA\_F).*

#### **4.12.2 Syntax**

**.**  
**for AFFE\_CHAR\_MECA**

**/**  
**DDL\_IMPO=\_F**

**(/ALL =**  
**“YES”,**

**/**  
**NODE**

**=**  
**lno**  
**, [l\_noeud]**

**/**  
**GROUP\_NO=**  
**lgn,**  
**[l\_gr\_noeud]**

**/**  
**NET**

**=**  
**lma**  
**, [l\_maille]**

**/**  
**GROUP\_MA=**  
**lgma,**  
**[l\_gr\_maille]**

**//DX =**  
**ux,**  
**[R]**

/  
***DY =***  
***uy,***  
***[R]***

/  
***DZ =***  
***uz,***  
***[R]***

/***DRX***  
***=***  
***X,***  
***[R]***

***/DRY***  
=  
***y,***  
***[R]***

***/DRZ***  
=  
***Z,***  
***[R]***

***/GRX***  
=  
***G, [R]***

***/PRES= p, [R]***

**/ PHI**  
**=**  
**, [R]**

**/ TEMP= T, [R]**

**/ PRE1=**  
**pr1**  
**, [R]**

**/ PRE2=**  
**pr2**  
**, [R]**

**/ GONF=**  
**trops,**  
**[R]**  
**/**  
**LIAISON=**  
**“EMBEDS”**

)

*The list of the others ddls being able to be imposed is:*

**UI2... UI6, UO2... UO6, VI2... VI6, VO2... VO6,**

**WI2... VI6, WO2... WO6,**

**WO,**

**WI1,**

**WO1**

**[R]**

.

**for AFFE\_CHAR\_MECA\_F**

**/**

**DDL\_IMPO=\_F**

**(/ALL =**

**“YES”,**

**/**

**NODE**

**=**

**lno**

**, [l\_noeud]**

**/**

**GROUP\_NO=**

*lgn*,  
[*l\_gr\_noeud*])

/

**NET**

=

*lma*  
, [*l\_maille*]

/

**GROUP\_MA=**

*lgma*,  
[*l\_gr\_maille*]

// **DX =**  
*ux*,  
[*function*]

/

**DY =**  
*uyf*  
, [*function*]

/

***DZ =  
uzf  
, [function]***

***/DRX  
=  
xf, [function]***

***/DRY  
=  
yf, [function]***

***/DRZ  
=  
zf, [function]***

*/ GRX*  
=  
*gf*  
,  
*[function]*

*/ PRES=*  
*PF*  
,  
*[function]*

*/ PHI*  
=  
*F,*  
*[function]*

*/ TEMP=*  
*Tf*  
,



*[function]*

*/ PRE1= pr1f, [function]*

*/ PRE2= pr2f, [function]*

*/  
LIAISON=  
“EMBEDS”*

*)  
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### 4.12.3 Operands

**/DDL\_IMPO**

*All the specified values are defined in the TOTAL reference mark of definition of the grid.*

.

**DX = ux or uxf**

*Value of the component of displacement in imposed translation*

.

**DY = uy or uyf**

*on the specified nodes*

.

**DZ = uz or uzf**

*Only if the specified nodes belong to discrete elements of translation - rotation, of beam or hull:*

.

**DRX = X or xf**

*Value of the component of displacement in rotation imposed on*

.

**DRY = y or yf**

*specified nodes*

.

**DRZ = Z or zf**

*Only if the specified nodes belong to elements of beam "POU\_D\_TG":*

.

**GRX = G or gf**

*Value of the warping of the beam*

*Only if the specified nodes belong to elements fluid or fluid structure:*

.

**CLOSE = p or PF**

*Acoustic pressure in the fluid (modeling "3D\_FLUIDE")*

.  
***PHI = or F***

***Potential of displacements of the fluid (modelings “3D\_FLUIDE”  
and “FLUI\_STRU”)***

***Only if the specified nodes belong to elements of free face:***

.  
***DZ = uz or uzf***

***Imposed displacement of the free face (modeling  
“2D\_FLUI\_PESA”)***

.  
***PHI = or F***

***Potential of displacements of the fluid (modeling  
“2D\_FLUI\_PESA”)***

***Only if the specified nodes belong to elements THM:***

.  
***PRES= p***

***Pressure of the interstitial fluid (modelings “3D\_JOINT\_CT”)***

.  
***TEMP= T***

***Temperature (modelings “” with  
= 3D or AXIS or D\_PLAN  
YYYY = THM or THHM or THH)***

.  
***PRE1= p1***

***Capillary pressure or pressure of the liquid or gas  
(modelings “” with  
= 3D or AXIS or D\_PLAN  
YYYY = THM or THHM or THH or HM or HHM)***

.  
***PRE2= p2***

***Pressure of gas  
(modelings “” with  
= 3D or AXIS or D\_PLAN  
YYYY = THH or THHM or HHM)***

***Only if the specified nodes belong to elements “PIPE”.  
These elements have 15 DDL of hull:***

***U: warping***

***V, W: ovalization***

***I: “in plane”***

***O: “out of planes”***

***That is to say:***

.  
***UI2 VI2 WI2 UO2 VO2 WO2***  
***DDL related to mode 2***

.  
***UI3 VI3 WI3 UO3 VO3 WO3***  
***DDL related to mode 3***

.  
***WO WI1 WO1***  
***DDL of swelling and mode 1 on W***

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***Only if the specified nodes belong to elements “TUYAU\_6M”.***

.  
***UI4 VI4 WI4 UO4 VO4 WO4***  
***DDL related to mode 4***

.  
***UI5 VI5 WI5 UO5 VO5 WO5***  
***DDL related to mode 5***

.

**UI6 VI6 WI6 UO6 VO6 WO6**  
**DDL related to mode 6**

*Only if the specified nodes belong to elements “XXX\_INCO”.*

**GONF**  
*swelling*

**CONNECTION = “EMBEDS”**

*Allows to embed directly nodes, c.a.d. to force to zero the ddl translation and of rotation. The others ddl are not modified.*

#### **4.12.4 Checks and recommendations**

*It is checked that the specified ddl exists in this node for the elements affected in the MODEL to meshes which contain the node.*

*However, if the same boundary condition is specified twice by two calls to AFFE\_CHAR\_MECA (for example, with two values of imposed displacement), that led to one singular matrix.*

*If it is specified twice (or more) in only one call to AFFE\_CHAR\_MECA, the rule of overload apply and a message of alarm (indicating the overload) is transmitted.*

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**4.13 Key word****FACE\_IMPO****4.13.1 Drank**

*Key word factor usable to impose, with all the nodes of a face defined by a mesh or one group meshes, one or more values of displacement (or certain associated sizes).*

*According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_MECA) or via a concept function (AFFE\_CHAR\_MECA\_F).*

**4.13.2 Syntax**

*.*  
*for AFFE\_CHAR\_MECA*

*/*  
*FACE\_IMPO=\_F*  
*(/MESH =*

*lma*  
*, [l\_maille]*  
*/*  
*GROUP\_MA=*  
*lgma,*  
*[l\_gr\_maille]*

*//DX =*

*ux, [R]*

/  
**DY =**

**uy, [R]**

/  
**DZ =**

**uz, [R]**

**/DRX**

**=**

**X, [R]**

**/DRY**

**=**

**y, [R]**

**/ DRZ**  
**=**  
**Z, [R]**

**/ GRX**  
**=**  
**G**  
**,**  
**[R]**

**/ PRES=**  
**p**  
**,**  
**[R]**



**/ PHI**  
**=**  
**, [R]**

**/ TEMP=**  
**T**  
**,**  
**[R]**

**/**  
**PRE1=**  
**pr1**  
**, [R]**

**/**  
**PRE2=**  
**pr2**  
**, [R]**

//**DNOR=**  
**one**  
,  
**[R]**

/**DTAN=**  
**C**  
,  
**[R]**

)  
.  
**for AFFE\_CHAR\_MECA\_F**

/  
**FACE\_IMPO=\_F**  
**(/MESH =**

**lma**  
**, [l\_maille]**  
/  
**GROUP\_MA=**  
**lgma,**  
**[l\_gr\_maille]**

// ***DX*** =

***uxf***  
**, [function]**

/  
***DY*** =

***uyf***  
**, [function]**

/  
***DZ*** =

***uzf***  
**, [function]**

***/DRX***  
=  
***xf, [function]***

***/DRY***  
=  
***yf, [function]***

***/DRZ***  
=  
***zf, [function]***

***/GRX***  
=  
***gf***  
,  
***[function]***

**/ PRES=**  
**PF**  
,  
**[function]**

**/ PHI**  
**=**  
**F, [function]**

**/ TEMP=**  
**Tf**  
,  
**[function]**

/  
**PRE1=**  
**pr1f,**  
**[function]**

/  
**PRE2=**  
**pr2f,**  
**[function]**

// **DNOR=**  
**one**  
**,**  
**[function]**

/**DTAN=**  
**C**  
**,**  
**[function]**

)  
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**Operators AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F**

**Date:**

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**Author (S):**

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### **4.13.3 Operands**

**//DX =**

**/**  
**DY =**

**/**  
**DZ =**

**/DRX**  
**=**

***/DRY***

=

***/DRZ***

=

***/GRX***

=

***/PRES=***

***/PHI***

=

***/TEMP=***

***/PRE1=***

***/PRE2=***

***The components, imposed on all the nodes belonging to the specified meshes, are defined in the TOTAL reference mark of definition of the grid.***

***The faces considered are made up:***

- ***maybe of TRIA3, TRIA6, QUAD4, QUAD8, QUAD9 in dimension 3,***
- ***maybe of SEG2 or SEG3 in dimension 2 (the face is reduced on a board).***

***Note:***

***The components of displacement in rotation DRX, DRY, DRZ cannot intervene***



*that on nodes which belong to elements of beam or hull (see DDL\_IMPO [§4.10]),*

*component GRX on elements of beam “POU\_D\_TG”,*

*components NEAR and PHI on elements of modelings “3D\_FLUIDE” and “FLUI\_STRU”, components DZ and PHI on elements of modeling “2D\_FLUI\_PESA”.*

*Components TEMP, PRE1, PRE2 on elements of modeling THM.*

*//DNOR*

*=*

*/DTAN*

*=*

*The imposed components are defined according to the normal or the tangent with a mesh (local reference mark).*

*DNOR: normal component (see [U4.44.01 §4.1]),*

*DTAN: tangential component (see [U4.44.01 §4.1]).*

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## **4.14 Key word LIAISON\_DDL**

### **4.14.1 Drank**

**Key word factor usable to define a linear relation between degrees of freedom of two or several nodes.**

**According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_MECA) or via a concept function (AFFE\_CHAR\_MECA\_F).**

### **4.14.2 Syntax**

**.  
for AFFE\_CHAR\_MECA  
LIAISON\_DDL=\_F (  
/NODE =**

**lno  
, [l\_noeud]  
/  
GROUP\_NO  
= lgn,  
[l\_gr\_noeud]**

**DDL=**

**/“DX”,**

*/“DY”,*

*/“DZ”,*

*/“DRX”,*

*/“DRY”,*

*/“DRZ”,*

*COEF\_MULT*

=

*I, [I\_R]*

*COEF\_IMPO*

=

*, [R]*

)  
.  
**for AFFE\_CHAR\_MECA\_F**  
**LIAISON\_DDL=\_F (**  
**/NODE =**

**lno**  
**, [l\_noeud]**  
**/**  
**GROUP\_NO**  
**=**

**lgn,**  
**[l\_gr\_noeud]**

**DDL=**

**/“DX”,**

**/“DY”,**

*/“DZ”,*

*/“DRX”,*

*/“DRY”,*

/“DRZ”,

***COEF\_MULT***

=

***I, [I\_R]***

***COEF\_IMPO***

=

***F, [function]***

)

#### ***4.14.3 Operands***

***GROUP\_NO or NODE: list nodes Nor (I = I, R) ordered in a natural way:***

.

***in the order of the list of groups of nodes, and for each group of nodes, in the order of definition of the group by GROUP\_NO,***

.

*in the order of the list of nodes for NODE.*

*DDL: list ddl*

*(I = 1, R) of R texts taken among:*

*“DX”, “DY”, “DZ”, “DRX”,*

*“DRY”,*

*“DRZ”*

*COEF\_MULT: list*

*(I = 1, R) of coefficients (of real type for AFFE\_CHAR\_MECA and for AFFE\_CHAR\_MECA\_F).*

*COEF\_IMPO: coefficient for AFFE\_CHAR\_MECA, function of time for AFFE\_CHAR\_MECA\_F.*

*The following kinematic condition will be applied:*

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#### **4.14.4 Precautions of use**

##### **4.14.4.1 Components in rotation**

The components of displacement in rotation *DRX*, *DRY*, *DRZ* can intervene only in combinations **only** assigned to nodes which belong to **discrete** elements of translation-rotation, of **beam** or **hull** (see *DDL\_IMPO*: cf [§4.10]).

##### **Linear 4.14.4.2 Relation between the ddl of the same node**

In this particular case, one will as many repeat behind the key word *NODE* the name of the node time as there is

of *ddl* in the relation. Example: to impose on the *N1* node, one will write:

*LIAISON\_DDL* = *\_F* (*NODE* = ("N1", "N1"),

*DDL* = ("DX", "DY"),

*COEF\_MULT*

=

(1.,

-1.),

*COEF\_IMPO*

=  
0.,

)

#### ***Linear 4.14.4.3 Relation between groups of nodes***

*It is important to note that to an occurrence of the key word factor LIAISON\_DDL corresponds one and one only linear relation.*

*If one wants to impose the same relation between 2 groups of nodes GRN01 and GRN02 (even displacement node with node for example) **one cannot write:***

*LIAISON\_DDL = \_F (GROUP\_NO = ("GRN01", "GRN02"),*

*DDL = ("DX" "DX"),*

*COEF\_MULT*

=

*(1.*

,

*-1.),*

*COEF\_IMPO*

=

*0.,*

)

*This writing has direction only if GRN01 and GRN02 contain each one one node. It will be necessary*

*in the case above to clarify each linear relation, node by node, or to use LIAISON\_GROUP [§4.14] which makes it possible to condense the writing of same linear relations between two groups of nodes in opposite.*

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#### **4.15 Key word**

**LIAISON\_OBLIQUE**

##### **4.15.1 Drank**

*Key word factor usable to apply, with nodes or groups of nodes, the same value of displacement definite component by component in an unspecified oblique reference mark.*

*According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_MECA)*

*or*

*via a concept function (AFFE\_CHAR\_MECA\_F).*

##### **4.15.2 Syntax**

.

*for AFFE\_CHAR\_MECA*

*/ LIAISON\_OBLIQUE*

$=_F$   
(/NODE =  
No,  
[node]  
/  
GROUP\_NO  
= gno  
, [gr\_noeud]

/ DX

=  
ux  
,  
[R]

/ DY

=  
uy  
,  
[R]

*/ DZ*

=

*uz,*

,

*[R]*

*/ DRX*

=

*X,*

*[R]*

*/ DRY*

=

*y,*

*[R]*

*/ DRZ*

*=*

*Z,*

*[R]*

*ANGL\_NAUT =*

*(,), [L\_R]*

*)*

*.*

*for AFFE\_CHAR\_MECA\_F*

*I LIAISON\_OBLIQUE*

*=\_F*

*(/NODE =*

*No,*

*[node]*

*/*

*GROUP\_NO*

*= gno*

*, [gr\_noeud]*

/  $DX =$

$uxf$   
, [function]

/  $DY =$

$uyf$   
, [function]

/  $DZ =$

$uzf$   
, [function]

*/ DRX*  
=  
*xf, [function]*

*/ DRY*  
=  
*yf, [function]*

*/ DRZ*  
=  
*zf, [function]*

*ANGL\_NAUT =*  
*(), [l\_R]*



)

### 4.15.3 Operands

/  
**LIAISON\_OBLIQUE**

.  
**DX = ux or uxf**

*Value of the component of displacement in translation in*

.  
**DY = uy or uyf**

*oblique reference mark imposed on the specified nodes*

.  
**DZ = uz or uzf**

*Only if the specified nodes belong to discrete elements of translation-rotation, of beam or hull.*

.  
**DRX = X or xf**

*Value of the component of displacement in rotation in*

.  
**DRY = y or yf**

*oblique reference mark imposed on the specified nodes*

.  
**DRZ = Z or zf**

**ANGL\_NAUT**

=

(,,),

*The nautical angles defined in **degrees**, are the angles making it possible to pass from TOTAL reference mark of definition of the co-ordinates of the nodes to a reference mark obliques unspecified (see AFFE\_CARA\_ELEM [U4.42.01]).*

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#### **4.15.4 Checking**

*It is checked that the specified ddl exists in this node for the elements affected in the MODEL to meshes which contain the node.*

#### **4.15.5 Limitation**

*Into an occurrence of the key word factor, one can introduce for the moment one node or one only group of nodes containing one node.*

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**4.16 Key word****LIAISON\_GROUP****4.16.1 Drank**

*Key word factor usable to define the same linear relation between certain degrees of freedom of couples of nodes, these couples of nodes being obtained while putting in opposite two lists of meshes or of nodes [§4.14.5].*

*According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_MECA) or via a concept function (AFFE\_CHAR\_MECA\_F).*

**4.16.2 Syntax**

*.*  
*for AFFE\_CHAR\_MECA*

```
LIAISON_GROUP=_F
(//MAILLE_1 = lma1, [l_maille]
/
GROUP_MA_1 =
lgma1,
[l_gr_maille]
```

```
/MAILLE_2 = lma2, [l_maille]
/
GROUP_MA_2 =
lgma2,
[l_gr_maille]
```

*//NOEUD\_1 = lno1, [l\_noeud]*

*/*

*GROUP\_NO\_1 =*

*lgnol,*

*[l\_gr\_noeud]*

*//NOEUD\_2 = lno2, [l\_noeud]*

*/*

*GROUP\_NO\_2 =*

*lgnol,*

*[l\_gr\_noeud]*

*//SANS\_NOEUD = lno*

*, [l\_noeud]*

*/*

*SANS\_GROUP\_NO*

*=*

*lgnol,*

*[l\_gr\_noeud]*

*DDL\_1 =/| “DX”,*

*/ “DY”,*

*/ “DZ”,*

*/ “DRX”,*

/ “DRY”,

/ “DRZ”,

/ “DNOR”,

DDL\_2 = / “DX”,

/ “DY”,

/ “DZ”,

/ “DRX”,

/ “DRY”,

/ “DRZ”,

/“DNOR”,

$COEF\_MULT\_1 = 1i, [l\_R]$

$COEF\_MULT\_2 = 2i, [l\_R]$



*COEF\_IMPO*

=

, [R]

*SUMMIT*

=

“YES”,

*CENTER*

=

*Lr*

,

[l\_R]

*ANGL\_NAUT*

=

*Lr*

,

[l\_R]

*TRAN*

=

*Lr*

,

*[l\_R]*

)

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.

*for AFFE\_CHAR\_MECA\_F*

*LIAISON\_GROUP=\_F*

*(//MAILLE\_1 = lma1, [l\_maille]*

/

*GROUP\_MA\_1 =*

*lgma1,*

*[l\_gr\_maille]*

*//MAILLE\_2 = lma2, [l\_maille]*

*/*

*GROUP\_MA\_2 =*

*lgma2,*

*[l\_gr\_maille]*

*//NOEUD\_1 = lno1, [l\_noeud]*

*/*

*GROUP\_NO\_1 =*

*lgnol,*

*[l\_gr\_noeud]*

*//NOEUD\_2 = lno2, [l\_noeud]*

*/*

*GROUP\_NO\_2 =*

*lgnol,*

*[l\_gr\_noeud]*

*/SANS\_NOEUD = lno*  
*, [l\_noeud]*  
*/*  
*SANS\_GROUP\_NO*  
*=*  
*lgn,*  
*[l\_gr\_noeud]*

*DDL\_1 =/| “DX”,*

*/ “DY”,*

/ “DZ”,

/ “DRX”,

/ “DRY”,

/ “DRZ”,

/“DNOR”,

DDL\_2 =/| “DX”,

| “DY”,

| “DZ”,

/ “*DRX*”,

/ “*DRY*”,

/ “*DRZ*”,

/“*DNOR*”,

*COEF\_MULT\_1 = 1i, [l\_R]*

*COEF\_MULT\_2 = 2i, [l\_R]*

*COEF\_IMPO*

=

*F,*

*[function]*

*SUMMIT*

=

*“YES”,*



*CENTER*

=

*Lr*

,

*[l\_R]*

*ANGL\_NAUT*

=

*Lr*

,

*[l\_R]*

*TRAN*

=

*Lr*

,

*[l\_R]*

)

### **4.16.3 Operands**

/

**/GROUP\_MA\_1**

=

/

**MAILLE\_1**

=

*These operands define the first list of meshes in relation (noted 1).*

**/GROUP\_MA\_2**

=

/

**MAILLE\_2**

=

*These operands define the second list of meshes in relation (noted 2).*

**/GROUP\_NO\_1**

=

/

**NOEUD\_1**

=

*These operands define the first list of nodes in relation.*

**/GROUP\_NO\_2**

=

/

**NOEUD\_2**

=

*These operands define the second list of nodes in relation.*

*The two lists must have the same length.*

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*These operands make it possible to remove list of the couples of nodes in opposite [§4.14.5] all the couples of which at least one of the nodes belongs to the list of nodes described by these operands.*

*That makes it possible to avoid the accumulation of linear relations on the same node with the course various repetitions of the key word factor LIAISON\_GROUP, which leads the majority time with a singular matrix.*

**DDL\_1 (\_2) =**

*The argument of DDL\_1 or \_2 must be a list of texts taken among (DX', "DY", "DZ", "DRX", "DRY", "DRZ") or "DNOR".*

**COEF\_MULT\_1 (resp. COEF\_MULT\_2) =**

*List realities dimensioned exactly with the number of degrees of freedom declared in DDL\_1 (resp. DDL\_2) corresponding to the multiplying coefficients of the linear relation.*

**COEF\_IMPO =**

*Coefficient of blocking of the linear relation:*

*: reality for AFFE\_CHAR\_MECA*

*: function for AFFE\_CHAR\_MECA\_F*

*The operands CENTERS/ANGL\_NAUT/TRAN make it possible to define a transformation virtual (rotation and/or translation) approximate of 1 in 2 in order to ensure the bijectivity of the function opposite [§4.14.5].*

*The order carries out initially rotation, then the translation.*

**CENTER**

*= coordinated centre of rotation (in the total reference mark)*

**ANGL\_NAUT**

*= nautical angles defining rotation (in degrees)*

**TRAN** = *component of the vector translation*

**Note:**

.

*It is checked that the ddl specified in these operands exist for each one of nodes of the elements affected in the MODEL to the meshes which contain it node,*

.

*to use argument “DNOR”, it is obligatory to have stated the edges with assistance of meshes and that the calculation of a normal on these meshes is possible.*

**SUMMIT = “YES”**

*When the meshes of edge are quadratic (thus SEG3) the use of SUMMIT: “YES” force the algorithm of pairing to associate the tops of the SEG3 others tops, and mediums of the SEG3 in other mediums. In the case of fine grids, that allows in certain cases to avoid the problems of conflicts of opposite.*

**4.16.4 Example of use**

*One wants to impose a cyclic condition of repetitivity (even normal displacement) between FACE 1 and FACE 2 of the geometry below:*

**FACE 1**

**0**

**FACE 2**

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*Let us suppose that FACE 1 (resp. FACE 2) is made up of the list of meshes lma1 (resp. lma2).*

*One wants to write the following linear relations:*

*node of face 1 of opposite*

*where nbno is the number of nodes of face 1 (and of face 2).*

*The data of LIAISON\_GROUP will be written:*

*LIAISON\_GROUP = \_F (MAILLE\_1 = lma1,*

*MAILLE\_2*

*=*

*lma2,*

*DDL\_1*

*= "DNOR",*

*DDL\_2*

*= "DNOR",*

*COEF\_MULT\_1*

*=*

*1.,*

*COEF\_MULT\_2*

*=*

*-1.,*

*COEF\_IMPO*

*=*

*0,*

*CENTER*

=

*(X0, Y0, Z0),*

*ANGL\_NAUT*

=

*(,0.,0.),*

)

#### ***4.16.5 Determination of the couples of nodes in opposite***

***It is in the same way made that in AFFE\_CHAR\_THER.***

***Initially, one draws up the two lists of nodes to be put in opposite (IE to be paired), for each occurrence of the key word factor LIAISON\_GROUP:***

.

***for key words GROUP\_NO\_1 and GROUP\_NO\_2, they are the nodes constituting them groups of nodes,***

.

***for key words GROUP\_MA\_1 and GROUP\_MA\_2, they are the nodes of the meshes setting up the groups of meshes.***

***The redundancies being eliminated, the two lists of nodes obtained must have the same one length.***

***The determination of the couples of nodes in opposite is done in several stages:***

.

***for each N1 node of the first list, one seeks the node image  $N2 = F(N1)$  of second list. If  $F$  is not injective (a node  $N2$  is the image of two distinct nodes  $N1$  and  $N1'$ ), the error message according to is emitted:***

***<F> <AFFE\_CHAR\_MECA> <PACOAP> CONFLICT IN WITH RESPECT TO THE NODES***

***The NODE N2 EAST IT WITH RESPECT TO the NODES N1 AND N1'***

.

***for each node N2 of the second list, one seeks the node N1 image =  $G(N2)$  of***

*first list. If  $G$  is not injective (a  $N1$  node of two distinct nodes  $N2$  is the image and  $N2'$ ), the error message according to is emitted:*

**<F> <AFFE\_CHAR\_MECA> <PACOAP> CONFLICT IN WITH RESPECT TO THE NODES**

**The NODE  $N1$  EAST IT WITH RESPECT TO the NODES  $N2$  AND  $N2'$**

*it is checked that  $G = f1$ , i.e. the couples obtained by the stages has) and b) are them same (one wants to have a bijection  $F$  between the two lists of nodes). If  $F$  is not surjective, the error message according to is transmitted:*

**<F> <AFFE\_CHAR\_MECA> <PACOAP> CONFLICT IN OPPOSITE GENERATE**

**SUCCESSIVELY FROM LISTS LIST1 AND LIST2**

**The NODE OF the FIRST  $N1$  LIST IS NOT the IMAGE Of ANY NODE BY CORRESPONDENCE OPPOSITE**

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*For a node NR given, one calls node image F (NR) the node of the other list of nodes which carry out the minimum of the distance with NR. to facilitate pairing, in particular in the case of particular geometries (where borders 1 and 2 could “almost” result one from the other by the composition of a translation and a rotation), one makes it possible to do one virtual geometrical transformation of the first group of nodes (translation and rotation before to calculate distances (key words TRAN, CENTER and ANGL\_NAUT).*

*For each occurrence of the key word factor LIAISON\_GROUP, one builds the list thus of new couples in opposite. When all the occurrences were swept, list is removed couples in double.*

*Note:*

*In the couples of nodes in opposite, the order of the nodes is important. If for first occurrence of LIAISON\_GROUP, a node NR belonged to the first group of nodes and a node M with the second group of node, and that for the second occurrence LIAISON\_GROUP, it is the reverse, one will obtain with the exit pairing the couples (NR, M) and (M, NR). They will not be eliminated during detection of the redundancies; by against, the matrix obtained will be singular. Thus, one advises to keep same logic during the description of the edges in opposite.*

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*4.17 Key word*

*LIAISON\_MAIL*

*4.17.1 Drank*



***Key word factor usable to define linear relations allowing “to restick” two “edges” of one structure.***

***The characteristic of this key word (compared to LIAISON\_GROUP for example) is to make it possible to bind displacements of unconstrained nodes on the grid. Grids of FACE 1 and FACE 2 can be incompatible.***

***Examples:***

***) a condition of periodicity has (study of a cell of homogenisation)***

***FACE 1  
FACE 2***

***b) a cyclic condition of repetitivity***

***FACE 1  
FACE 2***

***c) a condition of simple sticking together***

***FACE 1 FACE 2***

***In the continuation of this paragraph, one will speak about the face “slave” (FACE 2) and about the face “Master” (FACE 1).***

***The “sticking together” of the 2 faces will be done by writing of linear relations between the ddls of the 2 faces.***

***Displacements of the nodes of the face slave will be connected to displacements of their projections on the face Master. For each node of the face slave, one will write 2 (in 2D) or 3 (in 3D) relations linear.***

***If FACE 1 and FACE 2 are not geometrically confused but that there is a isometry (rotation + translation) between the two, the user must define this isometry (that which transforms FACE 2 opposite 1).***

***An application of this functionality is for example the sticking together of a formed grid of elements linear (P1) on another quadratic grid (P2). In this case it is rather advised to choose like face “slave” the quadratic face.***

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**4.17.2 Syntax (in AFFE\_CHAR\_MECA only)**

**LIAISON\_MAIL =\_F**

**(**

**/GROUP\_NO\_ESCL**

**=**

**ligno2**

**,**

**[l\_gr\_noeud]**

**/NOEUD\_ESCL =**

**lno2**

**,**

**[l\_noeud]**

**/GROUP\_MA\_ESCL**

**=**

**lgamma2**

**,**

**[l\_gr\_maille]**

**/ MAILLE\_ESCL**

=

**lma2**

,

**[l\_maille]**

**/ GROUP\_MA\_MAIT**

=

**lgma1**

,

**[l\_gr\_maille]**

**/ MAILLE\_MAIT**

=

**lma1**

,

**[l\_maille]**

/

**CENTER**

=

**(xc,**

**yc,**

**[zc]),**

**[l\_R]**

**ANGL\_NAUT**

**= (alpha, [beta, gamma]),**

**[l\_R]**

/

**TRAN**

=

**(tx,**

**ty,**

**[tz]),**

**[l\_R]**

***DDL\_MAIT***

=

***“DNOR”***,

***DDL\_ESCL***

=

***“DNOR”***,

***ELIM\_MULT***

=

/

***“NOT”***,

***[DEFECT]***

/

***“YES”***,

)

### ***4.17.3 Operands***

#### ***4.17.3.1 GROUP\_NO\_ESCL/NOEUD\_ESCL/GROUP\_MA\_ESCL/MAILLE\_ESCL***

*These key words make it possible to define the whole of the nodes of the face slave. One takes all them nodes specified by key words **GROUP\_NO\_ESCL** and **NOEUD\_ESCL** more all nodes carried by meshes specified by key words **GROUP\_MA\_ESCL** and **MAILLE\_ESCL**.*

#### ***Note:***

*When one wants to restick only normal displacements of the faces (cf key words **DDL\_MAIT** and **DDL\_ESCL**), it is necessary to be able to determine the normal direction of the faces. The normal direction is calculated on the face slave. It is thus necessary in this case to use key words **GROUP\_MA\_ESCL** and **MAILLE\_ESCL** with meshes of the type “facets”.*

#### ***4.17.3.2 GROUP\_MA\_MAIT/MAILLE\_MAIT***

*These key words make it possible to define the whole of the meshes where they with respect to the nodes will be sought face slave.*

**Caution:**

*In 3D, one should not give meshes of surface, but the voluminal meshes adjacent with face. The specified meshes are “candidates” for the research of the points opposite. One can in giving too much, that is not awkward.*

*In the same way, in 2D, the meshes “Masters” must be surface (QUAD, SORTED) and nonlinear*

**4.17.3.3 CENTERS/ANGL\_NAUT/TRAN**

*These key words make it possible to define the geometrical transformation (rotation and/or translation) allowing to pass from the face main slave to the face.*

*If these key words miss, it is that the geometrical transformation is “the identity” i.e. the faces Master and slave are geometrically confused.*

*It should be noted that the program carries out initially rotation and then the translation. Caution: the direction transformation is slave --> main.*

**4.17.3.4 DDL\_MAIT/DDL\_ESCL**

*If one wants to restick only normal displacements with the faces, it is necessary to specify:*

*DDL\_MAIT = “DNOR”*

*DDL\_ESCL = “DNOR”*

**Note:**

*The normal direction is calculated on the face slave (it is necessary to give meshes of facet). This normal direction is transformed by the possible rotation of the geometrical transformation for to determine the normal direction on the face Master.*

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#### **4.17.3.5 ELIM\_MULT= “YES”/“NOT” (defect)**

*This key word is used to solve the difficulty which can arise when several surfaces are restuck adjacent slaves (i.e who have one or more common nodes).*

*Let us imagine for example that one writes (in 2D):*

```
LIAISON_MAIL= (  
_F (GROUP_MA_ESCL=' LIGNE_AB', GROUP_MAIT=...)  
_F (GROUP_MA_ESCL=' LIGNE_BC', GROUP_MAIT=...)
```

*If the user forces ELIM\_MULT=' OUI', the program will treat each occurrence of LIAISON\_MAIL in way independent. The node B, pertaining to LIGNE\_AB and LIGNE\_BC will be eliminated 2 times and it*

*is unfortunately probable that calculation will stop during the factorization of the matrix with message “Pivot almost no one...” because the linear relations generated by LIAISON\_MAILLE are redundant.*

*Most of the time, defect (ELIM\_MULT=' NON') is the good choice. The only case where the user could use ELIM\_MULT=' OUI' is that of the use of key word DDL\_ESCL=' DNOR' bus if in the 2 occurrences, the normals “slaves” are not the same ones, elimination is not redundant.*

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#### ***4.18 Key word***

***LIAISON\_CYCL***

##### ***4.18.1 Drank***

***Key word factor usable to define the linear relations allowing to impose conditions of cyclic symmetry with taking into account of a dephasing. It is mainly dedicated to being used in the restrictive framework of dynamic calculation with cyclic symmetry.***

***The characteristic of this key word (with the image of LIAISON\_MAIL) is to make it possible to bind displacements unconstrained nodes on the grid. The grids of FACE G and FACE D can be incompatible.***

***The cyclic condition of repetitivity applied within the framework of dynamics is based on method of duplication of grid. The operator thus leaves on the postulate that the initial grid one sector is duplicated in two grids identical to the image of the following figure.***

***In the continuation of this paragraph, one will speak about the face “slave” and the face “Master”. The “sticking together” of the 2 faces will be done by writing of linear relations between the ddls of the 2 faces.***

***Displacements of the nodes of the face slave will be connected to displacements of their projections on the face Master. For each node of the face slave, one will write 2 (in 2D) or 3 (in 3D) relations linear.***

***If FACE G and FACE D are not geometrically confused but that there is a isometry (rotation + translation) between the two, the user must define this isometry (that which transforms***

**FACE G opposite D).**

**Note:**

**An application of this functionality is for example the sticking together of a formed grid linear elements (P1) on another quadratic grid (P2). In this case it is rather advised to choose like face “slave” the quadratic face.**

**The expression of the cyclic condition of symmetry for a dephasing AND element given and in considering G as the interface slave is as follows:**

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**In order to write the linear relations making it possible to take into account this condition, it is necessary**

**to give two occurrences of the key word factor LIAISON\_CYCL:**

**.**

**The first makes it possible to bind the ddls face G of grid 1 with the face D of same grid and the face D of grid 2. The coefficients (cos () and sin ()) must be well informed by key words COEF\_MAIT1, COEF\_MAIT2.**

**.**

**The second makes it possible to bind the ddls face G of grid 2 with the face D of same grid and the face D of grid 1. Coefficients (- sin () and cos ()) must be well informed by key words COEF\_MAIT1, COEF\_MAIT2**



## **4.19 Syntax**

**(in  
AFFE\_CHAR\_MECA only)**

**LIAISON\_CYCL = \_F**

**(**

**/GROUP\_NO\_ESCL**

**=**

**lgn02**

**,**

**[l\_gr\_noeud]**

**/NOEUD\_ESCL =**

**lno2**

**,**

**[l\_noeud]**

**/GROUP\_MA\_ESCL**

**=**

**lgma2**

**,**

**[l\_gr\_maille]**

**/MAILLE\_ESCL**

**=**

**lma2**

**,**

**[l\_maille]**

**/GROUP\_MA\_MAII1 = lgma1**

**,**

**[l\_gr\_maille]**

**/MAILLE\_MAII1**

**=**

**lma1**

,  
*[l\_maille]*  
*/GROUP\_MA\_MAIT2 =*  
*lgma1*

,  
*[l\_gr\_maille]*

*/MAILLE\_MAIT2*  
*=*  
*lma1*

,  
*[l\_maille]*

*/*  
*CENTER*  
*=*  
*(xc,*  
*yc,*  
*[zc]),*  
*[l\_R]*

*ANGL\_NAUT*  
*=*  
*(alpha,*  
*[beta, gamma]),*  
*[l\_R]*

*/*  
*TRAN*  
*=*  
*(tx,*  
*ty,*  
*[tz]),*  
*[l\_R]*

*/*  
*COEF\_MAIT1 =, [R]*

/  
**COEF\_MAIT2 =, [R]**

/  
**COEF\_ESCL**  
 =  
 , [R]

**DDL\_MAIT**  
 =  
 “DNOR”,

**DDL\_ESCL**  
 =  
 “DNOR”,

)

## **4.20 Operands**

### **4.20.1 GROUP\_NO\_ESCL/NOEUD\_ESCL/GROUP\_MA\_ESCL/MAILLE\_ESCL**

*These key words make it possible to define the whole of the nodes of the face slave. One takes all the nodes specified by key words **GROUP\_NO\_ESCL** and **NOEUD\_ESCL** more all nodes carried by meshes specified by key words **GROUP\_MA\_ESCL** and **MAILLE\_ESCL**.*

#### **Note:**

*When one wants to restick only normal displacements of the faces (cf key words **DDL\_MAIT** and **DDL\_ESCL**), it is necessary to be able to determine the normal direction of the faces. The normal direction is calculated on the face slave. It is thus necessary in this case to use key words **GROUP\_MA\_ESCL** and **MAILLE\_ESCL** with meshes of the type “facets”.*

### **4.20.2 GROUP\_MA\_MAIT1/MAILLE\_MAIT1**

*These key words make it possible to define the whole of the meshes Masters of grid 1 (or 2) where one will seek them with respect to the nodes of the face slave of grid 1 or 2.*

**Caution:**

*In 3D, one should not give meshes of surface, but the voluminal meshes adjacent with face. The specified meshes are “candidates” for the research of the points opposite. One can in giving too much, that is not awkward.*

*In the same way, in 2D, the meshes “Masters” must be surface (QUAD, SORTED) and nonlinear*

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### **4.20.3 GROUP\_MA\_MAIT2/MAILLE\_MAIT2**

*These key words make it possible to define the whole of the meshes of 1 (or 2) where one will seek opposite nodes of the face slave of grid 1 or 2.*

**Caution:**

*In 3D, one should not give meshes of surface, but the voluminal meshes adjacent with face. The specified meshes are “candidates” for the research of the points opposite. One can in giving too much, that is not awkward.*

*In the same way, in 2D, the meshes “Masters” must be surface (QUAD, SORTED) and nonlinear*

#### **4.20.4 CENTER/ANGL\_NAUT/TRAN**

*These key words make it possible to define the geometrical transformation (rotation and/or translation) allowing to pass from the face main slave to the face.*

*If these key words miss, it is that the geometrical transformation is “the identity” i.e. the faces Master and slave are geometrically confused.*

*It should be noted that the program carries out initially rotation and then the translation. Caution: the direction transformation is slave --> main.*

#### **4.20.5 COEF\_MAIT1/COEF\_MAIT2/COEF\_ESCL**

*These key words make it possible to define the coefficients of the linear relation to apply, in the case of cyclic symmetry it acts of the cosine and sines of the angle of dephasing AND element considered. These coefficients must thus be coherent with the definition of the interfaces Masters and slaves. coefficient COEF\_ESCL makes it possible to pass a coefficient in front of the dds slaves.*

*For example:*

#### **4.20.6 DDL\_MAIT/DDL\_ESCL**

*If one wants to restick only normal displacements with the faces, it is necessary to specify:*

*DDL\_MAIT = “DNOR”*

*DDL\_ESCL = “DNOR”*

*Note:*

*The normal direction is calculated on the face slave (it is necessary to give meshes of facet). This normal direction is transformed by the possible rotation of the geometrical transformation for to determine the normal direction on the face Master.*

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***4.21 Key word***

***CONTACT***

***4.21.1 Drank***

***Key word factor usable to describe the zones subjected to conditions of unilateral contact with or without friction. These zones (for each occurrence of the key word factor), include/understand each one two surfaces being able to come into contact which are described by the data of the meshes which them constitute.***

***The sets of meshes potentially in contact are: surface and linear in dimension 3 (QUAD9, QUAD8, QUAD4 and TRIA7, TRIA6, TRIA3 and SEG2, SEG3), linear and concentrates in dimension 2 (SEG2, SEG3 and POI1).***

***Caution:***

***In dimension 3, treatment of the contact with quadratic surface meshes (QUAD8 and TRIA6 or QUAD9 and TRIA7 associated with modeling COQUE\_3D) require to bind them nodes mediums on the sides at the tops in order to have correct results. This operation is made automatically in the Code. Nevertheless, for calculations 3D mediums continuous with quadratic elements, the use of elements HEXA27 (with faces QUAD9) is strongly advised.***

***There is a modified version of projection with quadratic surface meshes of which the polynomials are incomplete. This projection (usable with HEXA20 and QUAD8) ensure has minimum that the reactions of contact are coherent. One activates it via the option PROJECTION = "QUADRATIC".***

***The studied structures can undergo great slips one compared to the other. This formulation, nodal contact or node-facet in reactualized geometry, with reactualization of pairing controlled by the user, is described in the document [R5.03.50] and is established in operators STAT\_NON\_LINE [U4.51.03] and DYNA\_NON\_LINE [U4.53.01].***

*Before making a calculation with contact using the key word CONTACT, it is essential to have read reference material [R5.03.50] and notes it HI-75/97/034/A of councils to the users, who clarify the role of the majority of the key words described below and give the precautions of use.*

*It is also recommended to consult the documentation of use of the contact [U2.04.04].*

#### **4.21.2 Syntax (AFFE\_CHAR\_MECA (\_F))**

*There are several methods to deal with the problems of contact/friction. One separated below operands suitable for each one.*

**CONTACT = \_F (**  
**/MAILLE\_MAIT**  
**=**  
**lma1,**  
**[l\_maille]**  
**/**  
**GROUP\_MA\_MAIT**  
**=**  
**lgma1,**  
**[l\_gr\_maille]**

**/**  
**MAILLE\_ESCL**  
**=**  
**lma2,**  
**[l\_maille]**  
**/**  
**GROUP\_MA\_ESCL**  
**=**  
**lgma2,**  
**[l\_gr\_maille]**

**PAIRING**  
**=**  
**/**  
**“MAIT\_ESCL”,**

*[DEFECT]*

/  
“NODAL”,  
/  
“MAIT\_ESCL\_SYME”,  
/  
“NOT”,  
/“VERIF”

*SEEK*

=  
/  
“NOEUD\_VOISIN”,  
*[DEFECT]*  
/  
“NOEUD\_BOUCLE”,

*NORMAL =*

/  
“MAIT”, *[DEFECT]*  
/  
“MAIT\_ESCL”,

*SMOOTHING =*

/  
“NOT”,  
*[DEFECT]*  
/  
“YES”,



*PROJECTION =*  
*/*  
*“LINEAR”,*  
*[DEFECT]*  
*/“QUADRATIC”,*

*NB\_RESOL*

*=*  
*/*  
*10,*  
*[DEFECT]*  
*/*  
*N,*  
*[I]*

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*TOLE\_PROJ\_EXT*

*=*  
*/*

0.50,  
[DEFECT]  
/  
tole,  
[R]

TOLE\_PROJ\_INT  
=  
/  
0.001,  
[DEFECT]  
/  
tole,  
[R]

ITER\_MULT\_MAXI  
=  
/  
4,  
[DEFECT]  
/  
iter,  
[I]

/  
  
METHOD =  
/  
"FORCED",  
[DEFECT]

NOM\_CHAMP  
=

/  
“DEPL”, [DEFECT]  
/  
“CLOSE”,  
/  
“TEMP”,  
/  
“PRE1”,  
/  
“PRE2”,

FRICION =/“WITHOUT”  
, [DEFECT]

REAC\_GEOM  
=/“AUTOMATIC”  
, [DEFECT]  
/  
“WITHOUT”,  
/  
“CONTROL”,

NB\_REAC\_GEOM

=

N,  
[I]

*SANS\_NOEUD =*  
*lno,*  
*[l\_noeud]*

*SANS\_GROUP\_NO*  
*=*  
*lgrno,*  
*[l\_gr\_noeud]*

*SANS\_NOEUD\_QUAD*  
*=*  
*/*  
*“NOT”,*  
*[DEFECT]*

*/*  
*“YES”,*

*SLIDE*  
*=*  
*/*  
*“NOT”,*  
*[DEFECT]*

/  
“YES”,  
  
*ALARME\_JEU*

/  
0.0,  
[DEFECT]  
/  
*alarm\_jeu*, [R]  
/  
*DIST\_MAIT*  
=  
*R*,  
[R] ([function])  
*DIST\_ESCL*  
=  
*R*,  
[R] ([function])  
/  
*COEF\_IMPO*  
=  
*R*,  
[R]

*COEF\_MULT\_ESCL*  
=  
*R*,  
[R]

*VECT\_NORM\_ESCL*

=

(Vx, Vy, Vz),

[l\_R]

*VECT\_Y*

=

(Yx, Yy, Yz),

[R]

*STOP\_SINGULIER*

=

/

“YES”,

[DEFECT]

/

“NOT”,

/

*METHOD =*

“LAGRANGIAN”,

*NOM\_CHAMP*

=

*“DEPL”, [DEFECT]*

*SANS\_NOEUD =*

*lno*

,

*[l\_noeud]*

*SANS\_GROUP\_NO*

=

*lgn,*

*[l\_gr\_noeud]*

*SANS\_NOEUD\_QUAD*

=

/

*“NOT”,*

*[DEFECT]*

/

*“YES”,*

*DIST\_MAIT*

=

*R*,

*[R] ([function])*

*DIST\_ESCL*

=

*R*,

*[R] ([function])*

*STOP\_SINGULIER*

=

/

*“YES”*,

*[DEFECT]*

/

*“NOT”*,



*REAC\_GEOM*  
=/"AUTOMATIC", [DEFECT]  
/  
"WITHOUT",  
/  
"CONTROL",

*NB\_REAC\_GEOM*

=

*N*,  
[I]

*FRICION* =/"WITHOUT", [DEFECT]  
/  
"COULOMB",  
*COULOMB* = *R*,  
[R]

*COEF\_MATR\_FROT* =/0. ,  
[DEFECT]  
/  
*R*,  
[R]

*VECT\_Y*  
=  
(*Yx*, *Yy*, *Yz*),  
[R]

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/

*METHOD =*

*“PENALIZATION”,*

*NOM\_CHAMP*

=

*“DEPL”, [DEFECT]*

*E\_N*

=

*R,*

*[R]*

*SANS\_NOEUD* =  
*lno*,  
*[l\_noeud]*

*SANS\_GROUP\_NO*  
=  
*lgn*o,  
*[l\_gr\_noeud]*

*SANS\_NOEUD\_QUAD*  
=  
/  
“NOT”,  
*[DEFECT]*

/  
“YES”,

*DIST\_MAINT*  
=  
*R*,  
*[R] ([function])*

*DIST\_ESCL*

=

*R*,

[*R*] (*[function]*)

*STOP\_SINGULIER*

=

/

“*YES*”,

[*DEFECT*]

/

“*NOT*”,

*REAC\_GEOM*

=/“*AUTOMATIC*”, [*DEFECT*]

/

“*WITHOUT*”,

/

“*CONTROL*”,

*NB\_REAC\_GEOM*

=

*N*,

*[I]*

*FRICION* =/"WITHOUT", *[DEFECT]*

/

"COULOMB",

*COULOMB* = *R*,

*[R]*

*COEF\_MATR\_FROT* =/0. ,

*[DEFECT]*

/

*R*,

*[R]*

*VECT\_Y*

=

*(Yx, Yy, Yz)*,

*[R]*

*E\_T*

=

*R*,

*[R]*

/

*METHOD* =  
“CONTINUES”,

*SLIDE*  
=  
/  
“NOT”,  
[DEFECT]

/

“YES”,

*ALARME\_JEU*

/

0.0,  
[DEFECT]

/

*alarm\_jeu*, [R]

*DIST\_MAIT*

=

*R,*  
*[R] ([function])*

*DIST\_ESCL*  
=  
*R,*  
*[R] ([function])*

*NOM\_CHAMP*  
=  
"DEPL", *[DEFECT]*

*COEF\_REGU\_CONT = /100. ,*  
  
*[DEFECT]*  
*/R,*

*ITER\_GEOM\_MAXI =*  
*/*  
*2,*  
*[DEFECT]*

/  
I,

*ITER\_CONT\_MAXI* =/30,  
[DEFECT]  
/I,

*INTEGRATION* =/"NODE", [DEFECT]  
/  
"GAUSS",  
/  
"SIMPSON",  
/  
"SIMPSON1",  
/  
"SIMPSON2",  
/  
"NCOTES",  
/  
"NCOTES1",  
/  
"NCOTES2",

*MODL\_AXIS*  
=



/“NOT”,

/

“YES”,

*FORMULATION* =/“DEPL”, [DEFECT]

/

“QUICKLY”,

*DIRE\_APPA*

=

/

(X,

y,

Z), [R]

/

(0,

0,

0), [DEFECT]

*FRICITION* =/“WITHOUT”, [DEFECT]

/

“COULOMB”,

*COULOMB* = R,

[R]

*COEF\_REGU\_FROT* =/100. , [DEFECT]

/R,

*SEUIL\_INIT* =/0. ,  
[DEFECT]

/R,  
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*VECT\_Y*

=

*(Yx, Yy, Yz),*

*[R]*

*VECT\_Z*

=

*(Zx, Zy, Zz),*

*[R]*

*SANS\_NOEUD =*

*lno,*

*[l\_noeud]*

*SANS\_GROUP\_NO*

=

*lgn,*

*[l\_gr\_noeud]*

*ITER\_FROT\_MAXI =*

/

*2,*

*[DEFECT]*

*/I,*

*COMPLIANCE*

=  
/  
"NOT",  
[DEFECT]

/  
"YES",  
ASPERITY

=  
/  
asperity,  
[R]  
E\_N

=  
/  
e\_n,  
[R]

E\_V =  
/  
0.,  
[DEFECT]  
/  
e\_v,  
[R]

/  
METHOD =  
"VERIF",

STOP\_INTERP =/"NOT",

*[DEFECT]*

/  
“YES”,  
*TOLE\_INTERP* =/0. ,  
*[DEFECT]*

/  
*e\_v*,  
*[R]*

*DIST\_MAIT*  
=  
*R*,  
*[R]* (*[function]*)

*DIST\_ESCL*  
=  
*R*,  
*[R]* (*[function]*)

*VECT\_NORM\_ESCL*  
=  
(*Vx*, *Vy*, *Vz*),  
*[l\_R]*

*VECT\_Y*  
=  
(*Yx*, *Yy*, *Yz*),  
*[R]*

)  
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### 4.21.3 Operands

**MAILLE\_MAIT** or **GROUP\_MA\_MAIT**,

**MAILLE\_ESCL** or

**GROUP\_MA\_ESCL**

*The user provides the list of the potential meshes of contact of surface 1 (MAILLE\_MAIT or GROUP\_MA\_MAIT) and of surface 2 (MAILLE\_ESCL or GROUP\_MA\_ESCL). These meshes must be surface or linear in dimension 3 (QUAD9, QUAD8, QUAD4 and TRIA7, TRIA6, TRIA3 and SEG2, SEG3), linear and concentrates in dimension 2 (SEG2, SEG3 and POI1). The number of meshes and of nodes of two surfaces can be different.*

#### **Caution:**

*It is important to check that the connectivity of these meshes is such as the **normal is outgoing with the structure** (with this intention, to see MODI\_MAILLAGE key word ORIE\_PEAU\_2D, ORIE\_PEAU\_3D or ORIE\_NORM\_COQU [U4.23.04]). In addition, it should be made sure that the structures “do not hold that by the contact” (in particular in the case of a loading in imposed force): movements of rigid body must be blocked by boundary conditions suitable. One good way of checking it is to carry out a calculation with operator STAT\_NON\_LINE without to take into account the contact.*

*Subsequently, the master-slave concept will be used: nodes of surface slave cannot “penetrate” in the facets (or the nodes) of surface Master. In the case of the pairing of the type “MAIT\_ESCL”, surface Master is that defined by “MAILLE\_MAIT” or*

*“GROUP\_MA\_MAIT” (for councils on the main choice of surface, to refer to the note HI-75/97/034/A). In the case of the pairing of the “NODAL” type, surface Master is that which comprise the most nodes.*

**Note:**

*It is impossible to mix purely two-dimensional modelings (plane constraints, plane and axisymmetric deformations) with three-dimensional modelings. Surfaces Master and slave must be of comparable nature (2D/2D or 3D/3D). An error message you will stop in the contrary case:*

*<CFCRSD> MIXTURE 2D and 3D IN the CONTACT*

*Let us note that a beam, a plate or a hull are of dimension 3 and that it is thus possible to make contact poutre/3D or beam/plate.*

#### **4.21.4 Operands NOM\_CHAMP**

*This operand makes it possible to specify the nature of the field on which will carry the unilateral relations.*

*In mechanics, it is about the field of displacement (“DEPL”); in thermics, it is about the field of temperature (“TEMP”); in thermo-hydro-mechanics, it is about the field of displacement or of temperature or of pressure (“NEAR”, “PRE1” or “PRE2”). One can use fields PRE1, PRE2 to impose a condition of seepage in THM.*

#### **4.21.5 Operand PAIRING**

*Pairing can be nodal (“NODAL”) or node-facet (“MAIT\_ESCL”). For pairing nodal, one writes a relation of nonpenetration between a main node and a node slave, whereas for pairing node-facet, one writes this relation between a node slave and his projection on net main nearest (see [R5.03.50] for the details of the method of pairing).*

*Nodal pairing is disadvised because the method node-facet is more general and is the only one with to allow to take into account the great slips in a precise way.*

*Pairing “MAIT\_ESCL” has an alternative where one duplicates and one exchanges the roles of groups of meshes GROUP\_MA\_MAIT and GROUP\_MA\_ESCL. It is about pairing “MAIT\_ESCL\_SYME”. Nevertheless, its use is disadvised because it often leads to problems of convergence and tends on-to rigidify the contact.*

*In the cases of contact rigid or unilateral relations relating to the temperature or the pressure, pairing can also be useless: APPARIEMENT='NON' then is informed.*

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**4.21.6 Operand COEF\_IMPO/COEF\_MULT\_ESCL**

*These operands make possible a rigid contact of type  $COEF\_MULT\_2^* (v.N) = COEF\_IMPO$  where  $NR$  is the normal on the surface slave at the point where one measures field  $v$  (displacement, temperature or pressure). These operands are used with  $APPARIEMENT='NON'$  and key words  $GROUP\_MA\_2$  or  $MAILLE\_2$  only.*

**4.21.7 Operand PROJECTION**

*This operand indicates the type of functions of form used during the projection of a node slave on a mesh Master. The taking into account of the quadratic character of an element allows best to describe its geometry and to improve quality of the result.*

.

*In 2D, one uses either of the linear functions of form or of the functions of form quadratic.*

.

*In 3D, one uses that linear functions of form. Except for the elements  $HEXA20$  which can use a modified version of the functions of form, via the option  $PROJECTION='QUADRATIQUE'$ .*

**4.21.8 Operand NB\_RESOL**

*A number of simultaneous resolutions made during the treatment of the contact. To increase  $nb\_resol$  made to save time CPU but to lose place memory.  $nb\_resol = 10$  is a good compromise.*

**4.21.9 Operand SEEKS**



*To seek the mesh Master which will be paired with each node slave, one seeks initially its main node nearest, by a systematic loop on all the main nodes of the zone (“NOEUD\_BOUCLE”), that is to say by examining only the neighbors of the old main node nearest (“NOEUD\_VOISIN”): this last approach supposes small slips of a step of time with the other (not more than two meshes), but makes it possible to save computing time. Nevertheless, it can lead to non convergence, in which case it is necessary to resort to “NOEUD\_BOUCLE”.*

#### **4.21.10 Operand REAC\_GEOM**

*This operand indicates on which geometrical configuration the problem of contact is dealt with.*

*REAC\_GEOM=' SANS': one works on the initial geometry.*

*REAC\_GEOM=' CONTROLE': if this option is indicated, the user must moreover indicate:*

*NB\_REAC\_GEOM=n: It is the number of geometrical reactualizations which will be carried out by step of load. We place at a step of load given.*

*- Value 1 indicates that with convergence, one reactualizes the geometry and one passes to the load according to.*

*- Value 2 indicates that to convergence, one does not pass to the step of load according to. One reactualizes the geometry and one reiterates until convergence.*

*- The value  $n > 2$  indicates that one makes  $N$  cycles reactualization geometrical-iterations until convergence.*

*REAC\_GEOM=' AUTO': one reactualizes the geometry i.e automatically the number of cycles reactualization geometrical-iterations until convergence is not fixed by advance but obeys an internal criterion of geometrical convergence.*

*Note:*

*IF you chose a reactualization not-automatic and that Aster detects the need for one geometrical reactualization, it will inform you by an alarm:*

**<CFCONV> REAC\_GEOM OF CONTACT HIGHER A 5%**

*With you to decide if this error of 5% is acceptable or not. It corresponds grosso-modo to a relative displacement of two surfaces of contact higher than 5% and thus a risk of error of pairing (the mesh was paired on a configuration which moved).*

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**4.21.11 Operands SANS\_NOEUD/SANS\_GROUP\_NO/SANS\_NOEUD\_QUAD**

*These operands make it possible to exclude from the nodes of the list of the nodes slaves, operation which is*

*recommended for nodes subjected to boundary conditions in the direction awaited of contact (embedding example).*

*The operand SANS\_NOEUD\_QUAD (which is worth “NOT” by defect) makes it possible to authorize or not the connection*

*linear realized automatically by the code in the case of quadratic meshes for the contact. This operand is useful in the case of redundancy between these linear constraints and certain conditions limits of the Dirichlet type. When the operand is worth “NOT”, although the nodes are excluded from the contact,*

*the nodes mediums of the quadratic meshes are always linearly related to the tops, which can to cause these interferences (null pivots). One can then use option SANS\_NOEUD\_QUAD=' OUI' to solve this conflict.*

**4.21.12 Operands DIST\_MAIT/DIST\_ESCL**

*These operands make it possible to take into account “holes” or “bumps” nonwith a grid, or the thickness of the hulls (the relations of contact are written between two average surfaces) for groups of meshes 1 (DIST\_MAIT) or 2 (DIST\_ESCL). One counts the distance positively in the direction of the outgoing normal to the structure (cf document [R5.03.50 § 3.3]). Sizes informed are either of the constants, or of the functions of the variables of space only.*

**4.21.13 Operand VECT\_NORM\_ESCL**

*This operand allows the contact between two nodes in a direction VECT\_NORM\_ESCL = (vx, vy, vz) given by the user. The contact is taken into account between meshes of the type POII and can be used only in the case of a nodal pairing. If this key word misses, the direction of*

*contact calculated at the time of the procedure of pairing is opposed to the normal Master.*

#### **4.21.14 NORMAL operand**

*This operand makes it possible to select a method of calculation of the normals according to the mesh Master considered (by defect or explicitly by the order: NORMAL = "MAIT") or according to one average enters the meshes Masters and slaves with the order: NORMAL = "MAIT\_ESCL".*

#### **4.21.15 Operand STOP\_SINGULIER**

*This operand makes it possible to decontaminate the fatal error appearing if the matrix of contact is singular by STOP\_SINGULIER = "NOT". One advises to use this operand only in 3D in the presence of quadratic meshes whose nodes mediums are related to the nodes tops.*

#### **4.21.16 Operand TOLE\_PROJ\_EXT**

*Under certain conditions, Aster detects contact between two surfaces whereas there is not. problem comes initially from an incorrect and imperfect definition of surfaces likely to enter in contact. Let us take the case of the contact in 2D (surfaces of contact are thus segments). Aster carries out a Re-projection on surface Master when a node slave is projected outwards surface Master:*

*slave*

*Master*

*A solution consists in prohibiting this Re-projection:*

*slave*

*Master*

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***This solution does not take account of the borderline cases and can cause interpenetrations inopportune if ever the grid is not “optimal” (what is difficult to ensure within the framework great transformations). One thus chose an intermediate solution by limiting the extension surface Master at the time of the reprojection.***

***slave***

***Master***

***Re-projection***

***No Re-projection***

***(one is in the tolerance)***

***The limiting value of this Re-projection is fixed by the keyword “TOLE\_PROJ\_EXT” which takes for argument the value (adimensional) of the extension da the mesh Master in which one authorizes Re-projection. By defect, this value is fixed at 0.50. What means that any node slave projecting with more than 50% on the right or on the left (in the case of a segment) the length of the mesh***

***Master will not be reprojété. To prohibit Re-projection completely, it is enough to fix TOLE\_PROJ\_EXT with zero. This operator is valid in 2D and 3D (in this last case, it acts of extension of a surface mesh of contact).***

***4.21.17 Operand TOLE\_PROJ\_INT***

***In certain cases, projection causes undesirable oscillations between two limiting situations (mathematically, the unicity of the normal is not assured). There are then problems of***

*convergence, particularly when automatic geometrical reactualization is made (REAC\_GEOM=' AUTO'). The limiting value fixed by keyword "TOLE\_PROJ\_INT" makes it possible to regulate finely the detection of projection on the internal geometrical entities. This adjustment is reserved with the very pathological cases and exclusively when one uses surfaces of contact made up of QUAD4.*

#### **4.21.18 Operand ITER\_MULT\_MAXI**

*This operand makes it possible to fix the maximum number of iterations of contact/friction. The number internal iterations maximum Nmax is fixed by the following relation:*

$$N_{max} = ITER\_MULT\_MAXI \times Neslaves$$

*where Neslaves is the number of nodes slaves of the couple of contact. By defect, ITER\_MULT\_MAXI is fixed at 4, except for the method of the active constraints where the value is not modifiable and remains fixed at two (value resulting from a theoretical result of convergence).*

*If one exceeds the maximum number of iterations of contact/friction, one obtains the error message "Failure in the treatment of the contact". One can then try to refine the grid, to subdivide the step of time, or to change the value of ITER\_MULT\_MAXI.*

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#### 4.21.19 Operands *VECT\_Y* and *VECT\_Z*

*For the discrete methods (LAGRANGIAN and PENALIZATION), operand VECT\_Y has two possible functions related to the contact with friction in 3D.*

*it makes it possible to define a local reference mark on the surface of an element, locates on which one*

*break up the displacement of the slipping nodes. The construction of this local dihedron is following: the first *V1* vector is obtained by orthogonal projection of *VECT\_Y* on surface element considered, second *V2* is obtained by vector product of *V1* with normal vector *NR*,*

*that is to say the block below whose face *SB* is blocked according to *y* and face *SF* is subjected to conditions of contact-friction. According to the line *L* can appear redundancies between blockings and conditions of friction in direction *Y*. the problem is insoluble (null pivots). One can raise these redundancies by informing *VECT\_Y* to (0, 1, 0), direction in which the redundancies appear. The problem can then be solved. This type of difficulty appears only with *METHOD* = "LAGRANGIAN".*

*Z*  
*SF*  
*y*  
*L*  
*X*  
*SB*

*This operand allows also the modeling of the contact between coplanar beams in 3D:*

*Are 2 beams in the *xOy* plan. *VECT\_Y* is the vector which, by vector product with tangent vector with the beam, gives the normal to be used. That is to say:*

$$VECT\_Y^T = NR$$

*T2*  
*Z*  
*y*  
*X*  
*T1*

*As here  $T1 = (1,0,0)$  and  $T2 = (-1,0,0)$ , with  $VECT\_Y = (0,0,1)$ , one obtains the normal wished for each beam:  $N1 = (0,1,0)$  and  $T2 = (0, -1,0)$ . Attention with the fact that all this is entirely related to the orientation of each beam.*

*For the method = "CONTINUES", these keywords allow the user to exclude from the directions from friction which is likely to enter in conflict with other boundary conditions of Dirichlet. They are used thus in agreement with SANS\_GROUP\_NO and SANS\_NOEUD. Excluded directions of friction are indicated by VECT\_Y (in 2D) and VECT\_Y/VECT\_Z (in 3D). The exclusion of the direction of friction makes it possible nevertheless to keep the contacting character of a node.*

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#### *4.21.20 Operand INTEGRATION/MODL\_AXIS*

*The operand "INTEGRATION" makes it possible to select a method of integration numerical for terms of contact and friction. Several methods are implemented; "NODE" for one diagram of integration to the nodes, "GAUSS" for the traditional diagram of Gauss, "SIMPSON" for diagram of Simpson (integration to the nodes and the mediums of the elements) and "DIMENSIONS" for one adaptive diagram in the case of the linear/quadratic contact. The operand `MODL\_AXIS` allows to take into account the axisymmetric character of the problem. These operands are usable only with the "CONTINUOUS" method.*

#### *4.21.21 Operand FORMULATION*

*The operand FORMULATION makes it possible to choose a formulation of the problem in*

*displacement or in*

*speed. This choice relates to the whole of calculation. One uses it in dynamics (it does not have no direction in*

*statics). In dynamics, the advantage of the formulation of speed is to eliminate the oscillations numerical speed and of the acceleration at the time of the impacts.*

*One uses this formulation with a diagram of a nature 1 of speed, available in DYNA\_NON\_LINE, called TETA\_METHODE. This diagram must be selected in the place of the diagram of Newmark or HHT. It*

*require a parameter TETA which takes its values between 0,5 and 1. TETA = 1 gives the maximum of numerical damping usable only with the "CONTINUOUS" method.*

#### **4.21.22 Operand ITER\_CONT\_MAXI/ITER\_FROT\_MAXI/ITER\_GEOM\_MAXI**

*These operands make it possible respectively to fix the maximum number of the iterations of contact, of*

*friction and geometrical. Let us recall that the geometrical loop is a loop which is used for to reactualize pairing, the loop of friction is a fixed loop of point on the threshold of Coulomb whereas the loop of contact is a loop of the type forced active which is used to determine them effective surfaces of contact. These operands are usable only with the method "CONTINUOUS".*

#### **4.21.23 Operand DIRECTION\_APPA**

*This operand makes it possible to specify a direction of research for pairing. The research of points likely to return in contact is not founded any more on the principle of the proximity (the points them*

*closer) but according to the direction DIRECTION\_APPA = (vx, vy, vz) given by the user. In the case of them where pairing by direction is not possible (not main point in direction given), one seeks the main point nearest in a close direction. This operand is usable only with the "CONTINUOUS" method.*

#### **4.21.24 Operand COMPLIANCE**

*This operand makes it possible to activate the model of compliance for the "CONTINUOUS" method. This model*

*takes into account the aspect microscopic of surfaces (asperities) and allows a regularization of model of contact of Signorini. Of dynamics, the contribution of this model consists of the possibility to introduce a density of damping percussion which corresponds to the dissipation of the energy of shock.*

*The law of compliance introduced into Code\_Aster is a polynomial law (see Doc. [R5.03.52]. The three parameters of the law of compliance are ASPERITY, E\_N and E\_V.*

*ASPERITY =/asperity,*

*[R]*



***E\_N***

=

/

***e\_n,***

**[R]**

***E\_V =***

/

***0.,***

**[DEFECT]**

/

***e\_v,***

**[R]**

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#### ***4.21.25 Operands of resolution***

***These operands make it possible to select a method of calculation following the type of contact (2D/3D and with or without friction) which one wants to treat.***

***METHOD***

=

/

**“FORCED”**

**[DEFECT]**

/

**“LAGRANGIAN”**

/

**“PENALIZATION”**

/

**“CONTINUES”**

/

**“VERIF”**

*This operand makes it possible to use the various methods of resolution.*

**CONSTRAINT**

*: By defect one deals with the problem of the exact unilateral contact without friction with the method of the active constraints of [R5.03.50].*

**LAGRANGIAN**

*: The Lagrangian method makes it possible to treat in an exact way, by multipliers of Lagrange, the problems of contact with or without friction in 2D and 3D.*

**PENALIZATION**

*: The penalized method makes it possible to treat is:*  
*- problems of contact penalized without friction 2D or 3D if  $E_N$  is informed;*  
*- problems of contact with friction in 2D or 3D with a penalization on the terms of friction only if one inform  $E_T$  and a penalization about the terms of contact and of friction if one informs  $E_T$  and  $E_N$ .*

**CONTINUOUS**

*The method continues makes it possible to treat in an exact way, by increased multipliers of Lagrange, the problems of contact with or without friction in 2D and 3D. Coefficients of increase (or regularization) are specified in*

***COEF\_REGU\_CONT and COEF\_REGU\_FROT (these coefficients are strictly positive values.)***

### ***VERIF***

***The method of checking makes it possible to control if two surfaces interpenetrate or not without imposing the conditions of contact.***

***It is thus a method which is worried only aspect geometrical and which is inexpensive in terms of time CPU.***

***One can use it for example to control that the two lips of a crack do not interpenetrate.***

### ***Note:***

***The “CONTINUOUS” method is a modern and promising method. It is however very recent in Code\_Aster. Also advises one with the users rather to choose in a first time one of the other methods and if required to test the method “CONTINUES” in one the second time.***

***For the methods penalized and Lagrangian, one returns for more details to [R5.03.51].***

### ***FRICION***

***=***

***/***

***“WITHOUT”***

***[DEFECT]***

***/***

***“COULOMB”***

***This operand makes it possible to activate the taking into account of a friction of Coulomb.***

### ***COULOMB***

***: value of the coefficient of friction for the criterion of Coulomb.***

### ***E\_T***

***: coefficient of penalization on the slip for the method penalized. It is not used and is not necessary when one another method of resolution that “PENALIZATION” is active.***

***A value about the smallest Young modulus of the solids in contact is initially recommended. The second calculation with***

*a value ten times larger east highly desirable to see*

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*sensitivity of the results compared to this coefficient. To increase then the value of the coefficient until obtaining results stable.*

*E\_N*

*: coefficient of penalization on the interpenetration for the method penalized. It is not used and is not necessary when one another method of resolution that "PENALIZATION" is active.*

*A value about the smallest Young modulus of the solids in contact is initially recommended. In practice the choice on E\_N is broader than that on E\_T and of great values are usable (107 or 108 times the smallest Young modulus). One increase the value of the coefficient until obtaining results stable. Moreover it is possible to control the distances of interpenetration and thus to refine its choice of coefficient, which is not the case of the slip, since one does not know a priori which are the slipping zones and not slipping whereas in case of contact one can check that the distances of interpenetration are not eccentric.*

*COEF\_MATR\_FROT*

*: coefficient, ranging between 0 and 1, of taking into account of the part negative of geometrical rigidity. More this coefficient is large better is convergence when one is close to balance and more the resolution is difficult far from balance. A value of 0.5 thus is initially advised. The defect of 0 ensures systematic convergence for a longer computing time. This coefficient is essential to treat contacts surface with friction in 3D. It is not used the remainder of time.*

#### **COEF\_REGU\_CONT**

*coefficient of increase for the method “CONTINUES” (Lagrangian increased) relating to the regularization of the laws of contact. It can take values of about size of the step time in dynamics (10-5, 10-6...) until much more important (500 for example).*

#### **COEF\_REGU\_FROT**

*coefficient of increase for the method “CONTINUES” (Lagrangian increased) relating to the regularization of the laws of friction.*

#### **SEUIL\_INIT**

*initial threshold value of friction for the method “CONTINUES” (Lagrangian increased). It is by defect null what corresponds to treat during the first iteration of threshold it contact without friction.*

#### **4.21.26 Method VERIF**

#### **STOP\_INTERP**

**=**  
**/**  
**“NOT”,**  
**[DEFECT]**

/  
“YES”,  
  
**TOLE\_INTERP** =/0. ,  
**[DEFECT]**  
/  
**e\_v**,  
**[R]**

*This method carries out a control of the interpenetration of two surfaces without imposing them conditions of contact (if there is interpenetration, it will remain). If there is interpenetration, there will be one*

*ALARM. Parameter STOP\_INTERP makes it possible to stop calculation instead of alarming the user.*

*TOLE\_INTERP regulates the value of interpenetration.*

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**4.21.27 Method SLIDE**

**SLIDE**

**=**

**/**

**“NOT”**,

**[DEFECT]**

/  
 “YES”,  
**ALARME\_JEU**

/  
 0.0,  
**[DEFECT]**  
 /  
 alarm\_jeu, [R]

*This option is available only for the “FORCED” method and the method “CONTINUOUS”.*

*It makes it possible to activate the mode of bilateral contact or out of slide, in which two surfaces finding in contact remain “stuck” (i.e. with a null play) some is the evolution of loading. It authorizes great relative slips and the slide mode is not activated before surfaces are indeed in contact (it does not stick a priori two surfaces distant of a play not no one if the loading does not imply it).*

*Operand “ALARME\_JEU” makes it possible to activate an alarm as soon as the algorithm detects that, without the method slide, there would be separation of two surfaces (a virtual play higher than zero). Its value is regulated by defect with 0, which alarms the user as soon as surfaces would have to take off without the activated option.*

#### **4.21.28 Operand SMOOTHING**

*This operand makes it possible to smooth the normals on the surfaces of contact intervening in calculation of the matrix of contact. One will note  $Q$  an unspecified node of surfaces of contact (Master or slave),  $P$  a node of surface slave and  $M$  the main node obtained by projection of the node  $P$ .*

**SMOOTHING**  
 =  
 /“NOT”  
**[DEFECT]**

*For a pairing of the “master-slave” type the calculated normal is the normal entering to the mesh containing  $M$ . For a pairing of the “nodal” type the calculated normal is*

*outgoing normal with the node slave P.*

**SMOOTHING**

=

/“YES”

*Smoothing is done in two stages:*

.

*the first stage of smoothing consists in carrying out an average of the normals with meshes which contain the node Q,*

.

*the second stage consists in calculating an average of the normals at the tops of net container Mr. This average being balanced by the functions of form associated Mr.*

**Note:**

*For a pairing of the NODAL type smoothing does not bring any difference.*

*For a pairing of the type MAIT\_ESCL smoothing has a behavior which varies according to key word NORMAL.*

**NORMAL**

=

/“MAIT”

*The calculation of the matrix of contact is done according to the normal smoothed with the main node.*

**NORMAL**

=

/“MAIT\_ESCL”

*The calculation of the matrix of contact is done according to the average of the normals smoothed with the node*

*slave and with the main node.*

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#### **4.21.29 Structure of data VALE\_CONT**

*All the methods of contact with or without friction produce a structure of data of the type VALE\_CONT, which is a cham\_no\_s with the following components, in each node slave:*

.

*CONT: indicator of rubbing contact*

*- 0: no the contact*

*- 1: slipping contact*

*- 2: adherent contact*

.

*PLAY: value of the play*

.

*RN: normal reaction of contact normalizes*

.

*RNX: component according to DX of the normal reaction of contact*

.

*RNY: component according to DY of the normal reaction of contact*

.

*RNZ: component according to DZ of the normal reaction of contact*

.

*GLIX: component according to **T1** of the tangential slip (local reference mark)*

.

*GLIY: component according to **t2** of the tangential slip (local reference mark)*

.

*GLI: normalizes tangential slip*

.

*RTAX: component according to DX of the tangential force of adherence*

.

*RTAY: component according to DY of the tangential force of adherence*

.

*RTAZ: component according to DZ of the tangential force of adherence*

.

*RTGX: component according to DX of the tangential force of slip*

.

*RTGY: component according to DY of the tangential force of slip*

.

*RTGZ: component according to DZ of the tangential force of slip*

.

*X-ray: component according to DX of the force of rubbing contact (RNX+RTAX+RTGX)*

.

*RY: component according to DY of the force of rubbing contact (RNY+RTAY+RTGY)*

.

*RZ: component according to DZ of the force of rubbing contact (RNZ+RTAZ+RTGZ)*

.

*R: force of rubbing contact normalizes*

*It is printed as follows in the form of table:*

```
MATABLE=POST_RELEVE_T (ACTION=_F (INTITULE=' INFOS FROTTMNT',
GROUP_NO=' ESCLAVE',
RESULTAT=U,
INST=10.,
TOUT_CMP=' OUI',
NOM_CHAM=' VALE_CONT',
OPERATION=' EXTRACTION',),);
```

```
IMPR_TABLE (TABLE=MATABLE);
```

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**4.22 Key word**

**FORCE\_NODALE**

### 4.22.1 Drank

**Key word factor usable to apply, with nodes or groups of nodes, nodal forces, defined component by component in the TOTAL reference mark or an oblique reference mark defined by three nautical angles.**

According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_MECA) or via a concept function (AFFE\_CHAR\_MECA\_F).

### 4.22.2 Syntax

**for AFFE\_CHAR\_MECA**

**FORCE\_NODALE=\_F**

**(**  
**/NODE =**

**lno**

**,**  
**[l\_noeud]**

**/GROUP\_NO**

**= lgrno,**

**[l\_gr\_noeud]**

**/FX=**

**fx**

**,**  
**[R]**

**/ FY=**  
**fy**  
,  
**[R]**

**/ FZ=**  
**fz**  
,  
**[R]**

**/ MX=**  
**MX**  
,  
**[R]**

**/ MY=**  
**my**

,  
[R]

/ MZ=  
mz

,  
[R]

ANGL\_NAUT  
= (,), [l\_R]

),

.  
for AFFE\_CHAR\_MECA\_F

FORCE\_NODALE=\_F

(  
/ NODE =  
lno

,  
[l\_noeud]

**/ GROUP\_NO**  
**= lgrno,**  
**[l\_gr\_noeud]**

**/ FX=**  
**fxf**  
**,**  
**[function]**

**/ FY=**  
**fyf**  
**,**  
**[function]**

**/ FZ=**  
**fzf**  
**,**  
**[function]**

*/ MX=*  
*mx f*  
,  
*[function]*

*/ MY=*  
*my f*  
,  
*[function]*

*/ MZ=*  
*mz f*  
,  
*[function]*

*ANGL\_NAUT*  
*= ( \_f, \_f, \_f),*  
*[l\_fonction]*

),

### 4.22.3 Operands

*fx, fy, fz, MX, my, mz*  
*or fxf, fyf, fzf, mx, my, mz*

*Values of the components of the nodal forces applied to the specified nodes. These forces nodal will come to superimpose itself on the nodal forces resulting, possibly, others loadings. Into axisymmetric, the values correspond to a sector of 1 radian (to divide it real loading by 2).*

*(,,)*  
*or (\_f, \_f, \_f)*

*List of the 3 angles, in degrees, which define the oblique reference mark of application of the nodal forces*

*(the last angles of the list can be omitted if they are null). The nautical angles allow to pass from the total reference mark of definition of the co-ordinates of the grid to an oblique reference mark*

*unspecified (see operator AFFE\_CARA\_ELEM [U4.42.01]). By defect the angles are identically null and thus the components of forces are defined in the TOTAL reference mark.*

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#### **4.23 Key word**

### **LIAISON\_SOLIDE**

#### **4.23.1 Drank**

*Key word factor allowing to model an indeformable part of a structure.*

*One imposes linear relations between the degrees of freedom of the nodes of this indeformable part so that relative displacements between these nodes are null.*

*These nodes are defined by the groups of meshes, the meshes, the groups of nodes or the list of nodes to which they belong.*

#### **4.23.2 Syntax**

*.*  
*for AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F*

**LIAISON\_SOLIDE**

**=\_F**

**(**

**/MESH**

**= lma**

**,**  
**[l\_maille]**

**/**

**GROUP\_MA**

**=**

**lgma**

**,**

**[l\_gr\_maille]**

**/**

**NODE**  
=  
**lno**  
,  
**[l\_noeud]**  
/  
**GROUP\_NO**  
=  
**lgrno**  
,  
**[l\_gr\_noeud]**

**NUME\_LAGR**  
=/"NORMAL",  
**[DEFECT]**  
/  
**"AFTER"**  
,

),

**NUME\_LAGR:**

.

*If "NORMAL", the two multipliers of Lagrange associated with the relation will be such as first will be located before all the terms implied in the relation and the second after, in the assembled matrix.*

.

*If "AFTER", the two multipliers of Lagrange associated with the relation will be located afterwards all terms implied in the relation, the assembled matrix.*

*This choice has the advantage of having an assembled matrix whose obstruction is more weak but has the disadvantage to be able to reveal a singularity in the matrix.*

*Note:*

*In a general way, one imposes:*

•  
*in 2D ( $nb\_ddl * nb\_noeud3$ ) relations*

•  
*in 3D ( $nb\_ddl * nb\_noeud6$ ) relations*

*where*

•  
 *$nb\_ddl$  is the number of degrees of freedom per node,*

•  
 *$nb\_noeud$  is the number of nodes of the list given after `LIAISON_SOLIDE`*

*since a solid is determined by the position of one of its points and a reference mark in it not.*

*Relations are written by taking the vectorial formula translating a movement of rigid body in small rotations:*

*where*  
*is an arbitrary node of the solid.*

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#### **4.24 Key word**

**LIAISON\_ELEM**

##### **4.24.1 Drank**

*While calling “left massive” a piece of structure modelled with isoparametric elements 3D, this key word factor makes it possible to model the connection:*

*of a massive part with a part beam [R3.03.03] or a pipe section [R3.08.06],*

*of a hull part with a part beam [R3.06.03] or a pipe section [R3.08.06].*

*The goal of this functionality is not to account for the scales length between the parts to connect but to allow a simplification of modeling by replacing a massive part by a beam part for example.*

*The connection is treated by imposing linear relations between the degrees of freedom of the nodes of junction of the two parts to be connected, without imposing superfluous relations.*

##### **4.24.2 Syntax (*AFFE\_CHAR\_MECA* only)**

**LIAISON\_ELEM**

**=\_F**

(

/

**OPTION**

=

/

**“3D\_POU”**,  
/  
**“COQ\_POU”**,

**AXE\_POUTRE=**  
**(X, y, Z), [l\_R]**

**CARA\_ELEM**  
**= will cara, [cara\_elem]**  
/  
**OPTION**  
**=**  
**“3D\_TUYAU”**,

**AXE\_POUTRE= (X, y, Z), [l\_R]**

**CARA\_ELEM**

= will cara, [cara\_elem]

/

**OPTION**

=

“COQ\_TUYAU”,

**AXE\_POUTRE** = (X, y, Z), [l\_R]

**CARA\_ELEM**

= will cara, [cara\_elem]

**/MAILLE\_1** = lma1, [l\_maille]

/

**GROUP\_MA\_1** =

lgma1,

[l\_gr\_maille]

***/NOEUD\_2 = lno2, [l\_noeud]***

***/***

***GROUP\_NO\_2 =***

***lgn2,***

***[l\_gr\_noeud]***

***NUME\_LAGR***

***="/"NORMAL",***

***[DEFECT]***

***/***

***"AFTER"***

***,***

***ANGL\_MAX =/1. ,***

***[DEFECT]***

***/***

***Eng,***

***[R]***

***),***

#### ***4.24.3 Operands of the option "3D\_POU"***

**OPTION = "3D\_POU"**

***This option makes it possible to connect a massive part 3D with a part modelled with beams of Euler or Timoshenko.***

**/MAILLE\_1 =  
/  
GROUP\_MA\_1  
=**

***These operands define the surface meshes of the massive part modelling trace section of the beam on this massive part. These meshes must have been affected by finite elements of faces of elements 3D before.***

**/NOEUD\_2 =  
/  
GROUP\_NO\_2  
=**

***These operands define the node of the beam to be connected to the massive part. Thus if one uses NOEUD\_2, one should give one node and if GROUP\_NO\_2 is used, one should give one group, this one containing one node.***

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***Precaution for use:***

***The massive part must be with a grid with quadratic elements because the coefficients relations to be imposed are numerically integrated geometrical quantities. For that these integrals are evaluated correctly, it is necessary to have elements quadratic.***

***Note:***

***A connection between a massive part 3D and a beam part requires six relations linear.***

***4.24.4 Operands of option “COQ\_POU”***

***This option makes it possible to connect a part with a grid in hull with a beam part.***

***AXE\_POUTRE***

=

***Allows to define the axis of the beam to be connected, whose end is lno2 or lgn2 (1 only node).***

***CARA\_ELEM = will cara***

***Concept created by order AFFE\_CARA\_ELEM, containing the geometrical characteristics hull.***

/MAILLE\_1 =

/

***GROUP\_MA\_1***

=

***These operands define the meshes of edge of the part with a grid in hulls (the meshes of edge are thus SEG2 or SEG3 following selected modeling). These meshes must have been affected by finite elements of edge of hulls before.***

/NOEUD\_2 =

/

***GROUP\_NO\_2***

=

***These operands define the node of the beam to be connected to the hull part. Thus if one uses NOEUD\_2 one should give one node, and if GROUP\_NO\_2 is used, one should not give that only one group, this one containing one node.***

***Precaution for use:***

***The trace of the section of the beam on the hull part must correspond exactly to the meshes of edge defined by MAILLE\_1 or GROUP\_MA\_1. This implies the identity of the centres of inertia, of surfaces of the sections hull and beam in opposite.***

***4.24.5 Operands of the option “3D\_TUYAU”***

***OPTION = “3D\_TUYAU”,***

***This option makes it possible to connect a massive part 3D with a part modelled with elements PIPE.***

***AXE\_POUTRE***

***=***

***Defines the axis of the pipe to connect, whose end is only one node (lno2 or lgn2).***

***CARA\_ELEM = will cara***

***Idem [§4.19.4].***

***/MAILLE\_1***

***=***

***/***

***GROUP\_MA\_1***

***=***

***These operands define the surface meshes of the massive part modelling the trace of the section of the pipe on this massive part. These meshes must be affected by finite elements of faces of elements 3D before.***

***/NOEUD\_2***

***=***

***/***

***GROUP\_NO\_2***

***=***

***These operands define the node of the pipe to be connected to the massive part.***

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### ***Note:***

***A connection between a massive part 3D and a pipe part requires six relations linear for the degrees of freedom of beam, plus a relation on the mode of swelling, plus twelve relations corresponding to the transmission of the modes of Fourier two and three of ovalization of the pipe.***

### ***4.24.6 Operands of option “COQ\_TUYAU”***

***OPTION = “COQ\_TUYAU”***

***This option makes it possible to connect a part with a grid in hull to a part with a grid with elements pipe.***

***AXE\_POUTRE***

***=***

***Allows to define the axis of the pipe to be connected, whose end is lno2 or lgn2 (only one node).***

***CARA\_ELEM = will cara,***

***Concept created by order AFFE\_CARA\_ELEM, containing the geometrical characteristics hull.***

***/MAILLE\_1***

***=***

***/***

***GROUP\_MA\_1***

***=***

***These operands define the meshes of edge of the part with a grid in hulls (the meshes of***

*edge are thus SEG2 or SEG3 following selected modeling). These meshes must have summer affected by finite elements of edge of hulls before.*

```
/NOEUD_2
=
/
GROUP_NO_2
=
```

*These operands define the node of the pipe to be connected to the hull part. Thus if one use NOEUD\_2 one must give one node, and if GROUP\_NO\_2 is used, one does not have to give that only one group, this one containing one node.*

*Precaution for use:*

*The trace of the section of the pipe on the hull part must correspond exactly to meshes of edge defined by MAILLE\_1 or GROUP\_MA\_1. This implies the identity of , surface centres of inertia of the sections hull and pipe in opposite. Consequently connections of the type “pricking” are impossible.*

*Note:*

*A connection between a hull part and a pipe part requires the same relations linear that option “COQ\_POU” on the ddl of beam of the element pipe in addition to relations on the ddl of ovalization, warping and swelling.*

#### **4.24.7 Operand ANGL\_MAX**

```
ANGL_MAX
= / 1.
, [DEFECT]
/
Eng,
[R]
```

*Angle (in degree) allowing to check if the meshes of the lists lma1 or lgma1 have normals forming an angle higher than Eng between them. If it is the case, there is emission of a message of alarm.*

*The programming is made only in the case 3D (thus “3D\_TUYAU” and “3D\_POU”).*

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#### **4.24.8 Operand NUME\_LAGR**

.

*If “NORMAL”, the two multipliers of Lagrange associated with the relation will be such as first will be located before all the terms implied in the relation and the second after, in the assembled matrix.*

.

*If “AFTER”, the two multipliers of Lagrange associated with the relation will be located afterwards all terms implied in the relation, the assembled matrix.*

*This choice has the advantage of having an assembled matrix whose obstruction is more weak but has the disadvantage to be able to reveal a singularity in the matrix.*

#### **4.25 Key word**

**LIAISON\_UNIF**

##### **4.25.1 Drank**

*Key word factor allowing to impose the same value (unknown) on degrees of freedom of one together of nodes.*

*These nodes are defined by the groups of meshes, the meshes, the groups of nodes or the list of nodes to which they belong.*

##### **4.25.2 Syntax**

.

*for AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F*

**LIAISON\_UNIF**

**=\_F**

(

**/MESH**

**= lma**

,

**[l\_maille]**

/

**GROUP\_MA**

=

**lgma,**

**[l\_gr\_maille]**

/

**NODE**

=

**lno**

,

**[l\_noeud]**

/

**GROUP\_NO**

=

**lgno,**

**[l\_gr\_noeud]**

**DDL**

**= / "DX",**

*/“DY”,*

*/“DZ”,*

*/“DRX”,*

*/“DRY”,*

*/“DRZ”,*

)

### **4.25.3 Operand**

*/MESH*

*/*

*GROUP\_MA*

*/*

*NODE*

*/*

*GROUP\_NO*

*These operands make it possible to define a list of nodes from which one eliminated them redundancies, (for MESH and GROUP\_MA, they are connectivities of the meshes).*

### **DDL**

*This operand makes it possible to define a list of degrees of freedom texts*

*taken among: “DX”, “DY”, “DZ”, “DRX”, “DRY”, “DRZ”*

*conditions resulting kinematics are:*

*for*

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**4.26** Key word

**LIAISON\_CHAMNO**

**4.26.1** Drank

**Key word factor usable to define a linear relation between all ddls present in a concept CHAM\_NO. This key word can be also used to impose on the structure (or a part) a work given, for a loading calculated as a preliminary with another AFFE\_CHAR\_MECA and leading to one**

**assembled vector produces by ASSE\_VECTEUR [U4.61.23].**

**4.26.2** Syntax (*AFFE\_CHAR\_MECA* only)

**LIAISON\_CHAMNO=F (**

**CHAM\_NO =**

**chamno,**

**[cham\_no]**

**COEF\_IMPO =**

**, [R]**

**NUME\_LAGR**

=

/

**“NORMAL”,**

**[DEFECT]**

/

**“AFTER”**

,

)

### 4.26.3 Operands

**CHAM\_NO =**

*Name of the cham\_no which is used to define the linear relation. The ddls connected are all those present in chamno. The coefficients to be applied to the ddls are the values of the chamno for these ddls.*

**Example:**

*Let us suppose that one has a bearing chamno on two nodes of name N01 and N02 respectively carriers of ddls “DX”, “DY” and “DZ” for the N01 node and “DX”, “DY”, “DZ”, “DRX”, “DRY” and “DRZ” for the N02 node.*

*Also let us suppose that the chamno has the following values for these ddls:*

2.

**“DX”**

**N01**

1.

**“DY”**

N01

3.

“DZ”

N01

1.

“DX”

N02

4.

“DY”

N02

2.

“DZ”

N02

3.

“DRX”

N02

5.

“DRY”

N02

2.

“DRZ”

N02

*The linear relation that one will impose is:*

$$2.*DX(N01) + 1.*DY(N01) + 3.*DZ(N01) \\ + 1.*DX(N02) + 4.*DY(N02) + 2.*DZ(N02) \\ + 3.*DRX(N02) + 5.*DRY(N02) + 2.*DRZ(N02) =$$

*COEF\_IMPO =*

*It is the value of the real coefficient to the second member of the linear relation.*

*NUME\_LAGR =*

.

*if “NORMAL”, the two multipliers of Lagrange associated with the relation will be such as first will be located before all the terms implied in the relation and the second after, in the assembled matrix,*

.

*if “AFTER”, the two multipliers of Lagrange associated with the relation will be located afterwards all terms implied in the relation, the assembled matrix.*

*This choice has the advantage of having an assembled matrix whose obstruction is more*

*weak but has the disadvantage to be able to reveal a singularity in the matrix.*

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#### **4.27 Key word**

**VECT\_ASSE**

##### **4.27.1 Drank**

***Key word allowing to assign a second member in the form of a CHAM\_NO in the orders STAT\_NON\_LINE and DYNA\_NON\_LINE. This CHAM\_NO is transmitted to these orders via the name of loading.***

##### **4.27.2 Syntax**

**VECT\_ASSE**

=

**chamno**

**[cham\_no\_DEPL\_R]**

##### **4.27.3 Operand VECT\_ASSE**

***chamno is the name of the CHAM\_NO which will serve as second member in the orders STAT\_NON\_LINE or DYNA\_NON\_LINE.***

***The mode of use can see itself in the following way:***

```
tank = AFFE_CHAR_MECA (  
MODEL  
=  
model,  
VECT_ASSE  
=  
chamno,  
  
);  
resu = STAT_NON_LINE  
(  
MODEL  
=  
model,  
EXCIT  
=  
_F  
(LOAD  
=  
tank),  
...  
)  
;
```

#### **4.28 Key word** ***FORCE\_FACE***

##### **4.28.1 Drank**

***Key word factor usable to apply surface forces to a face (of voluminal element) defined by one or more meshes or of the groups of meshes of the triangle type or quadrangle.***

***According to the name of the operator called, the values are provided directly (*AFFE\_CHAR\_MECA*) or via a concept function (*AFFE\_CHAR\_MECA\_F*).***

##### **4.28.2 Syntax**

.

***for AFFE\_CHAR\_MECA***

***FORCE\_FACE=\_F***

***(***

***/***

***NET =***

***lma***

***, [l\_maille]***

***/ GROUP\_MA=***

***lgma,***

***[l\_gr\_maille]***

***/ FX=***

***fx***

***,***

***[R]***

***/ FY=***

***fy***

***,***

***[R]***

**/ FZ=**

**fz**

**,**

**[R]**

**)**

**.**

**for AFFE\_CHAR\_MECA\_F**

**FORCE\_FACE=\_F**

**(**

**/**

**NET =**

**lma**

**, [l\_maille]**

**/ GROUP\_MA=**

**lgma,**

**[l\_gr\_maille]**

**/ FX=**

**fxf**

**, [function]**

**/ FY=**  
**fyf**  
**, [function]**

**/ FZ=**  
**fzf**  
**, [function]**

)  
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**Version**  
**8.2**

**Titrate:**  
**Operators AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F**

**Date:**  
**22/02/06**  
**Author (S):**  
**X. DESROCHES Key**  
**:**  
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**4.28.3 Operands**



*fx, fy, fz*

*values of the components in the TOTAL reference mark of the forces*

*fxf, fyf, fzf*

*surface applied to the face.*

#### **4.28.4 Modelings and meshes**

*This loading applies to the types of meshes and following modelings:*

*Net Modélisation*

*TRIA3, TRIA6,*

*3D, 3D\_SI, 3D\_INCO*

*QUAD4, QUAD8, QUAD9,*

*3D\_HHMD, 3D\_HMD,*

*QUAD8, TRIA6*

*3D\_THHD, 3D\_THHMD,*

*3D\_THMD*

#### **4.29 Key word**

**FORCE\_ARETE**

##### **4.29.1 Drank**

*Key word factor usable to apply linear forces, with an edge of voluminal element or of hull. This edge is defined by one or more meshes or of the groups of meshes of the type segment.*

*According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_MECA) or via a concept function (AFFE\_CHAR\_MECA\_F).*

##### **4.29.2 Syntax**

*.*  
*for AFFE\_CHAR\_MECA*  
*FORCE\_ARETE*  
*=\_F*  
*(*  
*/*  
*NET =*  
*lma*  
*,*  
*[l\_maille]*

**/ GROUP\_MA=**  
**lgma,**  
**[l\_gr\_maille]**

**/ FX=**  
**fx**  
**,**  
**[R]**

**/ FY=**  
**fy**  
**,**  
**[R]**

**/ FZ=**  
**fz**  
**,**  
**[R]**

*/ MX=*  
*MX*  
,  
*[R]*

*/ MY=*  
*my*  
,  
*[R]*

*/ MZ=*  
*mz*  
,  
*[R]*

)  
.  
*for AFFE\_CHAR\_MECA\_F*  
*FORCE\_ARETE*

**=\_F**  
(  
/  
**NET =**  
**lma**  
,  
**[l\_maille]**

**/ GROUP\_MA=**  
**lgma,**  
**[l\_gr\_maille]**

**/ FX=**  
**fxf**  
,  
**[function]**

**/ FY=**  
**fyf**  
,  
**[function]**

**/ FZ=**  
**fzf**  
,  
**[function]**

**/ MX=**  
**mxj**  
,  
**[function]**

**/ MY=**  
**myj**  
,  
**[function]**

**/ MZ=**  
**mzf**  
,  
**[function]**

)

### **4.29.3 Operands**

*fx, fy, fz, MX, my, mz*

*values of the components in the TOTAL reference mark*

*fxf, fyf, fzf, mxf, myf, mzf: linear forces applied to the edge.*

### **4.29.4 Modelings and meshes**

*This loading applies to the types of meshes and following modelings:*

*Net Modélisation*

*SEG2*

*DKT, DST, Q4G*

*SEG2, SEG3*

*3D, 3D\_SI, 3D\_INCO*

*COQUE\_3D*

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### **4.30 Key word**

## ***FORCE\_CONTOUR***

### ***4.30.1 Drank***

***Key word factor usable to apply linear forces, at the edge of a field (2D, AXIS or AXIS\_FOURIER) defined by one or more meshes or of the groups of meshes.***

***According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_MECA) or via a concept function (AFFE\_CHAR\_MECA\_F).***

### ***4.30.2 Syntax***

***.***  
***for AFFE\_CHAR\_MECA***

***FORCE\_CONTOUR=\_F***

***(***  
***/***  
***NET =***  
***lma***  
***,***  
***[l\_maille]***

***/ GROUP\_MA=***  
***lgma,***  
***[l\_gr\_maille]***

***/ FX=***  
***fx***  
***,***  
***[R]***

**/ FY=**  
**fy**  
,  
**[R]**

**/ FZ=**  
**fz**  
,  
**[R]**

**/ MX=**  
**MX**  
,  
**[R]**

**/ MY=**  
**my**



,  
**[R]**

**/ MZ=**  
**mz**

,  
**[R]**

)  
.  
**for AFFE\_CHAR\_MECA\_F**

**FORCE\_CONTOUR=\_F**  
(  
/  
**NET =**  
**lma**  
,  
**[l\_maille]**

**/ GROUP\_MA=**  
**lgma,**  
**[l\_gr\_maille]**

**/ FX=**  
**fxf**  
,  
**[function]**

**/ FY=**  
**fyf**  
,  
**[function]**

**/ FZ=**  
**fzf**  
,  
**[function]**

**/ MX=**  
**mx f**  
,  
**[function]**

**/ MY=**  
**myf**  
,  
**[function]**

**/ MZ=**  
**mzf**  
,  
**[function]**

)

### **4.30.3 Operands**

***fx, fy, fz, MX, values of the components in the TOTAL reference mark of the linear forces  
my, mz  
applied to contour.  
fxf, fyf, fzf,  
mxf, myf, mzf***

### **4.30.4 Modelings and meshes**

***This loading applies to the types of meshes and following modelings:***

## ***Net Modélisation***

### ***Component***

***SEG2, SEG3***

***C\_PLAN***

***Fx, Fy***

***D\_PLAN***

***Fx, Fy***

***AXIS***

***Fx, Fy***

***SEG2, SEG3***

***AXIS\_FOURIER***

***Fx (R), Fy (Z), Fz ()***

### ***Note:***

***In plan, the forces are to be provided per unit of length of the grid, into axisymmetric, then forces required are brought back to a sector of 1 radian (to divide the real loading by 2).***

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### ***4.31 Key word***

***FORCE\_INTERNE***

#### ***4.31.1 Drank***

***Key word factor usable to apply voluminal forces (2D or 3D), with a field defined by one or more meshes or of the groups of meshes of the voluminal type.***

*According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_MECA)  
or  
via a concept function (AFFE\_CHAR\_MECA\_F).*

#### *4.31.2 Syntax*

*.*  
*for AFFE\_CHAR\_MECA*

*FORCE\_INTERNE=\_F*  
*(*  
*/ALL =*  
*“YES”,*

*/|*  
*NET =*  
*lma*  
*,*  
*[l\_maille]*

*/GROUP\_MA*  
*= lgma,*  
*[l\_gr\_maille]*

*/ FX=*  
*fx*  
,

*[R]*

*/ FY=*  
*fy*  
,

*[R]*

*/ FZ=*  
*fz*  
,

*[R]*

)  
.  
*for AFFE\_CHAR\_MECA\_F*

*FORCE\_INTERNE=\_F*  
(  
*/ALL =*  
*“YES”,*

/ |  
**NET =**  
**lma**  
,  
**[l\_maille]**

**/ GROUP\_MA**  
**= lgma,**  
**[l\_gr\_maille]**

**/ FX=**  
**fxf**  
,  
**[function]**

**/ FY=**

*fyf*

,  
*[function]*

*/ FZ=*

*fzf*

,  
*[function]*

)

### **4.31.3 Operands**

*fx, fy, fz,*

*values of the components in the TOTAL reference mark of the forces*

*fxf, fyf, fzf:*

*voluminal applied to the field.*

### **4.31.4 Modelings and meshes**

*This loading applies to the types of meshes and following modelings:*

*Net Modélisation*

*HEXA8, HEXA20, HEXA27*

*PENTA6, PENTA15*

*3D, 3D\_SI, 3D\_INCO*

*TETRA4, TETRA10*

*3D\_HHMD, 3D\_HMD, 3D\_THHD, 3D\_THHMD,*

*PYRAM5, PYRAM13*

*3D\_THMD, 3D\_THHM, 3D\_THM, 3D\_HM, 3D\_THH,*

*3D\_HHM*



**TRIA3, TRIA6,  
C\_PLAN  
QUAD4, QUAD8, QUAD9  
D\_PLAN  
AXIS  
AXIS\_FOURIER  
AXIS\_SI  
AXIS\_INCO  
AXIS\_THHM, AXIS\_HM, AXIS\_THH, AXIS\_HHM,  
AXIS\_THM  
D\_PLAN\_THHM, D\_PLAN\_HM, D\_PLAN\_THH,  
D\_PLAN\_HHM, D\_PLAN\_THM**

**Note:**

*In 2D (resp 3D), the forces are to be provided per unit of area (resp volume), in axisymmetric, the forces required are brought back to a sector of 1 radian (to divide it real loading by 2).*

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**4.32 Key word**

**PRES\_REP**

**4.32.1 Drank**

*Key word factor usable to apply a **pressure** to a **field** of continuous medium 2D or 3D.*

According to the name of the operator called, the values are provided directly (*AFFE\_CHAR\_MECA*)  
or  
via a concept function (*AFFE\_CHAR\_MECA\_F*).

#### 4.32.2 Syntax

.

*for AFFE\_CHAR\_MECA*

/

*PRES\_REP=\_F*

(

*/ALL =*  
*“YES”,*

/|

*NET =*

*lma*

*, [l\_maille]*

*/GROUP\_MA*

*= lgma,*

*[l\_gr\_maille]*

**/CLOSE =  
P,**

**[R]**

**/  
CISA\_2D =  
T,**

**[R]**

**)  
.  
for AFFE\_CHAR\_MECA\_F**

**/  
PRES\_REP=\_F  
(**

**/ALL =  
“YES”,**

**//**

**NET =**  
**lma**  
**, [l\_maille]**

**/ GROUP\_MA**  
**= lgma,**  
**[l\_gr\_maille]**

**/ CLOSE =**  
**PF,**  
**[function]**

**/**  
**CISA\_2D =**  
**Tf,**  
**[function]**

)

### 4.32.3 Operands

**/CLOSE = P (PF)**

*Value of the imposed pressure*

*P (or PF) is positive according to the contrary direction of the normal to the element: that is to say the tensor*

*constraints, the imposed loading is:*

.

**/CISA\_2D = T (Tf)**

*Value of imposed shearing*

*T (or Tf) is positive according to the tangent with the element.*

*For the definition of the normals and tangents, one will refer to the definitions given to [§4.1].*

*Example:*

+

**T** **$p > 0$** **2**

+

**N****N****T****3****- pn****1****2****3****1**

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#### **4.32.4 Modelings and meshes**

*The loading of pressure applies to the types of meshes and following modelings:*

*Type of Mesh*

*Modeling*

**SEG2 SEG3**

**AXIS, D\_PLAN, C\_PLAN, AXIS\_FOURIER**

**D PLAN HHM, D PLAN HM, D PLAN THHM,**

**D\_PLAN\_THM**

**SEG3**

**AXIS\_HHM, AXIS\_HM, AXIS\_THHM, AXIS\_THM**

**TRIA6 QUAD8**

**3D\_HHM, 3D\_HM, 3D\_THHM, 3D\_THM**

**TRIA3, QUAD4**

**3D**

**TRIA6, QUAD8, QUAD9**

*The loading of shearing applies to the meshes and following modelings:*

*Type of Mesh*

*Modeling*

**SEG2 SEG3**

**AXIS, D\_PLAN, C\_PLAN, AXIS\_FOURIER**

#### **4.33 Key word**

**EFFE\_FOND**

*Key word factor usable to calculate the basic effect on a branch of piping (modeling 3D)*

*exclusively) subjected to a pressure P. interns.*

#### **4.33.1 Syntax**

.  
*for AFFE\_CHAR\_MECA*

*/ EFFE\_FOND*

*=\_F*

*(*

*/*

*NET =*

*lma*

*,*

*[l\_maille]*

*/ GROUP\_MA=*

*lgma,*

*[l\_gr\_maille]*

*GROUP\_MA\_INT*

*=*

*gtrou,*

*[l\_gr\_maille]*

**NEAR**

=

**p,**

**[R]**

)

.

**for AFFE\_CHAR\_MECA\_F**

**/ EFFE\_FOND**

**=\_F**

(

/

**NET =**

**lma**

,

**[l\_maille]**

**/ GROUP\_MA=**

**lgma,**

**[l\_gr\_maille]**

**GROUP\_MA\_INT**

=

**gtrou,**



*[l\_gr\_maille]*

**NEAR**

=

**PF,**

*[function]*

)

#### **4.33.2 Operands**

**Group of mesh: gmat**

**X**

**Group of mesh: gtrou**

**/GROUP\_MA = gmat,**

**/**

**NET**

=

**lma,**

*Together surface meshes modelling the material section of piping (gmat on appear) where the pressure will be applied.*

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**GROUP\_MA\_INT = gtrou,**

**Together linear meshes (SEG2 or SEG3) modelling the contour of the hole (option on appear).**

**The knowledge of these meshes is necessary because one needs to calculate the surface of the hole.**

**Indeed, the effort resulting (or basic effect) due to stopping from the hole at the end is worth:**

**This basic effort or effect applies to the wall of the tube (gmat). The effort divided correspondent is worth:**

**NEAR: p (or PF)**

**Pressure interns with piping. One applies in fact with gmat (with  $p > 0$  following the direction opposite of the normal to the element).**

**4.34 Key word**

**EPSI\_INIT**

**4.34.1 Drank**

**Key word factor usable to apply a loading of initial deformation to an element 2D, 3D or of structure. This “initial” deformation is usable for example to solve the problems elementary determining the elastic correctors in the basic cell (2D, 3D), in periodic homogenisation. The moduli of homogenized elasticity are obtained while calculating by operator POST\_ELEM [U4.81.22] key word ENER\_POT potential energy of elastic strain with balance starting from the correctors. But that can be useful for other applications.**

**The assignment can be done on one or more meshes, one or more groups of meshes or on all elements of the model.**

**4.34.2 Syntax**

.

**for AFFE\_CHAR\_MECA**  
**EPSI\_INIT**  
**=\_F**  
**(**  
**/ALL =**  
**“YES”,**

**/|**  
**NET =**  
**lma**  
**,**  
**[l\_maille]**

**/GROUP\_MA**  
**= lgma,**  
**[l\_gr\_maille]**

**/EPXX = epsxx**  
**,**  
**[R]**

/ *EPYY* =  
*epsyy*  
,  
*[R]*

/ *EPZZ* =  
*epszz*  
,  
*[R]*

/ *EPXY* =  
*epsxy*  
,  
*[R]*

/ *EPXZ* =  
*epsxz*  
,  
*[R]*

*/ EPYZ =*  
*epsyz*  
,

*[R]*

*/ EPX*  
*=*  
*epsx*  
,

*[R]*

*/ KY*  
*=*  
*ky*  
,

*[R]*

*/ KZ*  
*=*  
*kz*  
,

*[R]*

*/ EXX*  
=  
*exx*  
,  
*[R]*

*/ EYY*  
=  
*eyy*  
,  
*[R]*

*/ EXY*  
=  
*exy*  
,  
*[R]*

*/ KXX*  
=  
*kxx*

,  
[R]

/ *KYY*  
=  
*kyy*

,  
[R]

/ *KXY*  
=  
*kxy*

,  
[R]

)  
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**X. DESROCHES** Key

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.

for *AFFE\_CHAR\_MECA\_F*

*EPSI\_INIT*

= *\_F*

(

/ALL =

“YES”,

/|

NET =

*lma*

,

[*l\_maille*]

| *GROUP\_MA*

= *lgma*,

[*l\_gr\_maille*]



/  $EPXX = epsxxf$

,

[function]

/  $EPYY =$

$epsyyf$

,

[function]

/  $EPZZ =$

$epszzf$

,

[function]

/  $EPXY =$

$epsxyf$

,

[function]

/  $EPXZ =$

*epsxzf*  
,  
[function]

/ *EPYZ* =  
*epsyzf*  
,  
[function]

)

### **4.34.3 Operands**

/  
*EPXX* = *epsxx* or *epsxxf*

/  
*EPYY* = *epsyy* or *epsyyf*  
*components of the tensor of the deformations*

/  
*EPZZ* = *epszz* or *epszzf*  
*initial in the TOTAL reference mark*

/  
*EPXY* = *epsxy* or *epsxyf*

/  
*EPXZ* = *epsxz* or *epsxzf*

*(in 3D only)*

/  
 $EPYZ = \text{epsyz or epsyzf}$

**Note:**

*The second calculated elementary member will be where the tensor indicates of elasticity.*

*It corresponds to a loading and will not be taken into account in the calculation of the constraints into nonlinear. It thus does not correspond to an initial deformation into nonlinear.*

*For the elements beams only: constant field of deformations generalized by element:*

/  
 $EPX = \text{epsx}$ :

*elongation according to the axis of the beam*

/  
 $KY = ky$ :

*curve according to the local axis*

/  
 $KZ = kz$ :

*curve according to the local axis*

*For the curved beams, only EPX is taken into account currently. Emission of a message of fatal error if the user provides KY or KZ.*

*For the elements hulls only: field of initial deformations constant by element:*

/  
*EXX, EYY, EXY:*  
*deformations of membrane*

/  
*KXX, KYY, KXY: curves*  
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#### **4.34.4 Modelings and meshes**

***This loading applies to the types of meshes and following modelings:***

***Type of Mesh***

***Modeling***

***TRIA3, TRIA6***

***C\_PLAN, AXIS, D\_PLAN***

***QUAD4, QUAD8, QUAD9***

***HEXA8, HEXA20, HEXA27***

***3D***

***PENTA6, PENTA15***

***PYRAM5, PYRAM13***

***TETRA4, TETRA10***

***SEG2***

***POU\_D\_E, POU\_D\_T, POU\_D\_TG, POU\_C\_T***

***TRIA3, QUAD4***

**DKT, DST, Q4G**  
**HEXA20 3D\_SI**  
**QUAD8 AXIS\_SI,**  
**D\_PLAN\_SI**

**4.35 Key word**  
**FORCE\_POUTRE**

**4.35.1 Drank**

**Key word factor usable to apply linear forces, to elements of the beam type**  
(*POU\_D\_T\_\**, *POU\_D\_E*,...) defined on all the grid or one or more meshes or of the groups meshes. The forces are definite component by component, either in the *TOTAL* reference mark, or in the local reference mark of the element defined by operator *AFFE\_CARA\_ELEM* [U4.42.01].

According to the name of the operator called, the values are provided directly (*AFFE\_CHAR\_MECA*) or via a concept function (*AFFE\_CHAR\_MECA\_F*).

**4.35.2 Syntax**

.

**for AFFE\_CHAR\_MECA**  
**FORCE\_POUTRE**  
**=\_F**  
**(**  
**/ALL =**  
**“YES”,**

**/|**  
**NET =**  
**lma**  
**,**  
**[l\_maille]**

**/ GROUP\_MA**  
**= lgma,**

**[l\_gr\_maille]**

**// FX**  
**=**  
**fx**  
**,**  
**[R]**

**/ FY**  
**=**  
**fy**  
**,**  
**[R]**

**/ FZ**

=  
**fz**  
,  
**[R]**

/  
**/NR = N, [R]**

**/VY**  
=  
**vy**  
,  
**[R]**

**/VZ**  
=  
**vz**  
,  
**[R]**

***TYPE\_CHARGE =/"FORCE", [DEFECT]***

***/***  
***"WIND"***

***,***

***)***  
***.***  
***for AFFE\_CHAR\_MECA\_F***

***FORCE\_POUTRE***

***=\_F***

***(***

***/ALL =***

***"YES",***

***/|***

***NET =***

***lma***

***,***

***[l\_maille]***



**/ GROUP\_MA**

**= lgma,**

**[l\_gr\_maille]**

**// FX**

**=**

**fxf**

**,**

**[function]**

**/ FY**

**=**

**fyf**

**,**

**[function]**

**/ FZ**

**=**

**fzf**

**,**

**[function]**

/  
/ **NR**  
=  
**nf**  
,  
**[function]**

/ **VY**  
=  
**vyf**  
,  
**[function]**

/ **VZ**  
=  
**vzf**  
,  
**[function]**

***TYPE\_CHARGE =/"FORCE", [DEFECT]***

***/"WIND"***

)  
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***Code\_Aster*** ®

***Version***

***8.2***

***Titrate:***

***Operators AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F***

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### 4.35.3 Operands

**//fx**

:

**Force according to**

**X**

**[R]**

**or [function]**

**/fy**

:

**Force according to**

**Y**

**[R]**

**or [function]**

**/fz**

:

**Force according to**

**Z**

**[R]**

**or [function]**

**/**

**/N:**

**Effort of traction and compression**

**[R]**

**or [function]**

**/vy**

:

***Following transverse effort***

***Y***

***[R]***

***or [function]***

***/ vz***

***:  
Following transverse effort***

***Z***

***[R]***

***or [function]***

***Let us note that one must remain homogeneous in each occurrence of the key word factor  
FORCE\_POUTRE:***

***either all the components are defined in the TOTAL reference mark or all the components are  
defined in the reference mark of definition of the beam.***

***TYPE\_CHARGE = “WIND”***

***If p is the pressure exerted by the wind on a plane surface normal with its direction,***

***the unit vector having the direction and the direction the speed of the wind,***

***Ø the diameter of the cable on which the wind is exerted,***

***then:***

$$***F<sub>X</sub> = p Ø***$$

$$***F<sub>Y</sub> = p Ø***$$

$$***F<sub>Z</sub> = p Ø***$$

***TYPE\_CHARGE***

***=***

***“FORCE” [DEFECT]***

***Case of an unspecified linear force.***

#### **4.35.4 Modelings and meshes**

*This loading applies to the types of meshes and following modelings:*

*Net Modélisation  
SEG2 POU\_D\_T,  
POU\_C\_T,  
POU\_D\_E  
POU\_D\_TGM*

*This loading is not currently available for modeling POU\_D\_TG.*

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#### **4.36 Key word**

**DDL\_POUTRE**

##### **4.36.1 Drank**

*Key word factor usable to block DDL in a local reference mark of a beam.*

*The local reference mark of a beam is defined:*

*.*

*by axis X determined by the mesh to which the node belongs. The mesh is directed towards the specified node. To avoid the indetermination, it is necessary that the node to which relates condition belongs to only one SEG. In the case or it belongs to several meshes, the user defines the mesh giving the local orientation.*

*.*

by **VECT\_Y**: a vector whose projection on the orthogonal level with axis **X** defines axis **Y**.  
Axis **Z** is given using **X** and **Y**

by **ANGL\_VRIL**: angle of gimlet, given in degrees, makes it possible to direct a local reference mark around axis **X**.

#### 4.36.2 Syntax

for **AFFE\_CHAR\_MECA**  
**DDL\_POUTRE**  
= **\_F**  
(  
/  
**NODE** =  
**lno**  
,  
[**l\_noeud**]

/**GROUP\_NO**  
= **lgno**,  
[**l\_gr\_noeud**]

/**DX**  
=  
**ux**  
,  
[**R**]

***/DY***

=

***uy***

,

***[R]***

***/DZ***

=

***uz***

,

***[R]***

***/DRX***

=

***X***

,

***[R]***



***/DRY***

=

***y***

,

***[R]***

***/DRZ***

=

***Z***

,

***[R]***

***# definition of the local reference mark***

***/NET =***

***lma***

,

***[l\_maille]***

***/GROUP\_MA***

***= lgma,***

***[l\_gr\_maille]***

***/***

***ANGL\_VRIL***

=

**G,**  
**[R]**  
 /  
**VECT\_Y**  
 =

**(V1,**  
**V2,**  
**V3)**  
**[l\_R]**

)

### **4.36.3 Operands**

***DX = ux***  
*Value of the component of displacement in imposed translation*  
***DY = uy***  
*on the specified nodes*  
***DZ = uz***

***DRX = X***  
*Value of the component of displacement in rotation imposed on*  
***DRY = y***  
*specified nodes*  
***DRZ = Z***

***ANGL\_VRIL = G***  
*angle of gimlet, given in degrees, makes it possible to direct a local reference mark around axis X.*

***VECT\_Y = (V1, V2, V3)***  
*vector whose projection on the orthogonal level with axis X defines axis Y.*  
*Axis Z is given using X and Y*

### **4.36.4 Modelings and meshes**

***This loading applies to the types of meshes and following modelings:***

***Net Modélisation***

***SEG2 POU\_D\_T,***

***POU\_C\_T,***

***POU\_D\_TG, POU\_D\_E,***

***POU\_D\_TGM***

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***4.37 Key word***

***FORCE\_TUYAU***

***4.37.1 Drank***

***Key word factor usable to apply a pressure to elements pipe, defined by one or several meshes or of the groups of meshes.***

***4.37.2 Syntax***

***.***

***AFFE\_CHAR\_MECA:***

***/ FORCE\_TUYAU= \_F (***

***/ALL =***

**“YES”,**

//  
**NET =**  
**lma**  
,  
**[l\_maille]**

**/ GROUP\_MA**  
**= lgma,**  
**[l\_gr\_maille]**

**NEAR**  
**=**  
**p,**  
**[R]**

)  
.  
**AFFE\_CHAR\_MECA\_F:**

**/FORCE\_TUYAU=\_F (**  
**/ALL =**  
**“YES”,**

**/|**  
**NET =**  
**lma**  
**,**  
**[l\_maille]**

**/GROUP\_MA**  
**= lgma,**  
**[l\_gr\_maille]**

**NEAR**  
**=**

***PF,***  
***[function]***

)

### ***4.37.3 Operand***

***CLOSE =***  
***p (PF),***

***Value of the imposed pressure (real or function).***  
***p is positive when the pressure is internal with piping.***

### ***4.37.4 Modelings and meshes***

***This loading applies to the types of meshes and following modelings:***

***Net Modélisation***

***SEG3, SEG4***

***“TUYAU\_3M”***

***SEG3***

***“TUYAU\_6M”***

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#### **4.38 Key word**

**FORCE\_COQUE**

##### **4.38.1 Drank**

*Key word factor usable to apply surface efforts, to elements of the hull type (DKT, DST, Q4G,...) defined on all the grid or one or more meshes or of the groups of meshes.*

*According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_MECA) or via a concept function (AFFE\_CHAR\_MECA\_F).*

##### **4.38.2 Syntax**

*.*  
*for AFFE\_CHAR\_MECA*  
**FORCE\_COQUE**  
**=\_F**  
**(**  
**/ALL =**  
**“YES”,**

**/|**  
**NET =**  
**lma**  
**,**  
**[l\_maille]**

**/ GROUP\_MA**  
**= lgma,**  
**[l\_gr\_maille]**

**// FX**  
**=**  
**fx**  
**,**  
**[R]**

**/ FY**  
**=**  
**fy**  
**,**  
**[R]**

**/ FZ**  
**=**  
**fz**  
**,**



**[R]**

**/ MX**

=

**MX**

,

**[R]**

**/ MY**

=

**my**

,

**[R]**

**/ MZ**

=

**mz**

,

**[R]**

***PLAN =/“MOY”,***

***/“INF”,***

***/“SUP”,***

***/***  
***“EMAIL”, [DEFECT]***

/  
**NEAR**  
=  
**p,**  
**[R]**

/  
**/ F1**  
=  
**f1**  
,  
**[R]**

**/ F2**  
=  
**f2**  
,  
**[R]**

**/ F3**  
**=**  
**f3**  
**,**  
**[R]**

**/ MF1**  
**= mf1**  
**,**  
**[R]**

**/ MF2**  
**= mf2**  
**,**  
**[R]**

)

.

**for AFFE\_CHAR\_MECA\_F**  
**FORCE\_COQUE**  
**=\_F**  
**(**  
**/ALL =**  
**“YES”,**

**/|**  
**NET =**  
**lma**  
**,**  
**[l\_maille]**

**/ GROUP\_MA**  
**= lgma,**  
**[l\_gr\_maille]**

**// FX**  
**= fxf**  
**,**  
**[function]**

***/ FY***  
***= fyf***  
,  
***[function]***

***/ FZ***  
***= fzf***  
,  
***[function]***

***/ MX***  
***= mxf***  
,  
***[function]***

**/ MY**  
**= myf**  
,  
**[function]**

**/ MZ**  
**= mzf**  
,  
**[function]**

**PLAN =/"MOY",**

**/"INF",**

*/“SUP”,*

*/*  
*“EMAIL”, [DEFECT]*

*/*  
*NEAR*  
*=*  
*PF*  
*,*  
*[function]*

*/*  
*/ F1*  
*= f1f*



,  
*[function]*

*/ F2*  
*= f2f*

,  
*[function]*

*/ F3*  
*= f3f*

,  
*[function]*

*/ MF1*  
*=*  
*mf1f,*  
*[function]*

*/MF2*  
=  
*mf2f,*  
*[function]*

)  
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### *4.38.3 Operands*

*The operands of FORCE\_COQUE can be defined:*

*.*  
*in the TOTAL reference mark of axes X, Y and Z,*  
*.*

*in a reference mark of reference defined on each mesh or groups of mesh (definite reference mark on the variety); this reference mark is built around the normal with the element of hull (Z)*

*ref.*

*and of a direction fixed (X) (for the group of mesh) definite by the key word ANGL\_REP*

*ref.*

*at the same time as the thickness of the hull (see key word factor HULL operator AFFE\_CARA\_ELEM [U4.42.01]).*

**Z**

*zref (3)*

*yref (2)*

**3**

**Y**

**2**

**X**

**1**

*xref (1)*

*ANGL\_REP: (45. 0.)*

*//fx*

*: Force according to*

**X**

**[R]**

*or [function]*

*/fy*

*: Force according to*

**Y**

**[R]**

*or [function]*

*/fz*

*: Force according to*

**Z**

**[R]**

*or [function]*

*/ MX*  
*: Moment of axis*  
*X*  
*[R]*  
*or [function]*

*/ my*  
*: Moment of axis*  
*Y*  
*[R]*  
*or [function]*

*/ mz*  
*: Moment of axis*  
*Z*  
*[R]*  
*or [function]*

*/*  
*p*  
*:*  
*Normal pressure with the hull [R]*  
*or [function]*

*/| f1*  
*: Effort of membrane according to xref [R] or [function]*

*/ f2*  
*: Effort of membrane according to yref [R] or [function]*

*/ f3*  
*: Following normal effort zref*

*[R]*  
*or [function]*

*/ mf1*  
*:*  
*Bending moment of axis X*  
*[R]*  
*or [function]*

*/ mf2*  
*:*  
*Bending moment of axis Y*  
*[R]*  
*or [function]*

*Let us note that one must remain homogeneous in each occurrence of the key word factor FORCE\_COQUE: either all in component of effort in the TOTAL reference mark or all in component of effort in the reference mark of definition of the hull.*

*The pressure applied is positive according to the contrary direction of the normal to the element (defined by the first 3 nodes of each mesh (cf [§4.25.3])).*

*PLAN*  
*=*

/“MOY”,

/“INF”,

/

“SUP”,

/

“EMAIL”, [DEFECT]

*Allows to define a torque of efforts on the average, lower, higher level or of the grid.*

*If one notes D offsetting and H the thickness of the hull,*

*(F2X, F2Y, F2Z, M2X, M2Y, M2Z) the torque of the efforts on the level defined by the user (i.e. excentré)*

*(F1X, F1Y, F1Z, M1X, M1Y, M1Z) the torque of the efforts in the plan of the grid*

*The formulas of passage are as follows:*

.

*if the plan of calculation is the plan of the grid:*

$$F2 = F1$$

$$M2 = M1$$

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.  
if the plan of calculation is the excentré average layer:

$$F2 = F1$$

$$M2X = M1X + dxF1Y$$

$$M2Y = M1Y + dxF1X$$

.  
if the plan of calculation is the excentré higher layer:

$$F2 = F1$$

$$M2X = M1X$$

$$X F1Y$$

$$M2Y = M1Y +$$

$$X F1X$$

.  
if the plan of calculation is the excentré lower layer:

$$F2 = F1$$

$$M2X = M1X$$

$$X F1Y$$

$$M2Y = M1Y +$$

$$X F1X$$

/

“MOY” one applies the torque of efforts to the excentré average layer

/

“INF” one applies the torque of efforts to the lower skin

“SUP” one applies the torque of efforts to the higher skin

“EMAIL”  
one applies the torque of efforts to the level of the plan of the grid

#### **4.38.4 Modelings and meshes**

This loading applies to the types of meshes and following modelings:

##### **Net Modélisation**

TRIA3 QUAD4

DKT, DST

QUAD4 Q4G

TRIA7 QUAD9

## *COQUE\_3D*

### ***Note:***

*This loading is available only on one three-dimensional grid (defined by COOR\_3D).*

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#### **4.39 Key word**

**LIAISON\_COQUE**

##### **4.39.1 Drank**

***Key word factor making it possible to represent the connection enters of the hulls by means of relations***

***linear. The traditional approach admits that two plans with a grid in hulls are cut according to a line who belongs to the grid of the structure.***

***That has the disadvantage of twice counting the volume which is the intersection of the two hulls.***

***The idea is thus to stop the grid of a hull perpendicular to a hull given to the level of higher or lower skin of the latter.***

**A2**

**B2**

**A1 B1**

***One represented in features full volume with the hulls and in dotted lines the average plans of these hulls***

***(which results from the grid).***

***The horizontal hull stops in A1 A2 and the projection of A1 A2 on the average level of the vertical hull***

***is B1 B2 (which one represented in full features).***

***The link between the 2 hulls is made by connections of solid body between the nodes in with respect to***

*segments A1 A2 and B1 B2.*

*For example for the nodes A1 and B1, one will write the formula (valid in small rotations):*

*and equality of rotations:*

#### *4.39.2 Syntax*

*.*  
*for AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F*

*LIAISON\_COQUE*

*=*  
*\_F*

*(*  
*/ GROUP\_MA\_1 =*  
*l\_gma1*  
*,*  
*[l\_gr\_maille]*

*/ MAILLE\_1*  
*=*  
*l\_ma1*  
*,*  
*[l\_maille]*

*/ GROUP\_NO\_1 =*  
*l\_gno1*  
*,*  
*[l\_gr\_noeud]*

**/NOEUD\_1 =**  
**l\_no1**  
,  
**[l\_noeud]**

**/GROUP\_MA\_2 = l\_gma2**  
,  
**[l\_gr\_maille]**

**/MAILLE\_2**  
**=**  
**l\_ma2**  
,  
**[l\_maille]**

**/GROUP\_NO\_2 =**  
**l\_gno2**  
,  
**[l\_gr\_noeud]**

**/NOEUD\_2 =**  
**l\_no2**  
,  
**[l\_noeud]**

**NUME\_LAGR**

=  
/  
“NORMAL”,  
[DEFECT]  
/  
“AFTER”  
,

)  
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### **4.39.3 Operands**

**/GROUP\_MA\_1**

**/MAILLE\_1**

**/GROUP\_NO\_1**

**/NOEUD\_1**

**Using key words GROUP\_MA\_1, MAILLE\_1, GROUP\_NO\_1 and NOEUD\_1, one constitutes first list of nodes (nonredundant) representing the trace of the hull perpendicular to the current hull.**

*On our example, they would be the nodes of the segment B1 B2 or the segment A1 A2.*

*/GROUP\_MA\_2*

*/MAILLE\_2*

*/GROUP\_NO\_2*

*/NOEUD\_2*

*Using key words GROUP\_MA\_2, MAILLE\_2, GROUP\_NO\_2 and NOEUD\_2, one constitutes second list of nodes (nonredundant) pertaining to the perpendicular hull and in opposite nodes of the first list. Opposite is adjusted by the program according to the criterion moreover small distance.*

*On our example if the first list is consisted of the nodes of A1 A2, the second list is constituted of the nodes of B1 B2.*

*NUME\_LAGR*

*=*

*/*

*“NORMAL”,*

*[DEFECT]*

*/*

*“DEFECT”,*

*See key word LIAISON\_SOLIDE [§4.19].*

*Important remarks:*

*1) After key words GROUP\_MA\_, MAILLE\_, GROUP\_NO\_ and NOEUD\_, a node can to appear several times, it is the program which is given the responsibility to eliminate the occurrences*

*useless and thus to obtain a nonredundant list of nodes.*

*2) After the elimination of the useless occurrences of the nodes in the two lists of nodes, these two lists must be imperatively equal length.*

*3) Meshs given after key words GROUP\_MA\_1, GROUP\_MA\_2, MAILLE\_1 and MAILLE\_2 are of the meshes of edge of the type SEG2 or SEG3 of the elements of hull and for which one does not have inevitably affected mechanical modeling.*

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**4.40** Key word

**RELA\_CINE\_BP**

**4.40.1** Drank

**Key word factor allowing the definition of a loading of the type** *RELA\_CINE\_BP*.

**This type of loading can be defined for a mechanical system including/understanding a structure concrete**

**and its cables of prestressing. Initial profiles of tension in the cables, as well as the coefficients relations kinematics between the ddl of the nodes of the cables and the ddl of the nodes of the structure**

**concrete are beforehand given by operator** *DEFI\_CABLE\_BP* [U4.42.04]. **Concepts** *cabl\_precont* **produced by this operator brings all information necessary to definition of the loading.**

**The multiple occurrences are authorized for the key word factor** *RELA\_CINE\_BP*, **in order to allow in the same call to operator** *AFFE\_CHAR\_MECA* **to define the contributions of each one of groups of cables having been the subject of distinct calls to operator** *DEFI\_CABLE\_BP* [U4.42.04]. **With each group of cables considered, defined by a concept** *cabl\_precont*, **is associated one occurrence of the key word factor** *RELA\_CINE\_BP*.

**The loading thus defined is then used to calculate the state of balance of the unit structure concrete/ cables of prestressing. However, the taking into account of this type of loading is not effective in all the operators of resolution. The loading of the type** *RELA\_CINE\_BP* **is not recognized for the moment that by operator** *STAT\_NON\_LINE* [U4.51.03], **option** *COMP\_INCR* **exclusively.**

**4.40.2 Syntax (AFFE\_CHAR\_MECA only)****RELA\_CINE\_BP****=\_F****(****CABLE\_BP****=****cabl\_pr,****[cabl\_precont]****SIGM\_BPEL****=****/****“YES”,****/****“NOT”,****[DEFECT]****RELA\_CINE****=****/****“YES”,****[DEFECT]****/****“NOT”,****)****4.40.3 Operands****CABLE\_BP = cabl\_pr**

**Concept of the cabl\_precont type produces by operator DEF1\_CABLE\_BP [U4.42.04]. This concept bring on the one hand the chart of the initial constraints in the elements of the cables of same group, and in addition the lists of the relations kinematics between the ddl of the nodes of these**

*cables and ddl of the nodes of the structure concrete.*

**SIGM\_BPEL**

=

/

“YES”,

/

“NOT”,

[DEFECT]

*Indicator of the text type by which one specifies the taking into account of the initial constraints in cables; the default value is “NOT”.*

*In the case “NOT”, only the liaisonnement kinematic one is taken into account. It is useful if one connect STAT\_NON\_LINE whereas one has cables of prestressing. For the first STAT\_NON\_LINE it is necessary to have put “YES”, so that one sets up the tension in cables. On the other hand, for the following STAT\_NON\_LINE, one should not regard as loading that the connections kinematics and thus to define the loading with SIGM\_BPEL = “NOT”, if not the tension is counted twice.*

*Since the restitution the macro one to put in tension the cables, the user would not have any more to need to make a AFFE\_CHAR\_MECA with SIGM\_BPEL = “YES”, that should thus avoid risks of error.*

**RELA\_CINE**

=

/

“YES”,

[DEFECT]

/

“NOT”,

*Indicator of the text type by which one specifies the taking into account of the relations kinematics enters*

*ddl of the nodes of the cables and ddl of the nodes of the structure concrete; the default value is “YES”.*

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## **Operators *AF FE\_CHAR\_MECA* and *AF FE\_CHAR\_MECA\_F***

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### **4.41 Key word**

***FORCE\_ELEC***

#### **4.41.1 Drank**

***Key word factor usable to apply the force of LAPLACE acting on a principal driver, had with the presence of a secondary driver right (not being based on part of grid Aster) compared to this principal driver.***

***In fact, the loading defined by FORCE\_ELEC has a module which must be multiplied by the function temporal of intensity specified by operator DEF1\_FONC\_ELEC [U4.MK.10] to represent really the force of LAPLACE.***

***The principal driver is based on whole or part of the Aster grid made up of linear elements in space and defined in this operator by one or more meshes, of the groups of meshes or totality of the grid.***

**Note:**

***When the secondary driver is not rectilinear key word INTE\_ELEC will be used [§4.40].***

#### **4.41.2 Syntax**

***FORCE\_ELEC = \_F***

**(  
/ALL =  
“YES”,**

//  
**NET =**  
**lma**  
,  
**[l\_maille]**

**/ GROUP\_MA**  
**= lgma,**  
**[l\_gr\_maille]**

// **FX**  
**=**  
**fx,**  
**[R]**

**/ FY**  
**=**  
**fy,**  
**[R]**

**/FZ**  
=  
**fz,**  
**[R]**

**/POSITION = "PARA",**

**/TRANS**  
=  
**(ux, uy, uz,)**  
**[l\_R]**

**/**  
**DIST**  
=  
**D,**  
**[R]**

/  
**POINT2**  
=  
(**x2, y2, z2,**)  
**[l\_R]**

**/POSITION = "FINISHED",**

**POINT1**  
=  
(**x1, y1, z1,**)  
**[l\_R]**

**POINT2**  
=  
(**x2, y2, z2,**)  
**[l\_R]**

***/POSITION = "INFI"***

***POINT1***

=  
(*x1, y1, z1,*)  
*[l\_R]*

***POINT2***

=  
(*x2, y2, z2,*)  
*[l\_R]*

)

### ***4.41.3 Function of space***

***The function of space composing the linear density of force of LAPLACE exerted in a point driver 1 (principal driver) by the elements of driver 2 (secondary driver) is:***

***2***  
***ds***  
***I 2***  
***2***  
***e2***

*with  $e1 = e2 = 1$*

*R*

*e1*

*M*

*I*

*1*

*1*

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*Version*

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*Titrate:*

*Operators AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F*

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*In the case of a secondary right and finished driver, this expression becomes:*

*2*

*E*

*P1*

*2*

*P2*

*D*

*E D*

*2*

*with  $N = 2$*

*,  $D = D, N = 1$*

*D*

*1*

*e1 M*

*In the particular case of the secondary driver infinite right,  
tend towards  
, one has  
then:*

#### **4.41.4 Operands**

/  
**FORCE\_ELEC**

*If there are several secondary drivers infinite and parallel with the driver  
the main thing (key words **COUR\_PRIN** and **COUR\_SECO** in order **DEFI\_FONC\_ELEC**) one  
directly specify the components of the direction of the force of **LAPLACE** who must be  
normalized to 1.*

//  
**FX = fx,**  
  
**fx<sup>2</sup> + fy<sup>2</sup> + fz<sup>2</sup> = 1.**

/  
**FY = fy,**  
  
**(fx, fy, fz)**  
*colinéaire with the force of **LAPLACE***

/  
**FZ = fz,**

*If not, the direction of the force of **LAPLACE** can be defined by the position of the driver  
single secondary compared to the elements of the principal driver.*

/  
**POSITION**

/

**“PARA”**

*The secondary driver is considered infinite and parallel with the principal driver. One can define its position in two manners:*

*/TRANS: (ux uy uz)*

*ux*

*U uy*

*U X*

*U*

*Z*

*U U y*

*U defines the translation bringing*

*Z  
principal driver 1 with the driver  
secondary 2*

*2*

*1*

*/  
DIST*

*=*

*D,*

*/*

*POINT2*

*=*

*(x2, y2, z2),*

*The secondary driver 2 is defined*

*D*

*X*

*by its distance to the driver 1 and one*

*2*

*POINT2 y2*

*second point.*

*z2*

*2*



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**/**

**“FINISHED”**

**The secondary driver is defined by two points corresponding at its ends**

**X**

**X**

**1**

**2**

**POINT1 y**

**POINT2 y**

**1**

**2**

**Z**

**Z**

**1 and**

**2**

**.**

**POINT1**

**=**

**(x1, y1, z1),**

**POINT2 = (x2, y2, z2),**

*1*  
*x1*  
*POINT1 y1*  
*z1*  
*x2*  
*POINT2 y2*  
*1*  
*2*  
*z2*  
  
*/*  
*“INFI”*

*The secondary driver is defined by two unspecified points POINT1 and POINT2.*

*POINT1*  
*=*  
*(x1, y1, z1),*  
*POINT2 = (x2, y2, z2),*

*X*  
*1*  
*1*  
*POINT1 y1*  
*z1*  
*x2*  
*2*  
*POINT2 y2*  
*1*  
*z2*

*In both cases, it is preferable to choose POINT1 and POINT2 such as the current circulates POINT1 with POINT2.*

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## **4.42 Key word**

**INTE\_ELEC**

### **4.42.1 Drank**

***Key word factor usable to apply the force of LAPLACE acting on a principal driver, had with the presence of a secondary driver not necessarily right compared to this driver the main thing.***

***In fact, the loading defined by INTE\_ELEC has a module which must be multiplied by the function temporal of intensity specified by operator DEFI\_FONC\_ELEC [U4.MK.10] to represent really the force of LAPLACE.***

***The principal driver is based on part of Aster grid made up of linear elements in space and defined in this operator by one or more meshes, of the groups of meshes or totality grid.***

***The secondary driver is also based on part of Aster grid made up of elements linear in the space and also specified in this operator by one or more meshes, of groups of meshes, or by a translation (or a symmetry planes) compared to the driver the main thing.***

## **Note:**

***The difference of the use of key word INTE\_ELEC compared to key word FORCE\_ELEC reside in the fact that the geometry of the secondary driver can not be rectilinear and is based on part of Aster grid which one describes here.***

### **4.42.2 Syntax**

**INTE\_ELEC**

**=\_F**

(

**/ALL =**

**“YES”,**

//

**NET =**

**lma**

,

**[l\_maille]**

**/GROUP\_MA**

**= lgma,**

**[l\_gr\_maille]**

**//MAILLE2 = lma,**

**[l\_maille]**

/

**GROUP\_MA2 = lgma,**

**[l\_gr\_maille]**

/

**TRANS**

=

**(ux, uy, uz),**

**[l\_R]**

/

**SYME**

=

**(x0, y0, z0, ux, uy, uz),**

**[l\_R]**

)

### 4.42.3 Function of space

*The function of space composing the linear density of forces of LAPLACE exerted in a point*

*driver 1 (principal driver) by the elements of driver 2 (secondary driver)*

*can express itself:*

2

ds

l

2

2

**e2 with E = E**

l

2 = l

**R**

**e1**

**M**

l

l

l

*For each element I of the secondary driver, one calculates his contribution starting from the expression the preceding one and one summon:*

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2

**E**

*P1*

2

*P2*

**D**

**E D**

2

*with N = 2*

*, D = D, N = 1*

**D**

1

**e1 M**

**4.42.4 Operands ALL/MESH/GROUP\_MA/MAILLE2/GROUP\_MA2/TRANS/SYME**

**ALL, MESH, GROUP\_MA:**

*The geometry of the principal driver defines where the loading is affected.*

**MAILLE2, GROUP\_MA2:**

*The geometry of the secondary driver defines.*

**TRANS**

:

*A translation of the principal driver defines in the secondary driver.*

**SYME**

:

*A symmetry compared to a plan (given by a point (X defines ) and the normal ( )*

*0 y0 z0*

*ux uy uz*

*commune with the principal driver and the secondary driver).*

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**4.43 Key word**

**IMPE\_FACE** (“ACOUSTIC” Phenomenon)

### 4.43.1 Drank

The key word factor *IMPE\_FACE* makes it possible to apply an acoustic impedance, with a face defined by

one or more meshes or groups of meshes of the triangle type or quadrangle.

The values are directly given if the operator called is *AFFE\_CHAR\_MECA*; if it is *AFFE\_CHAR\_MECA\_F*, they come from a concept of the function type.

### 4.43.2 Syntax

.

for *AFFE\_CHAR\_MECA*

*IMPE\_FACE*

= *\_F*

(

/ *NET* =

*lma*

, [*l\_maille*]

/ *GROUP\_MA*=

*lgma*,

[*l\_gr\_maille*]

*IMPE*

=

*Q*,

[*R*]



)  
.  
*for AFFE\_CHAR\_MECA\_F*

*IMPE\_FACE*  
= *\_F*  
(  
/ *NET =*  
*lma*  
, [*l\_maille*]

/ *GROUP\_MA =*  
*lgma,*  
[*l\_gr\_maille*]

*IMPE*  
=  
*Qf,*  
[*function*]

)

### **4.43.3 Operand *IMPE\_FACE***

$$IMPE\_FACE = Q (Qf)$$

*Acoustic impedance applied to the face.*

### **4.43.4 Modelings and meshes**

*The loading applies to the types of meshes and following modelings:*

#### ***Type of Mesh***

#### ***Modeling***

*TRIA3, TRIA6*

*3D\_FLUIDE*

*QUAD4, QUAD8, QUAD9*

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*Operators *AFPE\_CHAR\_MECA* and *AFPE\_CHAR\_MECA\_F**

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### **4.44 Key word**

***VITE\_FACE*** (“ACOUSTIC” Phenomenon)

#### **4.44.1 Drank**

*The key word factor *VITE\_FACE* makes it possible to apply normal speeds, with a face defined by one or several meshes or groups of meshes of the triangle type or quadrangle.*

The values are directly given if the operator called is *AFFE\_CHAR\_MECA*, if it is *AFFE\_CHAR\_MECA\_F*, they come from a concept of the function type.

#### 4.44.2 Syntax

.

for *AFFE\_CHAR\_MECA*

*VITE\_FACE*

= *\_F*

(

/

*NET* =

*lma*

,

[*l\_maille*]

/ *GROUP\_MA* =

*lgma*,

[*l\_gr\_maille*]

*VNOR*

=

*V*,

[*R*]

)

.  
*for AFFE\_CHAR\_MECA\_F*

*VITE\_FACE*  
*=\_F*  
(  
/  
*NET =*  
*lma*  
,  
*[l\_maille]*

*/ GROUP\_MA=*  
*lgma,*  
*[l\_gr\_maille]*

*VNOR*  
*=*  
*Vf,*  
*[function]*

)

### **4.44.3 Operand VNOR**

$$VNOR = V(Vf)$$

*Normal speed applied to the face.*

#### ***4.44.4 Modelings and meshes***

*The loading applies to the types of meshes and following modelings:*

##### ***Type of Mesh***

##### ***Modeling***

*TRIA3, TRIA6*

*3D\_FLUIDE*

*QUAD4, QUAD8, QUAD9*

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**4.45 Key word**

**ONDE\_PLANE**

**4.45.1 Drank**

*Key word factor usable to impose a seismic loading by plane wave, corresponding to loadings classically met during calculations of interaction ground-structure by the equations integrals (see [R4.05.01]).*

**4.45.2 Syntax (*AFFE\_CHAR\_MECA\_F* only)**

**ONDE\_PLANE =\_F**

(

**TYPE\_ONDE**

= *ty*, [*txm*]

**DIRECTION**

=

(*kx*, *ky*, *kz*),

[*l\_R*]

***DIST\_ORIG***

=

***H,***  
***[R]***

***FONC\_SIGNAL***

=

***F,***  
***[function]***

)

### ***4.45.3 Operands***

***TYPE\_ONDE***

=

***ty,***

***Type of the wave: “P”***  
***wave of compression***

***“SV”***  
***waves of shearing***

***“HS”***  
***waves of shearing***

***DIRECTION***

= ***(kx, ky, kz),***

***Direction of the wave.***

***DIST\_ORIG***

= ***H,***

***Outdistance principal face of wave at the origin at the initial moment.***

***FONC\_SIGNAL = F,***

***Derived from the profile of the wave:***

***for***

.

***In harmonic, a wave planes elastic is characterized by its direction, its pulsation and sound type (wave P for the waves of compression, waves SV or HS for the waves of shearing). In transient, the data of the pulsation, corresponding to a standing wave in time, must to be replaced by the data of a profile of displacement which one will take into account propagation in the course of time in the direction of the wave.***

***More precisely, one characterizes:***

.

***a wave P by the function***

.

***a wave S by the function***

***With:***

.

***K, unit vector of direction***

.

***then represent the profile of the wave given according to the direction K.***

***Caution: it is the derivative that the user gives in FONC\_SIGNAL.***

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**O**

**“Principal” face of wave**

**K**

**corresponding at the origin**

**profile**

**H**

**Function F**

***H0 is the distance from the principal face of wave in the beginning O, carried by the directing vector of the wave with***

***the initial moment of calculation, H the distance from the principal face of wave in the beginning O, one moment***

***unspecified.***

#### **4.45.4 Modelings and meshes**

**Type of Mesh**

**Modeling**

**MECA\_FACE\_\***

**3D\_ABSO**

**MEPLSE2, MEPLSE3**

**2D\_ABSO**

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*4.46 Key word*

*ONDE\_FLUI (“ACOUSTIC” Phenomenon)*

*4.46.1 Drank*

*The key word factor ONDE\_FLUI makes it possible to apply an amplitude of pressure of incidental wave sinusoidal arriving normally at a face defined by one or more meshes or groups of meshes.*

*4.46.2 Syntax*

.

*for AFFE\_CHAR\_MECA*

*ONDE\_FLUI*

*=\_F*

(

/

*NET =*

*lma*

,

*[l\_maille]*

*/ GROUP\_MA=*

*lgma,*

*[l\_gr\_maille]*

**NEAR**

=

**P,**

**[R]**

)

**for AFFE\_CHAR\_MECA\_F**

**Not developed.**

#### **4.46.3 Operand NEAR**

**CLOSE = P,**

**Amplitude of pressure of sinusoidal incidental wave arriving normally at the face.**

#### **4.46.4 Modelings and meshes**

**The loading applies to the types of meshes and following modelings:**

**Type of Mesh**

**Modeling**

**TRIA3, TRIA6**

**3D\_FLUIDE**

**QUAD4, QUAD8, QUAD9**

**SEG2, SEG3**

**2D\_FLUIDE, AXIS\_FLUIDE**

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**4.47 Key word**

***FLUX\_THM\_REP***

**4.47.1 Drank**

***Key word factor usable to apply to a field of continuous medium 2D or 3D defined by meshes or groups of meshes a heat flow and/or a fluid contribution of mass (hydraulic flow).***

**4.47.2 Syntax**

**.  
for *AFFE\_CHAR\_MECA***

***FLUX\_THM\_REP***

**=\_F**

**(**

**/ALL =**

**“YES”,**

**// MESH**

**= lma**

**,**

**[l\_maille]**

**/ GROUP\_MA**  
**= lgma,**

**[l\_gr\_maille]**

**/ FLUN = T**

**,**  
**[R]**

**/ FLUN\_HYDR1 = E**

**,**  
**[R]**

**/ FLUN\_HYDR2 = v**

**,**  
**[R]**

)  
.  
*for AFFE\_CHAR\_MECA\_F*

*FLUX\_THM\_REP*  
*=\_F*  
(  
*/ALL =*  
*“YES”,*

*// MESH*  
*= lma*  
,  
*[l\_maille]*

*/GROUP\_MA*  
*= lgma,*  
*[l\_gr\_maille]*

***/ FLUN = Tf, [function]***

***/ FLUN\_HYDR1 = ef,  
[function]***

***/ FLUN\_HYDR2 = vf,  
[function]***

)

### ***4.47.3 Operands***

***/  
FLUN  
=  
T,***

***Value of the heat flow***

***with:  
: mass enthalpy of the liquid***

*: mass enthalpy of the vapor*

*: mass enthalpy of the air*

*and*

*are below definite hydraulic flows*

*/*  
*FLUN\_HYDR1*

*=*  
*E,*

*Value of the hydraulic flow associated the component water*

*/*  
*FLUN\_HYDR2*

*=*  
*v,*

*Value of the hydraulic flow associated the component air*

*with:*

*: density of the liquid*

*: density of the vapor*

*: pressure of liquid (PRE1)*

*: steam pressure (PRE2)*

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### ***4.47.4 Modelings and meshes***

***Normal flows apply to the types of meshes and following modelings:***

***Type of Mesh***

***Modeling***

***SEG2***

***D\_PLAN\_YYYY***

***SEG3***

***AXIS\_YYYY, D\_PLAN\_YYYY***

***FACE8***

***3D\_YYYY***

***with YYYY = THM or THH or THHM or HM or HHM.***

### ***4.48 Key word***

***HARLEQUIN***

#### ***4.48.1 Drank***

***Key word factor defining the parameters of the method Harlequin. This method consists in connecting models by volume. A priori, any combination of grids, interpolations and kinematics is possible. It thus makes it possible to enrich a model locally, to create the junction between two models, to substitute a model by another locally. This junction is ensured by weighting of the work of the elastic forces on space mediator: the trace of one of the two models on the zone of joining.***

#### ***4.48.2 Restrictions of use***

***Only two models can be superimposed on the same place. Only voluminal models (3D), surface (2D) and of hulls (2D and 3D) are authorized.***

#### ***4.48.3 Syntax***

.

***for AFFE\_CHAR\_MECA only***

**HARLEQUIN**

:(  
**GROUP\_MA\_1**

=  
**gma1**

,  
**[gr\_maille]**  
**GROUP\_MA\_2**

=  
**gma2**

,  
**[gr\_maille]**

**GROUP\_MA\_COLL**

=  
**gma**

,  
**[gr\_maille]**

**JOINING =**

/  
"COARSE",  
**[DEFECT]**  
/"FINE",  
/"GROUP\_MA1",  
/"GROUP\_MA2",

**/POIDS\_1 = 1**

,  
**[R]**

**/POIDS\_2 = 2**

,  
**[R]**

*/POIDS\_GROSSIER = F*

,  
*[R]*

*/POIDS\_FIN*

=  
*G*  
,  
*[R]*

*CARA\_ELEM*

=  
*will cara*  
,  
*[cara\_elem]*

)

#### **4.48.4 Operands**

***GROUP\_MA\_1 = gma1***

**GROUP\_MA\_2 = gma2**

*Names of the group of meshes defining the models overlapping. The relative position of borders, of the nodes and the meshes belonging to these two models is a priori independent. No node nor no mesh must be shared by the two models.*

*GROUP\_MA\_1 and GROUP\_MA\_2 play the same part, without distinction.*

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**GROUP\_MA\_COLL = gma**

*Group meshes defining the zone where the two models are connected. This zone must normally to correspond to meshes of GROUP\_MA\_1 or GROUP\_MA\_2 pertaining to the zone of covering of the two fields. It is however possible that it overflows of this zone of superposition. If the key word is not indicated, the exact zone of superposition is reserve in the algorithm.*

**JOINING =**

*Choice of the model used to define the multipliers of Lagrange of joining (GROUP\_MA\_1 or GROUP\_MA\_2 restricted at the zone of joining). A comparison of the average volume of meshes of the two models allows also the use of END or COARSE.*

**"/POIDS\_1**

**=**

*1,*  
*"/POIDS\_2*

*=*

*2,*  
*"/POIDS\_FIN*  
*= F,*  
*"/POIDS\_GROSSIER = G,*

*Reality lain strictly between 0. and 1. It makes it possible to define the value of the functions of weighting in the zone of superposition. POIDS\_i corresponds to the weight of model I. The data of 1 or 2 makes it possible to describe the couple (1,2) such as: (1,2) = (1,1 - 1) or (1 - 2, 2)*

*CARA\_ELEM =*

*Field of elementary characteristics resulting from AFFE\_CARA\_ELEM (thicknesses for hulls, sections for the beams). To specify obligatorily when one of the two models is composed of hulls.*

#### *4.48.5 Examples and councils of use*

*Operation of junction of models:*

*HARLEQUIN = \_F (*  
*GROUP\_MA\_1*  
*=*  
*gma1,*  
*GROUP\_MA\_2*  
*=*  
*gma2,*  
*[CARA\_ELEM*  
*=*  
*will cara,]*  
*JOINING*

*=*

*"COARSE",*

*POIDS\_FIN =*  
*0.99*

)

*Operation of substitution (introduction of defects...) :*

*HARLEQUIN = \_F (*

*GROUP\_MA\_1*

*= gma1,  
# models without defect*

*GROUP\_MA\_2*

*= gma2,  
# models with defect  
[CARA\_ELEM*

*=  
will cara,]*

*GROUP\_MA\_COLL*

*= gmac,  
# crowns encircling the defect,*

*#  
sufficient  
far*

*defect  
for*

*#  
that*

*2  
models  
are*

*#  
compatible  
mechanically*

## **JOINING**

```
=  
`GROUP_MA_2,  
  
POIDS_2  
=  
0.9999  
)
```

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**4.49 Key word**  
**GRAPPE\_FLUIDE**

### **4.49.1 Drank**

**Key word factor allowing the entry of the calculation data of the fluid forces at the time of the studies of fall of bunch.**

*This type of loading is specific to this kind of study. It is associated a preset grid. data entered via a file “include” suitable for the type of assembly of which one study the fall of bunch. Examples of files “include” and grid are available with the cases tests associated with this type of loading. They count, in the form of variables pythons, them data entered under the various single-ended spanner words of the key word factor GRAPPE\_FLUIDE. If one wishes to modify one, or several, values, it is possible to call again upon GRAPPE\_FLUIDE. According to the rule of overload, the last entered value is then that employed for*

*calculation.*

**Caution:**

*Even if, for purely data-processing reasons, the single-ended spanner words appear like optional, it is necessary that all the data entered, that is to say directly by the user, that is to say, as he it is recommended, via the file include.*

**4.49.2 Syntax**

*Applicable to AFFE\_CHAR\_MECA only:*

*GRAPPE\_FLUIDE = \_F (*

*# definition of the group of meshes modelling the tube, the spider and the pencil:*

*GROUP\_MA = “magrap”,*

*[gr\_maille]*

*# definition of the higher node of the tube:*

*/GROUP\_NO\_ORIG*

*= “grnori”,*

*[gr\_noeud]*

*/NOEUD\_ORIG =*

*“nonori”,*

*[node]*



*# definition of the lower node of the pencil:*

*/GROUP\_NO\_EXTR*

*= "grnoex",  
[gr\_noeud]*

*/NOEUD\_EXTR =  
"nonoex",*

*[node]*

*# depth of initial depression of the pencil in the heart:*

*Z0 =  
z0,  
[R]*

*# definition of the hydraulic data:*

*CARA\_HYDR = ("Q", "ROCK", "ROD", "ROP", "ROMANIAN", "ROML", "ROG",  
"NUC", "NUM", "NUML", "NUG", "P2", "P3", "P4", "CGG", "G"  
)*

*VALE\_HYDR = (Q, rock, rod, rop, Romanian, roml, rog,*

*nuc,  
num,  
numl,  
nug,  
p2, p3, p4, cgg, G), [R]*

*# definition of the geometrical data of bunch:*

*CARA\_GRAPPE= (*  
*“Me, “DTIGE”, “DTMOY”, “ROTIGE”, “LTIGE”, “LLT”, “LCT”,*  
*“VARAI”, “RORAI”, “DCRAY”, “ROCRAY”, “LCRAY”, “LCHUT”,*  
*“CFCM”, “CFCI”, “CFCG”, “HRUGC”, “HRUGTC”, “NCA”),*

*VALE\_GRAPPE= (*  
*m, dtige, dtmoy, rotige, ltige, llt, lct,*  
*will varai,*  
*will rorai,*  
*dcray,*  
*rocray,*  
*lcray,*  
*lchut,*  
*cfcM,*  
*cfcI,*  
*cfcG,*  
*hrugg,*  
*hrugtc,*  
*nca),*  
*[R]*

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*# definition of the geometrical data of the control drive:*

CARA\_COMMANDE  
=(  
“LI”, “LML”, “LG”, “LIG”, “DIML”, “DEML”, “DCSP”,  
“DG”, “HRUGML”, “HRUGCSP”, “HRUGG”),

VALE\_COMMANDE  
=(  
Li, lml, lg, lig, diml, deml, dcsp,  
dg,  
hrugml,  
hruggcsp,  
hrugg),  
[R]

*# definition of the geometrical data of the cuff and its adapter:*

CARA\_MANCHETTE= (  
“LM”, “”, “LIM”, “DIMT”, “DEML”, “DCMT”, “VMT”,  
“ROMT”, “DA”, “HRUGM”, “HRUGA”),  
[R]

VALE\_MANCHETTE= (  
lm, lim, dimt, deml, dcmt, vmt, romt,  
da,  
hrugmg,  
hruga),  
[R]

*# definition of the geometrical data of the tubes guides:*

CARA\_GUIDE  
=(  
“NRET”, “L0”, “L1”, “L2”, “L3”, “L4”,

“DTG”, “DR.”, “DOR”, “D0”, “D00”, “HRUGTG”),

VALE\_GUIDE

=(

nret, l0, l1, l2, l3, l4,

(dtg, Dr., dor, d0, D00, hrugtg),

[R]

*# definition of the geometrical data of the assemblies:*

CARA\_ASSEMBLAGE = (“SASS”, “DCC”, “DTI”, “NGM”, “NGMDP”,

“KM”, “KS”, “KI”, “KES”, “KEI”, “KF”),

VALE\_ASSEMBLAGE = (sass, dcc, dti, ngm, ngmp,

km, ks, ki, kes, kei, KF), [R]

*# definition of the loss ratios of singular load:*

CARA\_PDC = (“CD0”, “CD1”, “CD2”, “CDELARG”, “CDRET”,

“CDM”, “HALF-VALUE LAYER”, “CDML”, “TDCI”, “CDG”),

VALE\_PDC = (cd0, cd1, cd2, cdelarg, cdret,

*CDM, half-value layer, cdml, TDCI, cdret),*

*[R]*

*# definition of the point of application of the various fluid forces:*

*APPL\_FORC\_ARCHI =/"SET OUT AGAIN", [DEFECT]*

*/*  
*"CDG",*

*APPL\_FORC\_FPLAQ =/"SET OUT AGAIN", [DEFECT]*

*/*  
*"CDG",*

*/*  
*"ZONE",*

*/*  
*"MEDIUM",*

*/*  
*"DISTR",*

*APPL\_FORC\_FMEC =/"SET OUT AGAIN", [DEFECT]*

*/*  
*"CDG",*

*/*  
*"ZONE",*

*/*  
*"PTREP",*

*APPL\_FORC\_FTG =/"SET OUT AGAIN",*

*[DEFECT]*

/

“CDG”,

/

“ZONE”,

/

“PTREP”,

*# if APPL\_FORC\_ARCHI = “CDG” or*

*# if APPL\_FORC\_FPLAQ = “CDG” or*

*# if APPL\_FORC\_FMEC = “CDG” or*

*# if APPL\_FORC\_FTG = “CDG”*

*MASS\_INER = mass\_iner,*

*[tabl\_mass\_iner]*

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*# definition of the direction of the force of plating:*

*DIRE\_FORC\_FPLAQ = (n1, N2, n3), [l\_R]*

*# definition of the number of print unit of the forces:*

*UNITE\_IMPR\_FORCE = i1, [I]*

*# definition of the number of print unit of the nodes by zone:*

*UNITE\_IMPR\_NOEUD = i2, [I]*

*),*

### **4.49.3 Operands**

*The significance of the geometrical and hydraulic data is explained in the document [R4.07.06], fluid Loadings on a control rod in the course of fall. For one detailed description of the role of each one of these variables, one will thus refer to this document.*

#### **4.49.3.1 key Word APPL\_FORC\_ARCHI**

*APPL\_FORC\_ARCHI =/"SET OUT AGAIN", [DEFECT]*

*/*

*"CDG",*

*This key word makes it possible to define the point of application of the force of Archimedes:*

*.*

*that is to say distributed on all the bunch;*

*.*

*that is to say concentrated in the centre of gravity.*

*In the second case it is necessary to inform key word MASS\_INER.*

#### **4.49.3.2 key Word APPL\_FORC\_FPLAQ**

*APPL\_FORC\_FPLAQ =/"SET OUT AGAIN", [DEFECT]*

*/*

*"CDG",*

*/*

*"ZONE",*

*/*

*"MEDIUM",*

*/*

*"DISTR",*

*This key word makes it possible to define the point of application of the force of plating:*

*.  
that is to say distributed uniformly on all the bunch (“SET OUT AGAIN”);*

*.  
that is to say concentrated in the centre of gravity (“CDG”);*

*.  
that is to say distributed uniformly in the part of the bunch which is located in continuous guidance (“ZONE”);*

*.  
maybe in the middle of continuous guidance (“MEDIUM”);*

*.  
that is to say distributed according to a particular distribution (“DISTR”).*

*As for the preceding paragraph, if the key word takes value “CDG”, it is necessary to inform obligatorily key word MASS\_INER.*

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### **4.49.3.3 key Word *APPL\_FORC\_FMEC***

*APPL\_FORC\_FMEC* =/“SET OUT AGAIN”, [DEFECT]

/

“CDG”,

/

“ZONE”,



/

“PTREP”,

*This key word makes it possible to define the point of application of the force in the mechanism of lifting:*

.

*that is to say distributed uniformly on all the bunch (“SET OUT AGAIN”);*

.

*that is to say concentrated in the centre of gravity (“CDG”);*

.

*that is to say distributed uniformly in the part of the bunch which is located in the mechanism of lifting;*

.

*that is to say applied at the end of the bunch (“PTREP”).*

*If the key word takes value “CDG”, it is necessary to inform key word MASS\_INER obligatorily.*

#### **4.49.3.4 key Word APPL\_FORC\_FTG**

*APPL\_FORC\_FTG =/“SET OUT AGAIN”, [DEFECT]*

/

“CDG”,

/

“ZONE”,

/

“PTREP”,

*This key word makes it possible to define the point of application of the force before and after hammering:*

.

*that is to say distributed uniformly on all the bunch (“SET OUT AGAIN”);*

.

*that is to say concentrated in the centre of gravity (“CDG”)*

.

*that is to say distributed uniformly in the part of the bunch which is located before and after hammering;*

.

*that is to say applied at the end of the bunch (“PTREP”).*

*If the key word takes value “CDG”, it is necessary to inform key word MASS\_INER obligatorily.*

#### **4.49.3.5 key Word MASS\_INER**

*if APPL\_FORC\_ARCHI = "CDG" or  
if APPL\_FORC\_FPLAQ = "CDG" or  
if APPL\_FORC\_FMEC = "CDG" or  
if APPL\_FORC\_FTG = "CDG"*

*MASS\_INER = mass\_iner, [tabl\_mass\_iner]*

*This key word is to be informed only whenever the point of application of a force is the center of gravity.*

#### ***4.49.3.6 key Word DIRE\_FORC\_PLAQ***

*DIRE\_FORC\_FPLAQ = (n1, N2, n3), [l\_R]*

*The direction of the vector of the force of plating is possibly given under this key word. If this word key is not indicated, the direction of the force is colinéaire to the bunch.*

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#### **4.49.3.7 key Word UNITE\_IMPR\_FORCE**

*UNITE\_IMPR\_FORCE* = *i1*, [I]

Logical unit of impression of the fluid forces:

.  
Force of Archimedes;

.  
Force plating (*FPLAQ*);

.  
Forces in the mechanism of lifting: force pressure (*FPMEC*) and a viscous force (*FMEC*);

.  
Forces in the tube guides: force pressure (*FPTG*) and a viscous force (*FTG*);

.  
Forces in the dashpot: force pressure (*FPTG*), a viscous force (*FTG*) and forces hammering (*FTG'*).

#### **4.49.3.8 key Word UNITE\_IMPR\_NOEUD**

*UNITE\_IMPR\_NOEUD* = *i2*, [I]

Logical unit of impression of the nodes of the bunch by zone:

.  
Nodes located in the mechanism of lifting (zone 1);

*Nodes located in continuous guidance (zone 2);*

.

*Nodes located in the tube guides, the dashpot, hammering (zone 3).*

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#### ***4.49.4 Position of the points of application of the forces***

*Zone 1: mechanism of lifting*

*Zone 2: continuous guidance*

*Zone 3: tube guide/dahpot*

**FPMEC**

**Zon E 1:**

**FPMEC = force**

**FPMEC**

**pon ctu it in**

**high of the stem of**

**order**

**FMEC**

**FMEC = force**

**distributed on**

**FMEC**

**stem of**

**order**

**Zon E 2: Fplaq =**

*distributed on G cont*

**FPLAQ**

**FPLAQ**

**Zon E 3:**

**FTG**

**FTG = force distributed on the pencil**

**Before**

**FTG**

**absorbent**

**hammering**

**FTG = onctuelle force p in bottom of**

**FPTG**

**absorbing pencil**

**FTG '**

**After**

**hammering**

**FPTG '**

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*Organization (S): EDF-R & D /AMA*

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***Operators AFFE\_CHAR\_THER and  
AFFE\_CHAR\_THER\_F***

***1 Goal***

***To affect loadings and boundary conditions thermal on a model.***

***For operator AFFE\_CHAR\_THER, the affected values do not depend on any parameter and are defined by actual values.***

***For operator AFFE\_CHAR\_THER\_F, the values are related to one or two parameters to be chosen as a whole (INST, X, Y, Z) or temperature TEMP in nonlinear thermics.***

***These functions must be defined beforehand by the call to one of the operators:***

***.  
DEFI\_CONSTANTE [U4.31.01]***

***.  
DEFI\_FONCTION [U4.31.02]***

***.  
DEFI\_NAPPE [U4.31.03]***

***.  
CALC\_FONC\_INTERP [U4.32.01]***

***The produced concept is of char\_ther type.***

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***2 Syntax***

***general***

***CH [char\_ther] = AFFE\_CHAR\_THER***

***(MODEL***

***= Mo,***

***[model]***

***/ TEMP\_IMPO =***

***(see key word TEMP\_IMPO***

***[\$***

***4.4]***

***)***

/  
**FLUX\_REP =**

*(see key word FLUX\_REP*

*[\$ 4.5] )*

/ **RADIATION**  
**=**

*(see key word RADIATION*

*[\$ 4.7] )*

/  
**EXCHANGE =**

*(see key word EXCHANGE*

*[\$ 4.8] )*

/  
**SOURCE =**

*(see key word SOURCE*

*[\$ 4.9] )*

/ **GRAD\_TEMP\_INIT**  
**=**



*(see key word GRAD\_TEMP\_INIT [§ 4.10])*

*/ LIAISON\_DDL*

=

*(see key word LIAISON\_DDL  
[§ 4.11])*

*/  
LIAISON\_GROUP = (see key word LIAISON\_GROUP  
[§ 4.12])*

*/  
LIAISON\_MAIL =  
(see key word LIAISON\_MAIL [§  
4.13])*

*/  
ECHANGE\_PAROI = (see key word ECHANGE\_PAROI  
[§ 4.14])*

*/  
LIAISON\_UNIF =  
(see key word LIAISON\_UNIF [§  
4.15])*

/  
**LIAISON\_CHAMNO=** (*see key word LIAISON\_CHAMNO* [§ 4.16])

/  
**CONVECTION=**  
(*see key word CONVECTION*

[§ 4.17])

)

**CH** [*char\_ther*] = **AFFE\_CHAR\_THER\_F**

(**MODEL**  
= **Mo**,  
[*model*]

/ **TEMP\_IMPO =**  
(*see key word TEMP\_IMPO*

[§  
4.4]

)

/  
**FLUX\_REP =**

(*see key word FLUX\_REP*

[§ 4.5] )

/  
**FLUX\_NL =**

(see key word **FLUX\_NL**

[§ 4.6] )

/  
**RADIATION =**

(see key word **RADIATION**

[§ 4.7] )

/  
**EXCHANGE =**

(see key word **EXCHANGE**

[§ 4.8] )

/  
**SOURCE =**

(see key word **SOURCE**

[§ 4.9] )

/  
**GRAD\_TEMP\_INIT** = (see key word **GRAD\_TEMP\_INIT** [§ 4.10])

/ **LIAISON\_DDL**  
=  
(see key word **LIAISON\_DDL**  
[§ 4.11])

/  
**LIAISON\_GROUP** = (see key word **LIAISON\_GROUP**  
[§ 4.12])

/  
**ECHANGE\_PAROI** = (see key word **ECHANGE\_PAROI**  
[§ 4.14])

/  
**LIAISON\_UNIF** =  
(see key word **LIAISON\_UNIF** [§  
4.15])

/  
**CONVECTION** =  
(see key word **CONVECTION**)

[§ 4.17])

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### *3 General information*

#### *Possible error messages related to order AFFE\_CHAR\_THER*

*It happens sometimes that a thermal ordering of calculation (THER\_LINEAIRE, THER\_NON\_LINE,...)*

*stop in fatal error during the calculation of the second elementary members due to the loadings defined in the AFFE\_CHAR\_THER\_xx orders.*

*When the code stops during these elementary calculations, important information of the message of error is the name of the option of calculation requested by the code.*

*The name of this option is in general unknown to the user and it is thus difficult for him to include/ understand the message.*

*In the table below, one gives in with respect to the names of the options of calculation, the name of order and key word factor which make it possible to activate this option.*

#### *Elementary option of calculation*

**Order**

**Key word factor**

**CHAR\_THER\_FLUNL AF FE\_CHAR\_THER\_F  
FLUX\_NL**

**CHAR\_THER\_FLUN\_F AF FE\_CHAR\_THER\_F  
FLUX\_REP**

**CHAR\_THER\_FLUN\_R AF FE\_CHAR\_THER  
FLUX\_REP**

**CHAR\_THER\_FLUTNL AF FE\_CHAR\_THER  
CONVECTION**

**CHAR\_THER\_FLUTNL AF FE\_CHAR\_THER\_F  
CONVECTION**

**CHAR\_THER\_FLUX\_F AF FE\_CHAR\_THER\_F  
FLUX\_REP**

**CHAR\_THER\_FLUX\_R AF FE\_CHAR\_THER  
FLUX\_REP**

**CHAR\_THER\_GRAI\_F AF FE\_CHAR\_THER\_F  
GRAD\_TEMP\_INIT**

**CHAR\_THER\_GRAI\_R AF FE\_CHAR\_THER  
GRAD\_TEMP\_INIT**

**CHAR\_THER\_PARO\_F AF FE\_CHAR\_THER\_F  
ECHANGE\_PAROI**

**CHAR\_THER\_PARO\_R AF FE\_CHAR\_THER  
ECHANGE\_PAROI**

**CHAR\_THER\_SOUR\_F AF FE\_CHAR\_THER\_F  
SOURCE**

**CHAR\_THER\_SOUR\_R AF FE\_CHAR\_THER  
SOURCE**

**CHAR\_THER\_TEXT\_F AF FE\_CHAR\_THER\_F  
EXCHANGE**

**CHAR\_THER\_TEXT\_R AF FE\_CHAR\_THER  
EXCHANGE**

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## **4 Operands**

### **4.1** **General information on the operands**

#### **4.1.1 Two forms of operands under a key word factor**

**The operands under a key word factor are of two forms:**

- .**  
**operands specifying the topological entities where the loadings (key words are affected GROUP\_NO and GROUP\_MA, etc...). The arguments of these operands are identical for both operators.**
- .**  
**operands specifying the affected values (TEMP, COEF\_H, etc...). Significance of these operands is the same one for the two operators but the arguments of these operands are all the real type for operator AFFE\_CHAR\_THER and of the function type (created by one of operators DEFI\_FONCTION, DEFI\_NAPPE, DEFI\_CONSTANTE or CALC\_FONC\_INTERP) for operator AFFE\_CHAR\_THER\_F.**

**We will thus not distinguish in this document, except mention express of the opposite, both operators AFFE\_CHAR\_THER and AFFE\_CHAR\_THER\_F.**

#### **4.1.2 Topological entities of assignment of the loadings**

**In a general way, the topological entities on which values must be affected are defined:**

**.**  
**by nodes and in this case:**

**-**  
**maybe by operand GROUP\_NO allowing to introduce a list of group of nodes,**

-  
*maybe by the operand NODE allowing to introduce a list of nodes.*

.  
*by mesh and in this case:*

- is  
*by*  
*GROUP\_MA allowing to introduce a list of groups of meshes,*

- is  
*by*  
*NET allowing to introduce a list of meshes.*

***Regulate:***

*To define the field of assignment most simply possible, one uses the rule of overload it is the last assignment which precedes.*

## ***4.2 Operand MODEL***

***MODEL***  
***= Mo,***

***Concept produced by operator AFFE\_MODELE [U4.41.01] where the types of elements are defined stop affected on the grid.***

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### **4.3 Key word** **TEMP\_IMPO**

#### **4.3.1 Drank**

**Key word factor usable to impose, on nodes or groups of nodes, a temperature.**

**According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_THER)  
or  
via a concept of the type function (AFFE\_CHAR\_THER\_F).**

#### **4.3.2 Syntax**

.  
**for AFFE\_CHAR\_THER**

**TEMP\_IMPO = \_F (/**  
**ALL =**

**“YES”,**

**/**  
**NODE =**  
**lno,**

**[l\_noeud]**

**/GROUP\_NO**

=

**l<sub>gno</sub>,**

**[l<sub>gr\_noeud</sub>]**

**/NET**

= **l<sub>ma</sub>,**

**[l<sub>maille</sub>]**

**/GROUP\_MA**

= **l<sub>gma</sub>,**

**[l<sub>gr\_maille</sub>]**

**/TEMP = T,**

**[R]**

**/]**

***TEMP = T,***

***[R]***

***/ TEMP\_INF  
= tinf,  
[R]***

***/ TEMP\_SUP  
= tsup,  
[R]***

***)  
.  
for AFFE\_CHAR\_THER\_F***

***TEMP\_IMPO = \_F (  
ALL =  
“YES”,***

/  
**NODE =**  
**lno,**

**[l\_noeud]**

/ **GROUP\_NO**  
**=**

**lgn,**  
**[l\_gr\_noeud]**

/ **NET**

**= lma,**  
**[l\_maille]**

/ **GROUP\_MA**  
**= lgma,**

**[l\_gr\_maille]**

/  
**TEMP**  
=  
**tf,**  
**[function]**

// **TEMP = tf,**  
**[function]**

/ **TEMP\_INF**  
=  
**tinf,**  
**[function]**

/ **TEMP\_SUP**  
=  
**tsupf,**  
**[function]**

/  
**EVOL\_THER**  
=  
**evth,**  
**[evol\_ther]**

***DDL***

***=***

***“TEMP”,***

***)***

### ***4.3.3 Operands***

***/TEMP***

***=***

***Value of the temperature imposed on (S) the node (S) specified (S).***

***/For the elements of thermal hull only (Modeling: “HULL”):***

***/TEMP***

***Temperature on the average layer imposed on (S) the node (S) specified (S).***

***/TEMP\_INF***

***Temperature imposed on the lower wall of the hull.***

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**/TEMP\_SUP**

**Temperature imposed on the higher wall of the hull: cf "Note of use of the model of thermal thin hull " in booklet [U2].**

**These options make it possible to represent a parabolic variation of the temperature in the thickness.**

**Note:**

**The hull is directed by the connectivity of the nodes of the associated mesh (cf [U3.01.00]). That is to say  $N$  the normal vector directing the hull:**

**$N$**   
**Higher wall**  
**Lower wall**

**/EVOL\_THER**

**=**  
**(for AFFE\_CHAR\_THER\_F only)**

**Allows to affect on nodes an imposed temperature given via a structure of data `evol_ther` calculated beforehand. In each node, one extracts from the `evol_ther` a function  $TEMP = F(INST)$  and one affects this function like imposed temperature.**

**This possibility exists currently only for the degree of freedom "TEMP".**

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**4.4 Word**

**key**

***FLUX\_REP***

**4.4.1 Drank**

***Key word factor usable to apply normal flows, with a face of voluminal element or of thermal hull defined by one or more meshes or of the groups of meshes of the triangle type or quadrangle. This key word also makes it possible to apply a normal flow to an edge (in PLANE 2D or AXIS or AXIS\_FOURIER) on meshes of the segment type.***

***According to the name of the operator called, the values are provided directly (*AFFE\_CHAR\_THER*) or via a concept of the type function (*AFFE\_CHAR\_THER\_F*).***

**4.4.2 Syntax**

***for *AFFE\_CHAR\_THER****

***FLUX\_REP = \_F***

***(  
/ALL =***

***“YES”,***



/

/

**NET**

= *lma*,

[*l\_maille*]

/

**GROUP\_MA**

= *lgma*,

[*l\_gr\_maille*]

**/FLUN = fl**,

[**R**]

//

**FLUN\_INF**

= *flin*,

[**R**]

/  
**FLUN\_SUP**  
= *flsup*,  
**[R]**

)  
  
.  
**for AFFE\_CHAR\_THER\_F**

**FLUX\_REP = \_F**  
(

**/ALL =**

**“YES”,**

/  
/  
**NET**

= *lma*,  
**[l\_maille]**

/  
**GROUP\_MA**  
= *lgma*,  
*[l\_gr\_maille]*

**/FLUN**  
=  
*flf*,  
*[function]*

/  
/  
**FLUN\_INF**  
= *flinf*,  
*[function]*

/  
**FLUN\_SUP**  
= *flsupf*, *[function]*

/  
/  
**FLUX\_X**

= *flx*,  
**[function]**

/  
**FLUX\_Y**

= *fly*,  
**[function]**

/  
**FLUX\_Z**

= *flz*,  
**[function]**

)

### 4.4.3 Operands

/

*FLUN: fl normal flow imposed on the mesh.*

*This loading applies to the types of meshes and following modelings:*

*Net Modélisation*

*TRIA3, TRIA6,*

*3D, 3D\_DIAG*

*QUAD4, QUAD8, QUAD9*

*SEG2, SEG3*

*PLAN, AXIS, AXIS\_FOURIER,*

*PLAN\_DIAG, AXIS\_DIAG*

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*More precisely the boundary condition applied is:  $(\text{grad } T \cdot n) = fl$*

*where  $k$  is thermal conductivity and  $N$  is the normal directed in the direction of the classification of nodes of the mesh. The convention of orientation is that used in AFFE\_CHAR\_MECA [U4.44.01].*

*//*

*FLUN\_INF = flin*

*/*

***FLUN\_SUP = flsup***

***Normal flow imposed on the walls lower and higher of a thermal hull.***

***These loadings apply to the types of meshes and following modelings:***

***Net Modélisation***

***TRIA3, TRIA6***

***HULL***

***N being the normal directing surface [U4.44.01], the boundary condition applied is:***

***(grad T .n) = flin where flin is the normal flow imposed on the lower wall of the hull,***

***(grad T .n) = flsup where flsup is the normal flow imposed on the higher wall of the hull.***

***N***

***Higher wall***

***Lower wall***

***/***

***/***

***FLUX\_X = flx***

***/***

***FLUX\_Y = fly***

***/***

***FLUX\_Z = flz***

***Vectorial flow in the total reference mark (only for AFFE\_CHAR\_THER\_F) which one projects on the normal with the element (for the definition of the normal [U4.44.01]).***

***This loading applies to the types of meshes and modelings:***

***Net Modélisation***

***SEG2, SEG3***

***PLAN***

***PLAN\_DIAG***

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#### **4.5 Key word**

**FLUX\_NL**

##### **4.5.1 Drank**

Key word factor usable to apply **normal flows** functions of the temperature, with a **face** of voluminal element defined by one or more meshes or of the groups of meshes of the **triangle** type or **quadrangle**. This key word also makes it possible to apply a normal flow to an edge (in *PLANE 2D* or *AXIS*) on meshes of the segment type. One can thus model a condition of radiation of law type of *STEPHAN*. This type of flow is used only by orders *THER\_NON\_LINE* [U4.54.02] and *THER\_NON\_LINE\_MO* [U4.54.03].

The values are provided by a concept of the function type.

##### **4.5.2 Syntax**

.

For *AFFE\_CHAR\_THER\_F*

*FLUX\_NL* = *\_F* (

*/ALL* =

“YES”,

/

/

*NET*

= *lma*,

*[l\_maille]*

/

*GROUP\_MA*

= *lgma*,

*[l\_gr\_maille]*

*FLUN* =

*fl*,

*[function]*

)



### **4.5.3 Operands**

*FLUN: normal flow imposed on the mesh.*

*This loading applies to the types of meshes and following modelings:*

#### **Net Modélisation**

*TRIA3, TRIA6,  
3D, 3D\_DIAG  
QUAD4, QUAD8, QUAD9  
SEG2, SEG3  
PLAN, AXIS  
PLAN\_DIAG, AXIS\_DIAG*

*More precisely the boundary condition applied is:*

$$(grad T . n) = fl$$

*where is the normal directed in the direction of the classification of the nodes of the mesh. Orientation used in AFFE\_CHAR\_MECA document [U4.44.01].*

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### **4.6 Key word**

**RADIATION**

#### **4.6.1 Drank**

***Key word allowing to define the flow radiated ad infinitum according to the formula:***

***by the data of emissivity, the Boltzmann constant  
and the temperature ad infinitum  
expressed***

***into Centigrade. The temperature T will be it also expressed into Centigrade, it is thus necessary to  
take care, by coherence, with  
to use only degrees Celsius for all the study.***

#### **4.6.2 Syntax**

***.***  
***for AFFE\_CHAR\_THER***

***RADIATION = \_F (***

***/ALL =***

***“YES”,***

***/***  
***/***  
***NET =***

***lma,***

***[l\_maille]***

/  
**GROUP\_MA =**

*lgma,*  
*[l\_gr\_maille]*

**SIGMA**

=  
*sigma,*  
*[R8]*

**EPSILON**

=  
*epsilon,*  
*[R8]*

**TEMP\_EXT=**  
*tex,*

**[R8]**

)

.

**for AFFE\_CHAR\_THER\_F**

**RADIATION = \_F (**

**/ALL =**

**“YES”,**

/

/

**NET =**

**lma,**

**[l\_maille]**

/  
**GROUP\_MA =**

**lgma,**  
**[l\_gr\_maille]**

**SIGMA**

=  
**sigma,**  
**[function]**

**EPSILON**

=  
**epsilon,**  
**[function]**

**TEMP\_EXT=**

**tex,**  
**[function]**

)

### **4.6.3 Operands**

**SIGMA =**

*sigma*

**EPSILON =**

*epsilon*

**TEMP\_EXT**

*= tex*

*This loading applies to following modelings:*

*Net Modélisation*

*TRIA3, TRIA6,*

*3D, 3D\_DIAG*

*QUAD4, QUAD8, QUAD9*

*SEG2, SEG3*

*PLAN, AXIS*

*PLAN\_DIAG, AXIS\_DIAG*

*sigma:*

*Boltzmann constant, = 5.67 108 in units IF (W/m2.K4) (attention with this value if the units of grid change),*

*epsilon: emissivity,*

*tex:*

*temperature ad infinitum in degrees Celsius.*

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## **4.7 Key word EXCHANGE**

### **4.7.1 Drank**

*Key word factor usable to apply **conditions of exchange** with an outside temperature with a **face** of voluminal elements or hulls, defined by one or more meshes or of the groups meshes of the **triangle** type or **quadrangle**. This key word also makes it possible to apply conditions of exchange to an edge (in PLANE 2D or AXIS or AXIS\_FOURIER) on meshes of the segment type.*

*According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_THER) or via a concept of the type function (AFFE\_CHAR\_THER\_F).*

### **4.7.2 Syntax**

*.*  
*for AFFE\_CHAR\_THER*

*EXCHANGE = \_F (*

*/ALL =*

*“YES”,*

*/*  
*/*  
*NET*

*= lma,*

[l\_maille]

/  
*GROUP\_MA*  
= *lgma*,

[l\_gr\_maille]

/COEF\_H

= *H*,  
[R]

*TEMP\_EXT*  
= *tex*,  
[R]

/|  
*COEF\_H\_INF* = *hin*, [R]



*TEMP\_EXT\_INF*

=

*texin,*

*[R]*

/

*COEF\_H\_SUP = hsup,*

*[R]*

*TEMP\_EXT\_SUP = texsup,*

*[R]*

)

.

*for AFFE\_CHAR\_THER\_F*

*EXCHANGE = \_F (*

*/ALL =*

*“YES”,*

*/*  
*/*  
*NET*

*= lma,*  
*[l\_maille]*

*/*  
*GROUP\_MA*  
*= lgma,*  
*[l\_gr\_maille]*

*/COEF\_H =*

*HF,*  
*[function]*

*TEMP\_EXT*  
= *texf*,  
[function]

/|  
*COEF\_H\_INF* = *hinf*,  
[function]

*TEMP\_EXT\_INF* = *texinf*,  
[function]

/  
*COEF\_H\_SUP* = *hsupf*,  
[function]

*TEMP\_EXT\_SUP = texsupf,*  
*[function]*

)  
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### ***4.7.3 Operands***

*/COEF\_H = H,*

*TEMP\_EXT = tex,*

*This loading applies to the types of meshes and following modelings:*

#### ***Net Modélisation***

*TRIA3, TRIA6,*

*3D, 3D\_DIAG*

*QUAD4, QUAD8, QUAD9*

*SEG2, SEG3*

*PLAN, PLAN\_DIAG  
AXIS, AXIS\_FOURIER,  
AXIS\_DIAG*

*More precisely the boundary condition applied is:*

*where  $N$  is the normal directed in the direction of the classification of the nodes tops (orientation used in AFFE\_CHAR\_MECA [U4.44.01]).*

*/ /  
COEF\_H\_INF =  
hin,*

*TEMP\_EXT\_INF  
= texin,*

*/  
COEF\_H\_SUP =  
hsup,*

*TEMP\_EXT\_SUP  
= texsup,*

*This loading applies to the types of meshes and following modelings:*

***Net Modélisation***  
*TRIA3, TRIA6  
HULL*

*$N$  being the normal directing surface [U3.01.00], the boundary condition applied is:*

*where hin  
coefficient of exchange on the lower wall of the hull,  
and texin  
outside temperature, with dimensions lower wall.*

*where hsup  
coefficient of exchange on the higher wall of the hull,*

*and texsup  
outside temperature, with dimensions external wall.*

*N  
Higher wall  
Lower wall*

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## **4.8 Key word SOURCE**

### **4.8.1 Drank**

*Key word factor usable to apply **voluminal sources** (2D or 3D) to a definite **field** by one or more meshes or groups of meshes of the **voluminal** type.*

*According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_THER) or via a concept of the type function (AFFE\_CHAR\_THER\_F).*

### **4.8.2 Syntax**

*.  
for AFFE\_CHAR\_THER*

*SOURCE=\_F*

(

*/ALL =*

*“YES”,*

*/*

*/*

*NET =*

*lma,*

*[l\_maille]*

*/*

*GROUP\_MA*

*= lma,*

*[l\_gr\_maille]*

*SOUR =*

*S,*

*[R]*

/  
*SOUR\_CALCULEE*  
=  
*chs,*  
*[cham\_elem\_sour\_R]*

)

.

*for AFFE\_CHAR\_THER\_F*

*SOURCE=\_F*  
(

*/ALL =*

*“YES”,*

/

/

*NET =*

*lma,*

*[l\_maille]*



/  
*GROUP\_MA*  
= *lgma*,  
[*l\_gr\_maille*]

*SOUR* = *sf*,  
[*function*]

)

### **4.8.3 Operands**

*This loading applies to the types of meshes and following modelings:*

#### ***Net Modélisation***

*HEXA8, HEXA20, HEXA27*  
*3D, 3D\_DIAG*  
*PYRA5, PYRA13,*  
*PENTA6, PENTA15*  
*TETRA4, TETRA10*  
*TRIA3, TRIA6,*  
*PLAN, PLAN\_DIAG,*  
*QUAD4, QUAD8, QUAD9*  
*AXIS, AXIS\_FOURIER*  
*AXIS\_DIAG*

/  
*SOUR* = *S*,

*Value of the presumed constant source on the element.*

/  
*SOUR\_CALCULEE* = *chs*,

*Name of the cham\_elem\_sour\_R containing on each element the values of the source*

*discretized at the points of Gauss (1st family).*

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#### **4.9 Key word**

**GRAD\_TEMP\_INIT**

##### **4.9.1 Drank**

***Key word factor usable to apply to an element 3D or 2D (PLANE, AXIS) a gradient of presumed uniform temperature in the element. This “initial” variation in temperature is usable by example to solve the elementary problems determining the correctors of linear thermics stationary in the basic cell (2D, 3D), in periodic homogenisation.***

***The coefficients of homogenized conductivity are obtained while calculating by operator POST\_ELEM***

***[U4.81.22] key word ENER\_POT the energy dissipated thermically with balance in linear thermics with to leave the correctors.***

***Because of the thermal analogy, this step can be exploited to obtain the correctors in elasticity antiplane in the basic 2D cell, as well as in electric conduction.***

***The assignment can be done on one or more meshes, one or more groups of meshes or on all elements of the model.***

##### **4.9.2 Syntax**

.  
*for AFFE\_CHAR\_THER*

*GRAD\_TEMP\_INIT = \_F (*

*/ALL =*

*“YES”,*

*/*  
*/*  
*NET*

*= lma,*  
*[l\_maille]*

*/*  
*GROUP\_MA*  
*= lgma,*  
*[l\_gr\_maille]*

***/ FLUX\_X***

***=***

***flx,***  
***[R]***

***/ FLUX\_Y***

***=***

***fly,***  
***[R]***

***/ FLUX\_Z***

***=***

***flz,***  
***[R]***

***)***

### ***4.9.3 Operands***

***This loading applies to the types of meshes and following modelings:***

***Net Modélisation***

***TRIA3, TRIA6,***

***PLAN, AXIS,***

***QUAD4, QUAD8, QUAD9***

***PLAN\_DIAG, AXIS\_DIAG***

***HEXA8, HEXA20,***

**HEXA27**  
**PENTA6, PENTA15,**  
**3D, 3D\_DIAG**  
**TETRA4, TETRA10**  
**PYRA5, PYRA13**

/

**FLUX\_X = flx (flxf)**

/

**FLUX\_Y = fly (flyf)**

/

**FLUX\_Z = flz (flzf) (in 3D only)**

**Components of the variation in temperature  
in the total reference mark.**

**The second calculated elementary member is:**

where  
is the tensor of  
thermal conductivities.

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*The gradients can be a function of the geometry and/or time.*

.

*for AFFE\_CHAR\_THER\_F*

*GRAD\_TEMP\_INIT = \_F (*

*/ALL =*

*“YES”,*

*/MESH =*

*lma,*

*[l\_maille]*

*/*

*GROUP\_MA*

*= lgma,*

*[l\_gr\_maille]*

*/ FLUX\_X*

*=*

*flxf,*

*[function]*

*/ FLUX\_Y*  
=  
*flyf,*  
*[function]*

*/ FLUX\_Z*  
=  
*flzf,*  
*[function]*

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#### **4.10 Key word**

#### **LIAISON\_DDL**

##### **4.10.1 Drank**

*Key word factor usable to define a linear relation between degrees of freedom of two or several nodes.*

*According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_THER) or via a concept function (AFFE\_CHAR\_THER\_F).*

##### **4.10.2 Syntax**

.

*for AFFE\_CHAR\_THER*

*LIAISON\_DDL = \_F (*

*/NODE =*

*lno,*

*[l\_noeud]*

*/*

*GROUP\_NO*

*= lgn,*

*[l\_gr\_noeud]*

*DDL*

*=*

*/ "TEMP", [DEFECT]*



/  
"TEMP\_INF",

/ "TEMP\_SUP",

COEF\_MULT

=

I

,

[I\_R]

COEF\_IMPO

=

,

[R]

)  
.  
*for AFFE\_CHAR\_THER\_F*

*LIAISON\_DDL = \_F (*  
*/NODE =*

*lno,*

*[l\_noeud]*  
*/*  
*GROUP\_NO*  
*= lgn,*  
*[l\_gr\_noeud]*

*DDL*  
*=*  
*/ "TEMP", [DEFECT]*

*/ "TEMP\_INF",*

/ “TEMP\_SUP”,

*COEF\_MULT*

=

*I*

,

[*l\_R*]

*COEF\_IMPO*

=

*F*

,

[*function*]

)

### **4.10.3 Operands**

*The list of the nodes Nor ( $I = 1, R$ ) defined by GROUP\_NO or NODE is ordered in a natural way:*

.

*in the order of the list of group of nodes, and for each group of nodes, in the order of definition of the group by GROUP\_NO.*

.

*in the order of the list of nodes for NODE.*

*The argument of DDL must be a list of degrees of freedom  $T_i$  ( $I = 1, R$ ) of  $R$  texts taken among:*

“TEMP”

“TEMP\_SUP”

“TEMP\_INF”

If key word DDL is omitted, by defect the linear relation will carry on the degrees of freedom “TEMP”.

The argument of COEF\_MULT must be a list (I = 1, R) of coefficients (of real type for I

AFFE\_CHAR\_THER and AFFE\_CHAR\_THER\_F).

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The argument of COEF\_IMPO is a coefficient for AFFE\_CHAR\_THER, a function of space for AFFE\_CHAR\_THER\_F.

The following kinematic condition is applied:

**Note:**

Components “TEMP\_SUP” and “TEMP\_INF” can intervene only in combinations **only** assigned to nodes which belong to elements of **hull** (modeling “HULL”).

In the case of a linear relation between the degrees of freedom of the same node, one will repeat behind the key word NODE the name of the node as many time as there are degrees of freedom in relation. **Example:** to impose  $T_{sup} = T_{inf}$  on the node N1, one will write:

*LIAISON\_DDL = \_F (NODE  
= (N1, N1),*

*DDL  
=  
("TEMP\_SUP",  
"TEMP\_INF"),*

*COEF\_MULT  
=  
(1., -1.),  
COEF\_IMPO  
=  
0.,*

)

*It is important to note that to an occurrence of the key word factor LIAISON\_DDL one corresponds and only one linear relation.*

*If one wants to impose the same relation between 2 groups of nodes GRN01 and GRN02 (even temperature node with node for example) **one cannot write:***

*LIAISON\_DDL = \_F (GROUP\_NO = (GRN01,  
GRN02),*

*DDL  
=  
("TEMP",  
"TEMP"),*

*COEF\_MULT  
=  
(1., -1.),*

*COEF\_IMPO  
=  
0.,*

)

*This writing has direction only if GRN01 and GRN02 contain each one one node. It will be necessary in the case to above clarify each linear relation, node by node.*

***Key word LIAISON\_GROUP on the other hand makes it possible to condense the writing of the relations linear between 2 groups of nodes in opposite.***

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#### ***4.11 Key word***

#### ***LIAISON\_GROUP***

##### ***4.11.1 Drank***

*Key word factor usable to define linear relations between couples of nodes, these couples nodes being obtained while putting in opposite two lists of meshes or nodes.*

*According to the name of the operator called, the values are provided directly (AFFE\_CHAR\_THER) or via a concept function (AFFE\_CHAR\_THER\_F).*

## 4.11.2 Syntax

.

*for AFFE\_CHAR\_THER*

*LIAISON\_GROUP = \_F*

*(*

*/*

*/*

*MAILLE\_1*

*= lma1, [l\_maille]*

*/*

*GROUP\_MA\_1 =*

*lgma1,*

*[l\_gr\_maille]*

*/MAILLE\_2 = lma2, [l\_maille]*

*/*

*GROUP\_MA\_2 =*

*lgma2,*

*[l\_gr\_maille]*

*/*

*/*

*NOEUD\_1 = lno1,*

*[l\_noeud]*

*/*

*GROUP\_NO\_1 =*

*lgnol,*

*[l\_gr\_noeud]*

*/NOEUD\_2 = lno2,  
[l\_noeud]*

*/*

*GROUP\_NO\_2 =  
lgn2,  
[l\_gr\_noeud]*

*/*

*SANS\_NOEUD =  
lno,  
[l\_noeud]*

*/*

*SANS\_GROUP\_NO  
=  
lgn,  
[l\_gr\_noeud]*

*DDL\_1 = | "TEMP", [DEFECT]*



/ *“TEMP\_INF”*,

/ *“TEMP\_SUP”*,

*DDL\_2 = / “TEMP”, [DEFECT]*

/ *“TEMP\_INF”*,

/ "TEMP\_SUP",

COEF\_MULT\_1 = 1i, [l\_R]

COEF\_MULT\_2 = 2i, [l\_R]

COEF\_IMPO  
=  
, [R]

/  
CENTER  
=  
Lr  
,  
[l\_R]

/  
*ANGL\_NAUT*  
=  
*Lr*  
,  
*[l\_R]*

/  
*TRAN*  
=  
*Lr*  
,  
*[l\_R]*

*SUMMIT*  
=  
“*YES*”,

)  
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.  
for *AFFE\_CHAR\_THER\_F*

*LIAISON\_GROUP* = *\_F*

(

/

/

*MAILLE\_1*

= *lma1*, [*l\_maille*]

/

*GROUP\_MA\_1* =

*lgma1*,

[*l\_gr\_maille*]

*/MAILLE\_2* = *lma2*, [*l\_maille*]

/

*GROUP\_MA\_2* =

*lgma2*,

[*l\_gr\_maille*]

/

/

*NOEUD\_1 = lno1,*  
*[l\_noeud]*

/

*GROUP\_NO\_1 =*  
*lgnol,*  
*[l\_gr\_noeud]*

*/NOEUD\_2 = lno2,*  
*[l\_noeud]*

/

*GROUP\_NO\_2 =*  
*lgnol,*  
*[l\_gr\_noeud]*

/

*SANS\_NOEUD =*  
*lno,*  
*[l\_noeud]*

/

*SANS\_GROUP\_NO*  
*=*

*l*gno,  
[*l*\_gr\_noeud]

*DDL\_1* = | “TEMP”, [DEFECT]

|  
“TEMP\_INF”,

| “TEMP\_SUP”,

*DDL\_2* = | “TEMP”, [DEFECT]

/ "TEMP\_INF",

/ "TEMP\_SUP",

COEF\_MULT\_1 = 1i, [l\_R]

COEF\_MULT\_2 = 2i, [l\_R]

COEF\_IMPO

=

F

,

[function]

/  
*CENTER*  
=  
*Lr*  
,  
*[l\_R]*

/  
*ANGL\_NAUT*  
=  
*Lr*  
,  
*[l\_R]*

/  
*TRAN*  
=  
*Lr*  
,  
*[l\_R]*



*SUMMIT*

=

“YES”

)

### **4.11.3 Operands**

*T*

*O*

*1*

*2*

*Appear 4.11.3-a: Geometrical transformation  
of a border in another  
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***Kinematic condition “general”:***

```
//MAILLE_1  
=  
/  
GROUP_MA_1  
=
```

***These operands define  
via the meshes which make it up.***

```
/MAILLE_2  
=  
/  
GROUP_MA_2  
=
```

***These operands define 2 via the meshes which make it up.***

```
//NOEUD_1  
=  
/  
GROUP_NO_1  
=
```

***These operands define  
via the nodes which make it up.***

```
/NOEUD_2  
=  
/  
GROUP_NO_2  
=
```

***These operands define 2 via the nodes which make it up.***

```
/SANS_GROUP_NO  
=:  
/  
SANS_NOEUD
```

=

*These operands make it possible to remove list of the couples of nodes in opposite all the couples of which at least one of the nodes belongs to the list of nodes described by these operands.*

*That makes it possible to avoid the accumulation of linear relations on the same node during various iterations on the key word factor **LIAISON\_GROUP** what leads the majority of time with a singular matrix.*

**COEF\_MULT\_1** (resp. **COEF\_MULT\_2**)

*List realities dimensioned exactly with the number of degrees of freedom declared in **DDL\_1** (resp. **DDL\_2**) corresponding to the multiplying coefficients of the linear relation.*

**COEF\_IMPO**: coefficient of blocking of the linear relation:

*: reality  
for  
**AFFE\_CHAR\_THER**  
**F**  
: function  
for  
**AFFE\_CHAR\_THER\_F***

**CENTER**

*:  
co-ordinates of the centre of rotation*

**ANGL\_NAUT**

*: nautical angles in degrees defining rotation (see **AFFE\_CARA\_ELEM** [U4.42.01] key word **ORIENTATION**)*

**TRAN**: components of the vector translation

*These operands make it possible to define a virtual transformation (rotation and/or translation) approximate of 1 in 2 in order to ensure the bijectivity of the function opposite.*

**DDL\_1**

*(resp. **DDL\_2**):*

*List texts taken among:*

*“TEMP”, “TEMP\_INF”, “TEMP\_SUP”*

*“TEMP\_INF” and “TEMP\_SUP” can be used only for elements of hull thermics (modeling: “HULL”).*

*By defect, the degree of freedom considered for all the nodes of the linear relations is “TEMP”.*

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*SUMMIT = “YES”*

*When the meshes of edge are quadratic, the use of SUMMIT: “YES” force the algorithm of pairing to associate the nodes tops other nodes tops. In the case of fine grids, that makes it possible in certain cases to avoid the problems of conflicts of opposite.*

*4.11.4 Use of LIAISON\_GROUP*

*LIAISON\_GROUP generates linear relations only between 2 nodes (one on 1, one out of 2)*

*To generate linear relations on more than 2 nodes, to use key word LIAISON\_DDL.*

*determination of the couples of nodes in opposite:*

*initially, one draws up the two lists of nodes to be put in opposite (IE at to pair), for each occurrence of the key word factor LIAISON\_GROUP:*

*for key words GROUP\_NO\_1 and GROUP\_NO\_2, they are the nodes constituting them groups of nodes,*

*for key words GROUP\_MA\_1 and GROUP\_MA\_2, they are the nodes of the meshes setting up the groups of meshes.*

*The redundancies being eliminated, the two lists of nodes obtained must have the same one length.*

*The determination of the couples of nodes in opposite is done in several stages:*

*for each N1 node of the first list, one seeks the node image  $N2 = F(N1)$  of second list. If F is not injective (a node N2 is the image of two distinct nodes N1 and N1'), the error message according to is transmitted:*

**<F> <AFFE\_CHAR\_THER> <PACOAP> CONFLICT IN OPPOSITE**

**NODES**

*The NODE N2 EAST IT WITH RESPECT TO the NODES N1 AND N1'*

*for each node N2 of the second list, one seeks the node N1 image =  $G(N2)$  of first list. If G is not injective (a N1 node is the image of two distinct nodes N2 and N2'), the error message according to is transmitted:*

**<F> <AFFE\_CHAR\_MECA> <PACOAP> CONFLICT IN OPPOSITE**

**NODES**

*The NODE N1 EAST IT WITH RESPECT TO the NODES N2 AND N2'*

*it is checked that  $G = f1$ , i.e. the couples obtained by the stages has) and b) are them same (one wants to have a bijection  $F$  between the two lists of nodes). If  $F$  is not surjective, the error message according to is transmitted:*

**<F> <AFFE\_CHAR\_MECA> <PACOAP> CONFLICT IN OPPOSITE GENERATE  
SUCCESSIVELY FROM LISTS LIST1 AND LIST2**

***The NODE OF the FIRST N1 LIST IS NOT the IMAGE Of ANY NODE BY***

***CORRESPONDENCE  
OPPOSITE***

***For a node NR given, one calls node image  $F(NR)$  the node of the other list of nodes which carry out the minimum of the distance with NR. to facilitate pairing, in particular in the case particular geometries (where borders 1 and 2 could “almost” result one from the other by the composition of a translation and a rotation), one makes it possible to make a virtual geometrical transformation of the first group of nodes (translation and rotation (cf [Figure 4.11.3-a]) before calculating the distances (key words TRAN, CENTER and ANGL\_NAUT).***

***For each occurrence of the key word factor LIAISON\_GROUP, one builds the list thus of new couples in opposite. When all the occurrences were swept, one removes list the couples in double.***

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**U4.44.02-II Page****: 22/28****Note:**

*In the couples of nodes in opposite, the order of the nodes is important. If for first occurrence of LIAISON\_GROUP, a node NR belonged to the first group of nodes and a node M with the second group of nodes, and that for the second occurrence LIAISON\_GROUP, it is the reverse, one will obtain with the exit pairing the couples (NR, M) and (M, NR). They will not be eliminated during detection of the redundancies; on the other hand, stamp obtained will be singular. Thus, one advises to keep same logic at the time of description of the edges in opposite.*

**4.12 Key word****LIAISON\_MAIL****4.12.1 Drank**

*Key word factor allowing “to thermically restick” two edges of a structure. These edges can to be with a grid differently (incompatible grids) but must result one from the other by rotation and/or translation.*

**4.12.2 Syntax**

.

*in AFFE\_CHAR\_THER only***LIAISON\_MAIL****=\_F****(****/GROUP\_MA\_MAIT****=****lgma\_mait,****/****MAILLE\_MAIT =**

*lma\_mait,*

*/ GROUP\_MA\_ESCL*

=

*lgma\_escl,*

*/ MAILLE\_ESCL =*

*lma\_escl,*

*/ GROUP\_NO\_ESCL*

=

*lgnno\_escl,*

*/ NOEUD\_ESCL =*

*lno\_escl,*



*/ TRAN =  
(tx, ty, [tz]),*

*[l\_R]*

*/  
CENTER =  
(xc, yc, [zc]),*

*[l\_R]*

*ANGL\_NAUT = (alpha, [beta, gamma]), [l\_R]*

)

*Face 1 is called face “Master”, face 2 face “slave”.*

### ***4.12.3 Operands***

#### ***4.12.3.1 GROUP\_MA\_ESCL/MAILLE\_ESCL/GROUP\_NO\_ESCL/NOEUD\_ESCL***

*These key words make it possible to define the whole of the nodes of the face slave. One takes all them*

*nodes specified by key words GROUP\_NO\_ESCL and NOEUD\_ESCL more possibly nodes carried by the meshes specified by key words GROUP\_MA\_ESCL and MAILLE\_ESCL.*

#### **4.12.3.2 GROUP\_MA\_MAIT/MAILLE\_MAIT**

*These key words make it possible to define the whole of the meshes where they with respect to the nodes will be sought face slave.*

*One should not give the meshes of surface (in 3D) composing the face Master, but the meshes voluminal adjacent with the face Master. The specified meshes are candidates for research opposite. One can give too much of it.*

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#### **4.12.3.3 CENTERS/ANGL\_NAUT/TRAN**

*These operands make it possible to define the geometrical transformation (rotation and/or translation)*

*allowing to pass from the face main slave to the face. The order carries out initially rotation then translation.*

*Caution: the transformation is in the direction slave-Master.*

*This boundary condition applies to plane modelings (“PLAN” or “AXIS”) or voluminal (“3D”).*

### **4.13 Key word**

## ***ECHANGE\_PAROI***

### **4.13.1 Drank**

***Key word factor usable to apply conditions of heat exchange between 2 definite walls each one by one or more meshes or one or more groups of meshes.***

### **4.13.2 Syntax**

***.***  
***for AFFE\_CHAR\_THER***

***ECHANGE\_PAROI=\_F***

***(***  
***/***  
***GROUP\_MA\_1***

***=***  
***lgma,***  
***[l\_gr\_maille]***

***/***  
***MAILLE\_1***  
***= lma,***  
***[l\_maille]***

***/GROUP\_MA\_2***

***=***  
***lgma,***  
***[l\_gr\_maille]***

***/***  
***MAILLE\_2***  
***= lma,***  
***[l\_maille]***

***COEF\_H***

=

***H,***

***[R]***

***/TRAN***

=

***Lr,***

***[l\_R]***

***/ANGL\_NAUT***

=

***Lr,***

***[l\_R]***

***/CENTER***

=

***Lr,***

***[l\_R]***

)  
.  
*for AFFE\_CHAR\_THER\_F*

*ECHANGE\_PAROI=\_F*

(  
/  
*GROUP\_MA\_1*

=  
*lgma,*  
*[l\_gr\_maille]*  
/  
*MAILLE\_1*  
= *lma,*  
*[l\_maille]*

*/GROUP\_MA\_2*

=  
*lgma,*  
*[l\_gr\_maille]*  
/  
*MAILLE\_2*  
= *lma,*  
*[l\_maille]*

*COEF\_H*

=  
*HF,*  
*[function]*

***/TRAN***

**=**

***Lr***

**,**

***[l\_R]***

***/ANGL\_NAUT***

**=**

***Lr***

**,**

***[l\_R]***

***/CENTER***

**=**

***Lr***

**,**

***[l\_R]***

**)**

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### **4.13.3 Operands**

**/GROUP\_MA\_1**

**/**

**MAILLE\_1**

**/GROUP\_MA\_2**

**/**

**MAILLE\_2**

**T**

**N2**

**n1**

**O**

**1**

**2**

**Appear 4.13.3-a**

**These operands make it possible to define the 2 lists of meshes representing for the list subscripted *\_1* wall 1 for the subscripted list *\_2* wall 2.**

**The walls are in correspondence and must comprise the same number of meshes and nodes.**

***The limiting condition applied between these 2 walls is:***

***F representing the bijection which puts in opposite a node of 1 and one node of 2.***

***/COEF\_H***

***=***

***Coefficient of constant exchange enters the 2 walls:***

***reality for the operator AFFE\_CHAR\_THER, function for operator AFFE\_CHAR\_THER\_F.***

***/***

***TRAN = component of the vector translation***

***/ANGL\_NAUT***

***= nautical angles defining rotation***

***/CENTER***

***= coordinated centre of rotation***

***These operands make it possible to define a virtual transformation (rotation and/or translation) approximate of 1 in 2 in order to ensure the bijectivity of the function in opposite.***

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**TRAN**

*: characterize a translation T*

*in 2D one thus has*

*:*

*TRAN = (tx, ty)*

*in 3D one has*

*:*

*TRAN = (tx, ty, tz)*

**ANGL\_NAUT**

*:*

*nautical angle allowing to define a rotation*

*in 2D*

*:*

*1 angle*

*in 3D*

*:*

*3 angles (cf [U4.42.01])*

**CENTER**

*:*

*centre of rotation*

*in 2D*

*:*

*(OX, OY)*

*in 3D*

*:*

*(OX, OY, OZ)*

**4.13.4 Use of ECHANGE\_PAROI**

*The user gives two lists of meshes from which the couples from paired nodes will result. These lists are initially sorted by type of mesh: the paired nodes will come from meshes of the identical type. For each mesh of the first list, one determines the mesh nearest in the second list by calculating all the distances from the nodes taken two to two (one traverses all the permutations possible). The distance minimum obtained defines at the same time the mesh in opposite and the couples of nodes paired for the two meshes concerned. As in LIAISON\_GROUP [§4.11], it is possible to carry out a virtual geometrical transformation (rotation and/or translation) before to calculate the distances.*

#### ***4.13.5 Meshs and modelings supporting this loading:***

***Net edge***

***Modeling***

***Net coupling generated***

***SEG2, SEG3***

***PLAN, PLAN\_DIAG***

***SEG22, SEG33***

***AXIS, AXIS\_DIAG***

***TRIA3, TRIA6,***

***3D, 3D\_DIAG***

***TRIA33, TRIA66,***

***QUAD4, QUAD8, QUAD9***

***QUAD44, QUAD88, QUAD99***

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#### ***4.14 Key word***

***LIAISON\_UNIF***

##### ***4.14.1 Drank***

***Key word factor allowing to impose the same value (unknown) on the temperatures of a unit nodes.***

*These nodes are defined by the groups of meshes, the meshes, the groups of nodes or the list of nodes to which they belong.*

#### **4.14.2 Syntax**

·  
for *AFFE\_CHAR\_THER* and *AFFE\_CHAR\_THER\_F*

**LIAISON\_UNIF**

**=\_F**

(

**/MESH**

**= lma**

,  
**[l\_maille]**

/

**GROUP\_MA**

=

**lgma,**

**[l\_gr\_maille]**

/

**NODE**

=

**lno,**

**[l\_noeud]**

/

**GROUP\_NO**

=

**lgnno,**

**[l\_gr\_noeud]**

***DDL = / “TEMP”***

***,  
[DEFECT]***

***/ “TEMP\_INF”,***

***/ “TEMP\_SUP”,***

***)***

### ***4.14.3 Operands***

***/MESH***

***/***

***GROUP\_MA***

***/***

***NODE***

***/***

***GROUP\_NO***

***These operands make it possible to define a list of nodes from which one eliminated them redundancies (for MESH and GROUP\_MA, they are connectivities of the meshes).***

## ***DDL***

***This operand makes it possible to define a list of degrees of freedom texts taken among: “TEMP”, “TEMP\_INF”, “TEMP\_SUP”.***

***conditions “kinematics” resulting are:***

### ***Note:***

***Components “TEMP\_SUP”, “TEMP\_INF” can intervene only for nodes elements of hull.***

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### ***4.15 Key word***

***LIAISON\_CHAMNO***

#### ***4.15.1 Drank***

***Key word factor usable to define a linear relation between all the temperatures present in a concept CHAM\_NO.***

## 4.15.2 Syntax

**LIAISON\_CHAMNO = \_F (**  
**CHAM\_NO = *chamno*,**

**[*cham\_no*]**

**COEF\_IMPO =,**

**[R]**

**NUME\_LAGR**

**=**

**/**

**“NORMAL”,**

**[DEFECT]**

**/**

**“AFTER”**

**,**

**)**

### 4.15.3 Operands

**CHAM\_NO =**

*Name of the chamno which is used to define the linear relation. The temperatures connected are all those present in the chamno. The coefficients to be applied to the temperatures are the values of these temperatures in the chamno.*

**Example:**

*Let us suppose that one has a bearing chamno on 3 nodes of name N01, N02 and N03.*

*Let us suppose that the values of the temperatures in these 3 nodes in the chamno are respectively 2. , 5.4 and 9.1. The linear relation that one will impose is  $2.*Temp(N01) + 5.4*Temp(N02) + 9.1*Temp(N03) =$*

**COEF\_IMPO =**

*It is the value of the real coefficient to the second member of the linear relation.*

**NUME\_LAGR =**

*If "NORMAL", the 2 multipliers of Lagrange associated with the relation will be such as the first will be located before all the terms implied in the relation and the second after, in the assembled matrix.*

*If "AFTER", the 2 multipliers of Lagrange associated with the relation will be located after all the terms implied in the relation, the assembled matrix.*

*This choice has the advantage of having an assembled matrix whose obstruction is weaker but has the disadvantage to be able to reveal a singularity in the matrix.*

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#### **4.16 Key word**

**CONVECTION**

##### **4.16.1 Drank**

*Key word usable to take into account the term of transport of heat by convection of which the expression is*

*, appearing in the expression of the particulate derivative*

.

*In the case of a liquid medium, V indicates the speed imposed of the fluid particle on the current point.*

*In the case of a mobile solid medium, V indicates the speed of the solid. In all the cases, one supposes that the field speed is known a priori. The case of a mobile solid is rather frequent in practice. It relate to in particular the applications of welding or surface treatment which bring into play one heat source moving in a given direction and at a speed.*

*The thermal problem is then studied in a reference frame related to the source (cf*

**THER\_NON\_LINE\_MO**

**[U4.54.03]).**

##### **4.16.2 Syntax**

**CONVECTION = \_F (**  
**SPEED**

**=**

**v**

**[cham\_no\_depl\_R])**

##### **4.16.3 Operand**

**For AFFE\_CHAR\_THER and AFFE\_CHAR\_THER\_F,**



***SPEED =***

***Name of the field speed at the moment when calculation is carried out.***

***This field is a concept cham\_no of the cham\_no\_depl\_R type. It must have been defined on all it model for which one carries out calculation.***

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*Organization (S): EDF-R & D /AMA*

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***Operators AFFE\_CHAR\_CINE  
and AFFE\_CHAR\_CINE\_F***

## ***1 Goal***

***To define a loading of the type “imposed degrees of freedom”.***

***This order can be used with a mechanical, thermal or acoustic model.***

***treatment of these conditions “kinematics” will be done without dualisation and thus without addition of degrees of freedom of Lagrange.***

***Attention this type of loading is not admitted by all the orders (for example STAT\_NON\_LINE).***

***for AFFE\_CHAR\_CINE the affected values do not depend on any parameter and are defined by actual values (mechanics or thermics) or complex values (acoustics). These values can be null (blocking),***

***for AFFE\_CHAR\_CINE\_F the affected values can be related to one (or several) parameters to be chosen as a whole (INST, X, Y, Z).***

***Product a structure of data of the char\_cine\_\* type.***

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## ***2 Syntax***

## **General**

***CH [char\_cine\_\*] = AFFE\_CHAR\_CINE***

(  
***MODEL***  
=  
***Mo***  
,  
***[model]***

***/MECA\_IMPO =***

***(see key word MECA\_IMPO),***

***/THER\_IMPO =***

***(see key word THER\_IMPO),***

***/ACOU\_IMPO =***

***(see key word MECA\_IMPO),***

)

*if*  
*MECA\_IMPO*  
*then* [\*]  
*MECA*  
*if*  
*THER\_IMPO*  
*THER*  
*if*  
*ACOU\_IMPO*  
*ACOU*

*CH [char\_cine\_\*] = AFFE\_CHAR\_CINE\_F*

(  
*MODEL*  
=  
*Mo*  
,  
*[model]*

*/MECA\_IMPO =*

*(see key word MECA\_IMPO),*

/  
*THER\_IMPO =*

(see key word *THER\_IMPO*),

)

*if*  
*MECA\_IMPO*  
*then* [\*]

*MECA*  
*if*  
*THER\_IMPO*  
*THER*

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### *3 General information*

*These two orders create concepts of the type CHAR\_CINE\_\* (\_MECA/\_THER).*

*Order AFFE\_CHAR\_CINE can also create concepts of the type CHAR\_CINE\_ACOU.*

*These types are different from the type charges created by orders AFFE\_CHAR\_MECA [U4.44.01], AFFE\_CHAR\_THER [U4.44.02] or AFFE\_CHAR\_ACOU [U4.44.04].*

*The objects created are thus not interchangeable.*

*The advantage of the loads “kinematics” is that they do not increase the number of unknown factors of systems to be solved, contrary to the method of dualisation by multipliers of LAGRANGE, used in the orders producing a concept of the type charges.*

*On the other hand, the use of these loads comprises the following limitations:*

- *one can use them only in the case of relation of the type “ddl imposed” (and not for linear relations),*

- *these loads are not yet allowed in all the total orders. Today the possible orders are:*

- *MECA\_STATIQUE,*

- *THER\_LINEAIRE, THER\_NON\_LINE or THER\_NON\_LINE\_MO.*

- *for a calculation not using the total orders: assembly of a matrix, then resolution, the sequence of orders to be used is more complicated than with loads “ordinary” as one can see it in example 2 [§ 5.2].*

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## 4 Operands

### 4.1

#### *General information on the operands*

*The operands under the key words factors MECA\_IMPO, THER\_IMPO and ACOU\_IMPO are two forms:*

- *operands specifying the geometrical entities on which are affected them loadings (key words GROUP\_MA, GROUP\_NO, NODE...). Arguments of these operands are identical for the two operators.*

- *operands specifying the affected values (DX, DY, DZ, etc...). Significance of these operands is the same one for the two operators. The arguments of these operands are all real type for operator AFFE\_CHAR\_CINE and of the function type (or formulates) for operator AFFE\_CHAR\_CINE\_F.*

*This is true near with an exception: the key word factor ACOU\_IMPO (which does not exist in order AFFE\_CHAR\_CINE\_F) is always of complex type.*

*We will thus not distinguish in this document, except mention express of the opposite, both operators AFFE\_CHAR\_CINE and AFFE\_CHAR\_CINE\_F.*

*In a general way, the entities on which values must be affected are defined by nodes:*

- *maybe by the operand ALL = "YES" which makes it possible to indicate all the nodes of the grid,*

- *maybe by operand GROUP\_NO allowing to indicate a list of groups of nodes,*

- *maybe by the operand NODE allowing to indicate a list of nodes.*

- *maybe by the operands GROUP\_MA and MESH allowing to indicate all the nodes carried by the meshes indicated by the lists of MESH and GROUP\_MA.*

### 4.2

#### *Behavior in the event of overload:*

##### *4.2.1 Overload within one only order AFFE\_CHAR\_CINE*



*When one uses within the same order, several occurrences of MECA\_IMPO (or THER\_IMPO,...) and that certain nodes are affected several times, it is the last occurrence which precede. For example:*

*chcine= AFFE\_CHAR\_CINE (MECA\_IMPO= (  
\_F (TOUT=' OUI', DX= 1. ,...)  
\_F (NOEUD=' N3', DX= 3. ,...)*

*In this case, displacement imposed DX for the N3 node is worth: 3.*

#### **4.2.2 Overload between several orders AFFE\_CHAR\_CINE**

*If several different orders are used, the behavior is different. For example:*

*chcin1= AFFE\_CHAR\_CINE (MECA\_IMPO= \_F (TOUT=' OUI', DX= 1. ,...)  
chcin1= AFFE\_CHAR\_CINE (MECA\_IMPO= \_F (NOEUD=' N3', DX= 3. ,...)*

*In this case, displacement imposed DX for the N3 node is worth: 4! (1+3).*

#### **4.2.3 Overload**

*enter*

*AFFE\_CHAR\_CINE and AFFE\_CHAR\_MECA*

*In the same way, if one “mixes” orders AFFE\_CHAR\_MECA and AFFE\_CHAR\_CINE:*

*chcin1= AFFE\_CHAR\_CINE (MECA\_IMPO= \_F (TOUT=' OUI', DX= 1. ,...)  
chdua1= AFFE\_CHAR\_MECA (DDL\_IMPO= \_F (NOEUD=' N3', DX= 3. ,...)*

*In this case, displacement imposed DX for the N3 node is worth: 4! (1+3).*

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### **4.3 Operand MODEL**

**MODEL = Mo**

**Concept produced by operator AFFE\_MODELE [U4.41.01] where the types of elements are defined stop affected on the grid.**

### **4.4 Word**

**key**

**MECA\_IMPO**

#### **4.4.1 Drank**

**Key word factor usable to impose, with nodes or groups of nodes, a value of displacement, definite component by component in the total reference mark.**

**These boundary conditions will be treated, thereafter, by the method known as of elimination of the degrees of freedom imposed (i.e. without dualisation, contrary on the treatment of the same type of condition limit by the use of operators AFFE\_CHAR\_MECA or AFFE\_CHAR\_MECA\_F [U4.44.01]).**

#### **4.4.2 Syntax**

**AFFE\_CHAR\_CINE**

**/MECA\_IMPO = (\_F (**

**/**

**ALL**

**=**

**“YES”**

**,**

**/**

**/**

**NODE**

**=**

**lno**

**,**

**[l\_noeud]**  
/  
**GROUP\_NO**  
=  
**lgn**  
,

**[l\_gr\_noeud]**  
  
/  
**NET**  
=  
**lma**  
,

**[l\_maille]**  
  
/  
**GROUP\_MA**  
=  
**lgma**  
,

**[l\_gr\_maille]**  
  
/  
**DX**  
=  
**ux**  
,

**[R]**  
  
/  
**DY**  
=  
**uy**

,  
[R]

/  
... (see the list supplements below)  
),),

*AFFE\_CHAR\_CINE\_F*

*/MECA\_IMPO*

= (*\_F*

(

/

*ALL*

=

“*YES*”

,

/

/

*NODE*

=

*lno*

,

[*l\_noeud*]

/

*GROUP\_NO*

=

*lgnno*

,

[*l\_gr\_noeud*]

/NET =

*lma*

,

[*l\_maille*]

/  
**GROUP\_MA**  
=  
**lgma**  
,  
**[l\_gr\_maille]**

/ **DX**  
=  
**uxf**  
,

**[function (\*)]**

/ **DY**  
=  
**uyf**  
,  
**[function (\*)]**

/  
**... (see the list supplements below)**  
,),

*function (\*): function or formula*

*List key words available under MECA\_IMPO:*

**DCX DCY DCZ DRX DRY DRZ DX DY DZ E1X E1Y E1Z E2X E2Y E2Z E3X E3Y E3Z E4X  
E4Y E4Z GONF GRX H1X H1Y H1Z PHI PRE1 PRE2 CLOSE TEMP UI2 UI3 UI4 UI5 UI6  
UO2 UO3 UO4 UO5 UO6 VI2 VI3 VI4 VI5 VI6 VO2 VO3 VO4 VO5 VO6 W11 W12 W13  
WI4 W15 W16 WO WO1 WO2 WO3 WO4 WO5 WO6**

*They are the names of the degrees of freedom carried by the finite elements of the model. Significance of these*

*names is to be sought in the documentation of the finite elements.*

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### **4.4.3 Operands**

**/MECA\_IMPO**

***DX = ux or uxf***

***Value of the component of displacement***

***DY = uy or uyf***

***in imposed translation***

***DZ = uz or uzf***

***on the specified nodes***

*Only for the nodes of a model 3D comprising of the elements of beam, plates, hull, discrete:*

*DRX = X or xf*

*Value of the component of displacement*

*DRY = y or yf*

*in imposed rotation*

*on the specified nodes*

*DRZ = z or zf*

*For the “exotic” degrees of freedom more: GRX, TEMP, NEAR and PHI, one will refer to documentation of order AFFE\_CHAR\_MECA [U4.44.01 §3.9].*

*Caution:*

*It is checked that the degree of freedom specified exists in this node for at least one of the elements model (key word MODELS) which is based on this node.*

*Moreover, the rule of overload is applied when the same degree of freedom of same node is imposed several times: only the last value is retained.*

#### *4.5 Word*

*key*

*THER\_IMPO*

##### *4.5.1 Drank*

*Key word factor usable to impose, with nodes or groups of nodes, a value of nodal temperature.*

*These boundary conditions will be treated, thereafter, by the method known as of elimination of the degrees of*

*freedom imposed (i.e.: without dualisation contrary to the treatment of the same type of condition limit by the use of operators AFFE\_CHAR\_THER or AFFE\_CHAR\_THER\_F [U4.44.02])*

##### *4.5.2 Syntax*

*.*  
*for AFFE\_CHAR\_CINE*

*/THER\_IMPO = (\_F (*

*/*

*ALL*

=

**“YES”**

,

/

/

**NODE**

=

**lno**

,

**[l\_noeud]**

/

**GROUP\_NO**

=

**lgn0**

,

**[l\_gr\_noeud]**

/

**NET**

= **lma**

,

**[l\_maille]**

/

**GROUP\_MA**

=

**lgma**

,

**[l\_gr\_maille]**

**/ TEMP =**

**T**

,

**[R]**



*/ TEMP\_SUP*  
*= tsup*  
,  
*[R]*

*/ TEMP\_INF*  
*= tinf*  
,  
*[R]*

), ),

.  
*for AFFE\_CHAR\_CINE\_F*

*/THER\_IMPO = (\_F (*  
*/*  
*ALL*  
*=*  
*“YES”*  
,  
*/*  
*/*  
*NODE*  
*=*

*lno*  
,  
[*l\_noeud*]  
/  
*GROUP\_NO*  
=  
*lgn*  
,  
[*l\_gr\_noeud*]

/  
*NET*  
= *lma*  
,  
[*l\_maille*]

/  
*GROUP\_MA*  
=  
*lgma*  
,  
[*l\_gr\_maille*]

/  
*TEMP =*  
*ft*  
,  
[*function (\*)*]

/

*TEMP\_SUP*

= *ftsup*

,  
[function (\*)]

/ *TEMP\_INF*

= *ftinf*

,  
[function (\*)]

), )

*function (\*)*: function or formula

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### **4.5.3 Operands**

/  
**TEMP**

*Temperature imposed on the nodes (or on the average layer for the thermal hulls)*

/  
**TEMP\_INF**

*Temperature imposed on the lower face for the thermal elements of hulls.*

/  
**TEMP\_SUP**

*Temperature imposed on the higher face for the thermal elements of hulls.*

*For the hulls, the faces lower and higher are defined, mesh by mesh, the direction normal external deduced from classification of the nodes: to see FACE\_IMPO of AFFE\_CHAR\_MECA [U4.44.01].*

## **4.6 Word**

**key**

**ACOU\_IMPO**

### **4.6.1 Drank**

*Key word factor usable to impose, with nodes or groups of nodes, a value of acoustic pressure.*

*These boundary conditions will be treated, thereafter, by the method known as of elimination of the degrees of freedom imposed (i.e.: without dualisation contrary to the treatment of the same type of condition limit by the use of operator AFFE\_CHAR\_ACOU [U4.44.04]).*

### **4.6.2 Syntax**

.  
 For AFFE\_CHAR\_CINE

/ACOU\_IMPO = (\_F (

/  
**ALL**

=  
**“YES”**

,  
/  
/  
*NODE*  
=  
*lno*  
,  
[*l\_noeud*]  
/  
*GROUP\_NO*  
=  
*lgnno*  
,  
[*l\_gr\_noeud*]

/  
*NET*  
= *lma*  
,  
[*l\_maille*]

/  
*GROUP\_MA*  
=  
*lgma*  
,  
[*l\_gr\_maille*]

*NEAR*  
=  
*p*  
,  
[*C*]

), ),

.

*For AFFE\_CHAR\_CINE\_F*

*No key word ACOU\_IMPO because it does not have yet a complex function there.*

### **4.6.3 Operands**

*NEAR*

*Value of the acoustic pressure complexes imposed on (S) the node (S) specified (S).*

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## **5 Examples**

### **5.1**

***Degrees of freedom imposed in mechanics***

***chcine = AFFE\_CHAR\_CINE***

***(MODEL = Mo,***

***MECA\_IMPO= (\_F***

***(ALL = "YES"***

***, DRZ = 0.),***

**\_F**  
**(GROUP\_NO = "bord1", DX = 0. ,**  
**DY = 0. ,**  
**DZ =**  
**0.,**  
**DRX**  
**=**  
**0.,**  
**DRY = 0. ,)))**

*For this problem of plate in plan XY, one blocks all the degrees of freedom of rotation around of Z and one embeds the plate on his edge bord1.*

**5.2**  
**Compared use of the loads kinematics and "ordinary"**

**5.2.1 Orders**

**total**

**ch1**

**= AFFE\_CHAR\_THER**

**( ... )**

**ch2**

**=**

**AFFE\_CHAR\_CINE\_F**

**(TEMP\_IMPO =**

**\_F (...))**

**evoth = THER\_LINEAIRE**

**(**

**...**

**EXCIT**

**=**

**(**

**\_F**

**(LOAD**

**=**

**ch1),**

**\_F**

**(LOAD**  
=  
**ch2),)**  
...)

***There is no difference.***

## **5.2.2 Calculation “step by step”**

### ***Ordinary loads***

***ch1***

= *AFFE\_CHAR\_MECA* (...)  
*mel*

= *CALC\_MATR\_ELEM* (... *OPTION* = “*RIGI\_MECA*”, *LOAD* = *ch1*)

*subdued* = *ASSE\_MATRICE* (  
*MATR\_ELEM* = *mel*...)

*subdued* = *FACT\_LDLT* (*reuse* = *subdued*, *MATR\_ASSE* = *subdued*)

*U*  
= *RESO\_LDLT* (*MATR\_FACT* = *subdued*, *CHAM\_NO* = *F*)

### ***Loads kinematics***

***ch1***

= *AFFE\_CHAR\_CINE* (...)  
*mel*

= *CALC\_MATR\_ELEM* (... *OPTION* = “*RIGI\_MECA*”)

*subdued* = *ASSE\_MATRICE* (  
*MATR\_ELEM* = *mel*,..., *CHAR\_CINE* = *ch1*)

*subdued* = *FACT\_LDLT* (*reuse* = *subdued*, *MATR\_ASSE* = *subdued*,)

*vcine* = *CALC\_CHAR\_CINE* (... , *CHAR\_CINE* = *ch2*,)

*U*  
= *RESO\_LDLT* (*MATR\_FACT* = *subdued*, *CHAM\_NO* = *F*,  
*CHAM\_CINE*  
=



*vcine)*

*The terms induced by the loads kinematics are deferred to the second member what requires it calculation of an additional field to the nodes vcine by order CALC\_CHAR\_CINE [U4.61.03].*

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## ***Operator AFFE\_CHAR\_ACOU***

### ***1 Goal***

***To affect boundary conditions acoustic constant. The affected values do not depend of any parameter and are complex values.***

***Product a structure of data of the char\_acou type.***

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### ***2 Syntax***

***CH [char\_acou] = AFFE\_CHAR\_ACOU***

***(***

***MODEL***

=

**Mo**

**[model]**

**VERI\_DDL**

=

/

**“YES” [DEFECT]**

/

**“NOT”**

**I PRES\_IMPO**

= **F (**

**I**

**ALL = “YES”**

**I**

**NODE**

= **lno**

**[l\_noeud]**

**I**

**GROUP\_NO = lgn**

**[l\_gr\_noeud]**

***I***  
***NET***  
=  
***lma [l\_maille]***

***I***  
***GROUP\_MA = lma***  
***[l\_gr\_maille]***

***NEAR***  
=  
***pre***  
***[C]***

)

***I VITE\_FACE***

***= \_F (***

***/***

***ALL = "YES"***

***/***

***NET***

***=***

***lma [l\_maille]***

***/***

***GROUP\_MA = l<sub>g</sub>ma***

***[l<sub>gr</sub>\_maille]***

***VNOR***

***=***

***vn***

***[C]***

)

***I IMPE\_FACE***

***= \_F (***

***/***

***ALL = "YES"***

***/***

***NET***

***=***

***lma [l\_maille]***

***/***

***GROUP\_MA = lgamma***

***[l\_gr\_maille]***

**IMPE**

=

**Z**

**[C]**

)

**I LIAISON\_UNIF=**

**\_F (**

/

**NODE**

**= lno**

**[l\_noeud]**

/

**GROUP\_NO = lgrno**

**[l\_gr\_noeud]**

/  
**NET**  
=  
**lma [l\_maille]**

/  
**GROUP\_MA = lgma**  
**[l\_gr\_maille]**

**DDL**  
=  
**“CLOSE”**

)  
);

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Operator *AFFE\_CHAR\_ACOU*

Date:

20/12/04

Author (S):

**NR. GREFFET, F. STIFKENS** Key

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### **3 Operands**

#### **3.1 Operand**

**MODEL**

**MODEL = Mo**

*Name of the model whose grid supports the elements of acoustic calculation.*

#### **3.2 Operand**

**VERI\_DDL**

**VERI\_DDL =/“YES”**

/

**“NOT”**

*Allows to check that the DDLs goods are well presented, i.e. here the DDL “CLOSE” (cf [§3.4]).*

#### **3.3 Words**

keys

**PRES\_IMPO/VITE\_FACE/IMPE\_FACE**

##### **3.3.1 Drank**

*Key words factors giving it natural of the conditions imposed on the specified elements (nodes, or*

*groups of nodes, meshes or groups of meshes).*

***I  
PRES\_IMPO***

*Allows to impose the DDL of pressure.*

***I VITE\_FACE***

*Allows to specify the vibratory field speed imposed in loading on elements of border.*

***I IMPE\_FACE***

*Allows to specify the chart of impedance imposed in boundary condition on elements of border.*

### ***3.3.2 Operands***

***ALL/NODE/GROUP\_NO/MESH/GROUP\_MA***

*Declaration of the topological entities to which the loadings are applied, conditions with limits.*

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### 3.3.3 Operands

#### ***CLOSE/VNOR/IMPE***

***CLOSE = pre***

***Value (complex) of the acoustic DDL of pressure (only DDL in acoustic modeling) imposed on the nodes or groups of specified nodes.***

***VNOR = vn***

***Value (complex) of the component on the normal external with the meshes or groups of meshes specified, the vibratory speed of the fluid.***

***IMPE = Z***

***Value (complex) of the acoustic impedance imposed on the meshes or groups of meshes specified.***

### 3.4 Word

***key***

***LIAISON\_UNIF***

#### 3.4.1 Drank

***Key word factor allowing to impose the same value (unknown) on degrees of freedom of one together of nodes.***

#### 3.4.2 Operands

***NET/GROUP\_MA/NODE/GROUP\_NO***

***These operands make it possible to define a list of N nodes Nor from which one eliminated the redundancies (for MESH and GROUP\_MA, they are connectivities of the meshes).***

#### 3.4.3 DDL

***This operand can be worth in acoustic modeling, only the text “CLOSE”, defining only degree of freedom allowed, acoustic pressure p.***

***The resulting imposed conditions are:***

***$(p_{N1}) = (p_N)$  for  $I \{2, \dots, \} N$***

**I**

#### **4 Example**

```
cha = AFFE_CHAR_ACOU (MODEL = Mo,  
VITE_FACE  
=  
_F (  
NET  
=  
m4  
,  
VNOR = ("IH", 0.0135, 0. )),  
IMPE_FACE  
=  
_F (  
NET  
=  
m5  
,  
IMPE = ("IH", 442. , 0. )))
```

**Note:**

**The complex values are provided under one of two forms IH (left real, left imaginary) or MP (module, phase in degrees).**

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***:***

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***Organization (S): EDF-R & D /AMA***

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***Operator AFFE\_CHAR\_MECA\_C***

***1 Goal***

***To affect loadings and boundary conditions mechanical of complex type.***

***This operator supplements operators AFFE\_CHAR\_MECA and AFFE\_CHAR\_MECA\_F [U4.44.01] which***

***allow to affect loadings and boundary conditions mechanical of real type.***

***This operator must be used, at the time of a harmonic study (operator DYNA\_LINE\_HARM [U4.53.11]),***

*to impose different dephasings, either between each element of the model, or between various degrees of freedom within the same element.*

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*2 Syntax*

*general*

*CH [char\_meca] = AFFE\_CHAR\_MECA\_C*

*(MODELE= Mo,*

*[model]*

*/*

*DDL\_IMPO = \_F*

*(see*

*key word DDL\_IMPO*

*[\$ 3.4])*

/  
**LIAISON\_DDL = \_F** (*see*  
*key word LIAISON\_DDL* [§ 3.5])

/  
**FORCE\_POUTRE = \_F**  
(*see key word FORCE\_POUTRE* [§ 3.6])

**INFORMATION**

=  
/  
**1,**  
**[DEFECT]**

/ **2,**

**VERI\_DDL**  
= /  
**“YES”,**  
**[DEFECT]**

*/“NOT”,*

)

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*3 Operands*

*3.1*

*General information on the operands*

*3.1.1 Two categories of operands*

*The operands under a key word factor are of two forms:*

*.*

*operands specifying the geometrical entities on which are affected them  
loadings (key words GROUP\_NO, GROUP\_MA, etc...),*

*.*



*operands specifying the affected values (DX, DY, etc...). Arguments of these operands all are of the complex type.*

*This is true near with an exception: the argument of COEF\_MULT for the key word factor LIAISON\_DDL is obligatorily of real type.*

### *3.1.2 Designation of the topological entities of assignment of the loadings*

*In a general way, the entities on which values must be affected are defined:*

*.  
on all the grid by the operand ALL = "YES"*

*.  
by node and in this case:*

*- is by operand GROUP\_NO allowing to introduce a list of groups of nodes,*

*-  
maybe by the operand NODE allowing to introduce a list of nodes.*

*.  
by mesh and in this case:*

*- is  
by  
GROUP\_MA allowing to introduce a list of groups of meshes,*

*- is  
by  
NET allowing to introduce a list of meshes.*

### *3.1.3 Regulate of overload*

*To define the field of assignment most simply possible, the rule of overload is used defined in the document "Course of a study with Aster ":  
it is the last assignment which precedes.*

## *3.2 Operand MODEL*

*MODEL  
= Mo*

*Concept produced by operator AFFE\_MODELE [U4.41.01] where the types of elements are defined*

*stop affected on the grid.*

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*3.3 Operand*

*INFORMATION*

*INFORMATION*

*=*

*Level of the impressions on the file "MESSAGE"*

*1 :*

*nothing*

*2 :*

*nothing*

*3.4 Word*

*key*

*DDL\_IMPO*

*3.4.1 Drank*

*Key word factor usable to impose, with nodes or groups of nodes or nodes of meshes or of groups of meshes, one or more values of displacement (or some*

*associated sizes*).

### 3.4.2 Syntax

```
/  
DDL_IMPO  
=  
_F  
(  
/  
TOUT=  
“YES”,
```

```
// NOEUD=  
lno  
, [l_noeud]
```

```
/ GROUP_NO=  
lgn,  
[l_gr_noeud]
```

**/ GROUP\_MA=**

**lgma,**

**[l\_gr\_maille]**

**/**

**NET =**

**my,**

**[l\_maille]**

**/ DX=**

**ux,**

**[C]**

**/ DY=**

**uy,**

**[C]**

***/DZ=***  
***zu,***

***[C]***

***/DRX= theta\_x, [C]***

***/DRY= theta\_y, [C]***

***/DRZ= theta\_z, [C]***

**/ GRX= G,  
[C]**

**/ PRES=  
p,  
[C]**

**/ PHI= phi, [C]**

)  
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### **3.4.3 Operands: choice of the degree of freedom**

**/DDL\_IMPO**

**All the specified values are defined in the TOTAL reference mark of definition of the grid.**

**$DX = ux$**

**Value of the component of displacement in imposed translation**

**$DY = uy$**

**on the specified nodes**

**$DZ = uz$**

**Only if the specified nodes belong to discrete elements of translation - rotation and of beam:**

**$DRX = \theta_x$**

**Value of the component of displacement in rotation imposed on**

**$DRY = \theta_y$**

**specified nodes**

**$DRZ = \theta_z$**

**Only if the specified nodes belong to elements of beam "POU\_D\_TG":**

**$GRX = G$**

**Value of the warping of the beam**

**Only if the specified nodes belong to elements fluid or fluid structure:**

**$PRES = p$**

**Acoustic pressure in the fluid (modeling "3D\_FLUIDE")**

**$PHI = \phi$**

**Potential of displacements of the fluid (modelings "3D\_FLUIDE" and "FLUI\_STRU")**

**Only if the specified nodes belong to elements of free face:**

**$DZ = uz$**

**Imposed displacement of the free face (modeling**

**“2D\_FLUI\_PESA”**

***PHI = phi***

***Potential of displacements of the fluid (modeling***

**“2D\_FLUI\_PESA”**

### **3.4.4 Checks and recommendations**

***It is checked that the specified ddl exists in this node for the elements affected in the MODEL to meshes which contain the node.***

***However, if the same boundary condition is specified twice by two calls to AFFE\_CHAR\_MECA\_C (for example, with two values of imposed displacement), that led to one singular matrix.***

***If it is specified twice (or more) in only one call to AFFE\_CHAR\_MECA\_C, the rule of overload applies and a message of alarm (indicating the overload) is transmitted.***

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### **3.5 Word**

***key***

***LIAISON\_DDL***

#### **3.5.1 Drank**

***Key word factor usable to define a linear relation between degrees of freedom of two or***



*several nodes.*

### 3.5.2 Syntax

**LIAISON\_DDL = \_F (**

**/**

**NODE**

**= lno,**

**[l\_noeud]**

**/**

**GROUP\_NO**

**= lgrno,**

**[l\_gr\_noeud]**

**DDL=**

**/ "DX",**

**/ "DY",**

**/ "DZ",**

/ “DRX”,

/ “DRY”,

/ “DRZ”,

/ ...

*COEF\_MULT*

=

*alpha<sub>i</sub>, [l\_R]*

*COEF\_IMPO*

=

*beta, [C]*

)

### **3.5.3 Operands**

***GROUP\_NO or NODE: list nodes NR (I***

***R***

***I***

***= 1,) ordered in a natural way:***

.

***in the order of the list of groups of nodes, and for each group of nodes,  
in the order of definition of the group by GROUP\_NO,***

.

***in the order of the list of nodes for NODE.***

***DDL: list ddl U (I***

***R***

***I***

***= 1,) of R texts taken among:***

***“DX”,***

***“DY”,***

***“DZ”,***

***“DRX”,***

**“DRY”,**  
**“DRZ”**

**COEF\_MULT: list alpha (I**

**R**  
**I**  
**= 1,) of coefficients of the real type.**

**COEF\_IMPO: coefficient beta of the complex type.**

**R**  
**The following kinematic condition will be applied: alpha U = beta**

**I**  
**I**

**I = 1**

### **3.5.4 Precautions of use**

#### **3.5.4.1 Components in rotation**

**The components of displacement in rotation DRX, DRY, DRZ can intervene only in combinations only assigned to nodes which belong to elements discrete or of beam (see DDL\_IMPO).**

#### **Linear 3.5.4.2 Relation between the ddl of the same node**

**In this particular case, one will as many repeat behind the key word NODE the name of the node time as it**

**y has ddl in the relation. Example: to impose  $U = U$**

**X**  
**y on the node N1, one will write:**

**LIAISON\_DDL = \_F (NODE**

**= (“N1”, “N1”),**

**DDL**

**=**

**(“DX”**

**“DY”),**

**COEF\_MULT**

**=**

**(1., -1.),**

**COEF\_IMPO**

**=**

**(IH**

0.,  
0.),

)  
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### **Linear 3.5.4.3 Relation between groups of nodes**

**It is important to note that to an occurrence of the key word factor *LIAISON\_DDL* one corresponds and only one linear relation.**

**If one wants to impose the same relation between 2 groups of nodes *GRN01* and *GRN02* (even displacement *Ux* node with node for example) one cannot write:**

***LIAISON\_DDL* = *\_F* (*GROUP\_NO* = (“*GRN01*”, “*GRN02*”),  
*DDL*  
=  
 (“*DX*”,  
 “*DX*”),  
*COEF\_MULT***

=  
 (1.,  
 -1.),  
**COEF\_IMPO**

=  
 (**IH**  
 0.,  
 0.)  
 , )

*This writing has direction only if GRNO1 and GRNO2 contain each one one node. It will be necessary in the case to above clarify each linear relation, node by node.*

### **3.6 Word**

*key*

**FORCE\_POUTRE**

#### **3.6.1 Drank**

*Key word factor usable to apply linear forces, to elements of the beam type (POU\_D\_T\_, POU\_D\_E,...) defined on all the grid or one or more meshes or of the groups meshes. The forces are definite component by component, either in the TOTAL reference mark, or in the local reference mark of the element defined by operator AFFE\_CARA\_ELEM [U4.42.01].*

#### **3.6.2 Syntax**

**FORCE\_POUTRE**

=\_F

(

/

**ALL**

=

**“YES”**,

// **MESH**

=

*lma,*  
*[l\_maille]*

*/GROUP\_MA*

=

*lgma,*  
*[l\_gr\_maille]*

*//FX*

=

*fx,*

*[C]*

*/FY*

=

*fy,*

*[C]*

**/ FZ**  
=  
**fz,**

**[C]**

/  
**/ NR**  
=  
**N,**  
**[C]**

**/ VY**  
=  
**vy,**

**[C]**



**/ VZ**

**=**

**vz,**

**[C]**

**TYPE\_CHARGE**

**=**

**/"FORCE", [DEFECT]**

**/**

**"WIND"**

**)**

### **3.6.3 Operands: forces**

//fx:  
*Force according to X*

[C]

/fy  
:  
*Force according to Y*

[C]

/fz  
:  
*Force according to Z*

[C]

/  
/N:  
*Effort of traction and compression*

[C]

/vy  
:  
*Following transverse effort*

Y  
[C]

/ vz  
:  
*Following transverse effort*  
Z  
[C]

*Let us note that one must remain homogeneous in each occurrence of the key word factor FORCE\_POUTRE: either all the components are defined in the TOTAL reference mark or all them components are defined in the reference mark of definition of the beam.*

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### ***3.6.4 Modelings and meshes***

***This loading applies to the types of meshes and following modelings:***

***Net Modélisation***  
***SEG2 POU\_D\_T,***  
***POU\_C\_T,***  
***POU\_D\_E***

*This loading is not currently available for modeling POU\_D\_TG.*

### **3.6.5 Operand**

**TYPE\_CHARGE**

**TYPE\_CHARGE**

=

**/“FORCE”,**

**/“WIND”,**

*If the excitation exerted on the element of beam is due to the wind, it is then regarded as following.*

### **3.7 Operand**

**VERI\_DDL**

**VERI\_DDL**

**=/“YES”,**

**/“NOT”,**

*Checking which DDLs specified exist well with the specified nodes of the elements affected in the model.*

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*Operator CREA\_RESU*

*Date:*

31/01/06

*Author (S):*

**J.P. LEFEBVRE, L. VIVAN** *Key*

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*Organization (S): EDF-R & D /AMA, CS IF*

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***Document: U4.44.12***

***Operator CREA\_RESU***

***1 Goal***

***To create or enrich a structure of data result starting from fields with the nodes. Assignment***

*possible of the fields to the nodes for various sequence numbers.*

*The assignment via a cham\_no of function produces by AFFE\_CHAM\_NO [U4.44.11] be carried out by evaluating each function using the parameter representing the time provided under key words LIST\_INST or INST.*

*The concept produced by this operator is, for the moment, of type evol\_elas, evol\_noli, evol\_ther, mult\_elas or fourier\_elas.*

*Moreover, three particular functionalities are accessible in this operator:*

*.  
the creation of a concept of the type EVOL\_CHAR by assignment of field or a formula analytical*

*.  
the creation of a concept result simulating the reorganization of the assemblies fuels,*

*.  
the projection of a thermal transient 1D on an axisymmetric grid 3D.*

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*2 Syntax*

*resu [result] = CREA\_RESU (*

*reuse = resu,*

*OPERATION =/"AFFE",*

*/"ECLA\_PG",*

*/*

*"PERM\_CHAM"*

*,*

*/*

*"PROL\_RTZ"*

*,*

*/# Construction of a result by assignments or evaluations successive  
# of cham\_no: (OPERATION: "AFFE")*

*/TYPE\_RESU*

*= "MULT\_ELAS"*

*,*

*NOM\_CHAM = "DEPL",*

*AFFE = \_F (CHAM\_GD = chno,  
[cham\_no\_DEPL\_R]*

*NOM\_CAS = nomc,  
[KN]*

),

*/TYPE\_RESU*

= /

*“EVOL\_ELAS”*

,

*/“EVOL\_NOLI”*,

*NOM\_CHAM = “DEPL”*,

*AFFE = \_F (CHAM\_GD = chno,  
[cham\_no\_DEPL\_R]*

*MODEL*

=

*Mo,*

*[model]*

*CHAM\_MATER =*

*chmat,*

*[cham\_mater]*



***CARA\_ELEM***

=

***carac,***

***[cara\_elem]***

***/INST = linst,***

***[l\_R8]***

/

***LIST\_INST =***

***litps,***

***[listr8]***

***NUME\_INIT =***

***numi,***

***[I]***

**NUME\_FIN = numf,**  
**[I]**

/  
**PRECISION =**  
**/prec,**  
**[R]**  
**/1.0D-3,**  
**[DEFECT]**

/  
**CRITERION**  
**= “RELATIVE”,**  
**[DEFECT]**  
**/“ABSOLUTE”,**

),

***/TYPE\_RESU***  
***= "FOURIER\_ELAS",***

***NOM\_CHAM = "DEPL",***

***AFFE = \_F (CHAM\_GD = chno,***  
***[cham\_no\_DEPL\_R]***

***MODEL***  
***=***  
***Mo,***  
***[model]***

***CHAM\_MATER =***  
***chmat,***  
***[cham\_mater]***

***CARA\_ELEM***

=

***carac,***

***[cara\_elem]***

***NUME\_MODE***

=

***num,***

***[I]***

***TYPE\_MODE***

=

***/"SYME",***

***[DEFECT]***

***/"ANTI",***

***/"ALL",***

***),***

***/TYPE\_RESU***

***= "EVOL\_THER",***

***NOM\_CHAM =***  
***/“TEMP”,***

***/***  
***“HYDR\_ELGA”,***

***AFFE = \_F (CHAM\_GD = chno,***  
***[cham\_no\_TEMP\_R]***

***MODEL***  
***=***  
***Mo,***  
***[model]***

***CHAM\_MATER =***  
***chmat,***  
***[cham\_mater]***

***CARA\_ELEM***

=

***carac,***

***[cara\_elem]***

***/INST = linst,***

***[l\_R8]***

/

***LIST\_INST =***

***litps,***

***[litr8]***

***NUME\_INIT =***

***numi,***

***[I]***

*NUME\_FIN = numf,*  
*[I]*  
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*Code\_Aster* ®  
*Version*  
*8.2*

*Titrate:*  
*Operator CREA\_RESU*

*Date:*  
*31/01/06*  
*Author (S):*  
*J.P. LEFEBVRE, L. VIVAN Key*  
*:*  
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*/*  
*PRECISION =*  
*/prec,*  
*[R]*  
*/1.0D-3,*  
*[DEFECT]*

/  
**CRITERION**

=  
/“**RELATIVE**”,  
[**DEFECT**]

/“**ABSOLUTE**”,

)

/**TYPE\_RESU**  
= “**EVOL\_VARC**”,

**NOM\_CHAM** =  
“**IRRA**”,

**AFFE** = **\_F** (**CHAM\_GD** = *chno*,  
[*cham\_no\_IRRA\_R*]

**MODEL**  
=  
**Mo**,



**[model]**

**CHAM\_MATER =**  
**chmat,**  
**[cham\_mater]**

**CARA\_ELEM**  
**=**  
**carac,**  
**[cara\_elem]**

**/INST = linst,**  
**[l\_R8]**

**/**  
**LIST\_INST =**  
**litps,**  
**[listr8]**

*NUME\_INIT =  
numi,  
[I]*

*NUME\_FIN = numf,  
[I]*

*/PRECISION = /prec,  
[R]  
/1.0D-3,  
[DEFECT]*

***/CRITERION  
=/"RELATIVE",  
[DEFECT]***

***/"ABSOLUTE",***

***),***

***/# Construction of a concept of the type EVOL\_CHAR by assignment or  
evaluation of a cham\_no***

***/TYPE\_RESU  
= "EVOL\_CHAR"***

***,***

***NOM\_CHAM = "CLOSE",***

***AFFE = \_F (CHAM\_GD = chno,  
[cham\_no\_PRES\_R]***

***MODEL  
=  
Mo,  
[model]***

**CHAM\_MATER =**  
**chmat,**  
**[cham\_mater]**

**/INST = linst,**  
**[l\_R8]**

**/**  
**LIST\_INST =**  
**litps,**  
**[listr8]**

**NUME\_INIT =**  
**numi,**  
**[I]**

*NUME\_FIN = numf,*  
*[I]*

*/*  
*PRECISION =*  
*/prec,*  
*[R]*  
*/1.0D-3,*  
*[DEFECT]*

*/*  
*CRITERION*  
*=*  
*/"RELATIVE",*  
*[DEFECT]*

*/"ABSOLUTE",*

)

***/# Construction of a result on a grid burst for visualization or  
# postprocessing (OPERATION: "ECLA\_PG")***

***TYPE\_RESU***

***=***

***/***

***"EVOL\_ELAS"***

***,***

***/"EVOL\_NOLI"***

***,***

***/"EVOL\_THER"***

***,***

***ECLA\_PG = \_F (... to see [U4.44.14]***

***),***

***/# Construction of a result dedicated to the fuel assemblies  
# (OPERATION: "PERM\_CHAM")***

***TYPE\_RESU***

***=***

***"EVOL\_NOLI",***

***NOM\_CHAM = / "DEPL",***

***/***

***"SIEF\_ELGA"***

***,***

***/***

***"VARI\_ELGA"***

***,***

***RESU\_INIT***

***=***

***resu\_2, [evol\_noli]***

**INST\_INIT**

**= tf,**

**[R]**

**PRECISION =/prec,**

**/**

**1.0E-3,**

**[DEFECT]**

**CRITERION =**

**/“ABSOLUTE”,**

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**/**

**“RELATIVE”**

**,**

**MAILLAGE\_INIT = ma\_1, [grid]**

**RESU\_FINAL = resu, [evol\_noli]**

**MAILLAGE\_FINAL = mo\_2, [grid]**

**PERM\_CHAM =\_F (GROUP\_MA\_FINAL =**

*gma\_2, [gr\_ma]*  
*GROUP\_MA\_INIT =*  
*gma\_1,*  
*[gr\_ma]*  
*TRAN =*  
*(tx, ty, tz),*  
*[l\_R]*

*PRECISION =/prec,*  
*/*  
*1.0E-3,*  
*[DEFECT]*

*),*

*)*

*/# Projection of a transient 1D on an axisymmetric grid*  
*# (OPERATION = "PROL\_RTZ")*

*TYPE\_RESU*  
*=*  
*"EVOL\_THER"*

*PROL\_RTZ=\_F (*  
*MAILLAGE\_FINAL = ma\_3D,*  
*[grid]*  
*COUNT*



=  
*post\_ID*,  
[*table*]  
/INST = *inst*,  
[*R*]  
/  
LIST\_INST  
=  
*linst*,  
[*l\_R*]

**PRECISION**

=/prec,  
/  
1.0E-6,  
[DEFECT]

**CRITERION**

=  
/  
"ABSOLUTE",  
/  
"RELATIVE",  
[DEFECT]

**PROL\_DROITE**  
=/"EXCLUDED",

**[DEFECT]**

/

**"LINEAR",**

/

**"CONSTANT",**

**PROL\_GAUCHE**  
=/"EXCLUDED",

**[DEFECT]**

/

**"LINEAR",**

/

**"CONSTANT",**

**LOCATE**

= "CYLINDRICAL",  
**ORIGIN = (ori1, ori2, ori3), [l\_R]**

**AXE\_Z**  
= (axe1, axe2, axe3),  
**[l\_R]**

),

)

**If TYPE\_RESU:**  
**“MULT\_ELAS”**

*then resu of the mult\_elas type*

**If TYPE\_RESU:**  
**“FOURIER\_ELAS”**

*then resu of the fourier\_elas type*

**If TYPE\_RESU:**  
**“EVOL\_THER”**

*then resu of the evol\_ther type*

**If TYPE\_RESU:**  
**“EVOL\_VARC”**

*then resu of the evol\_varc type*

**If TYPE\_RESU:**  
**“EVOL\_ELAS”**

*then resu of the evol\_elas type*

**If TYPE\_RESU:**  
**“EVOL\_NOLI”**

*then resu of the evol\_noli type*

**If TYPE\_RESU:**  
**“EVOL\_CHAR”**

*then resu of the evol\_char type*

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### **3 Operands**

#### **3.1 Operand**

##### **OPERATION**

**OPERATION = defines the type of operation to be carried out with this operator:**

**“AFFE”**

**: creation of a structure of data result starting from fields,**

**“ECLA\_PG”:** creation of a structure of data on a grid burst for visualization,

**“PERM\_CHAM”:** reorganization of the fuel assemblies,

**“PROL\_RTZ”:** prolongation of a field 1D on an axisymmetric structure.

**This key word makes it possible to guide the user during the construction of the command file using the tool *eficas*.**

**The structure of data result is *réentrante* and for OPERATION = AFFE the fields existing can be replaced according to the values of the variable of access INST by using them values indicated behind the key words PRECISION and CRITERION. When there is replacement of an existing field, the code transmits a message of alarm, if not the fields are stored at the end structure of data.**

#### **3.2 Operand**

##### **TYPE\_RESU**

**TYPE\_RESU:** Type of the structure of data result created.

#### **3.3 Operand**

##### **NOM\_CHAM**

**NOM\_CHAM:** Reference symbol of the affected size.

#### **3.4 Word**

**key**

## **CHAM\_GD**

### **3.4.1 Operand**

#### **CHAM\_NO**

**CHAM\_NO = chno**

*chno is a cham\_no of function created by order AFFE\_CHAM\_NO [U4.44.11] and in this case one evaluates for each node the function and each moment defined behind LIST\_INST or INST one creates a cham\_no realities, or chno is a cham\_no realities created by the order AFFE\_CHAM\_NO or RECU\_CHAMP and it field is as many duplicated once as the list of moments defined behind LIST\_INST or INST it require.*

### **3.4.2 Operands**

**MODEL, CHAM\_MATER, CARA\_ELEM**

*These operands optional are used to allow the filling of the structures of data result. This filling is essential if order CREA\_RESU is called by MACRO\_ELAS\_MULT to then use the orders of postprocessing which will seek this information in the SD.*

**MODEL = Mo,**

*Name of the model whose elements are the subject of calculation.*

**CHAM\_MATER = chmat,**

*Name of the material field.*

**CARA\_ELEM = carac,**

*Name of the characteristics of the structural elements (beam, hull, discrete,...) if they are used in the model.*

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### **3.4.3 Operands**

**LIST\_INST/NUME\_INIT/NUME\_FIN**

**/**

**LIST\_INST = litps**

**List realities produced by DEFI\_LIST\_REEL [U4.34.01].**

**NUME\_INIT = nuini**

**NUME\_FIN =**

**nufin**

**The moments of calculation are those defined in the concept litps taken between the nuini and it nufin number of moment. In the absence of key word NUME\_FIN, it is the size of the list of realities who is taken into account.**

### **3.4.4 Operands**

**INST**

**/**

**INST = linst**

**List realities: list moments for which the cham\_no of function will be evaluated, or well the cham\_no of realities will be affected.**

**Note:**

**The sequence number created in the concept result is is recovered starting from the value variable of access INST when it is present, is affected with the maximum value**

*immediately above.*

### **3.4.5 Operands**

#### **PRECISION/CRITERION**

*These operands make it possible to refine the access by real variables of access of time.*

#### **I PRECISION**

=

/

*prec*

[*R*]

/

**1.0D-3**

*or*

**1.0D-6**

[**DEFECT**]

*This key word makes it possible to indicate that one seeks all the fields of which the moment (respectively frequency) is in the interval “ $inst \pm prec$ ” (cf **CRITERION**).*

*By defect  $prec = 1.0D-3$ .*

#### **I CRITERION**

=

/

**“RELATIVE”**

[**DEFECT**]

/

**“ABSOLUTE”**

**“RELATIVE”**: *the interval of research is: [ $inst (1 - prec)$ ,  $inst (1 + prec)$ ]*

**“ABSOLUTE”**: *the interval of research is: [ $inst - prec$ ,  $inst + prec$ ].*

### **3.4.6 Operands**

#### **NUME\_MODE/TYPE\_MODE**

**NUME\_MODE** = *num*

*Entirety indicating the number of the harmonic of Fourier of the field stored in a concept of the type **fourier\_elas**.*

***TYPE\_MODE =/"SYME"***

***/***

***"ANTI"***

***/***

***"ALL"***

***The type of the mode of stored Fourier defines.***

***"SYME": symmetrical harmonic***

***"ANTI": antisymmetric harmonic***

***"ALL": symmetrical and antisymmetric harmonic***

### ***3.4.7 Operand***

***NOM\_CAS***

***NOM\_CAS = nomc***

***Character string defining the variable of access of the field stored in a concept of the type mult\_elas.***

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***4***

***Operands associated with the fields at the points with integration***

### ***4.1 Word***



**key**  
**ECLA\_PG**

*See [U4.44.14].*

**5**  
**Operands associated with the fuel assemblies**

### **5.1 Operands**

**RESU\_INIT**

**RESU\_INIT =**

*Name of the SD evol\_noli containing the fields to be transferred on the new grid.*

### **5.2 Operands INST\_INIT/PRECISION/CRITERE**

**INST\_INIT =**

*Moment characterizing in the SD evol\_noli indicated under RESU\_INIT, the fields to be transferred on the other grid. By defect, the last filed moment is selected*

**PRECISION =**

*Precision used to seek the moment specified by INST\_INIT in the SD evol\_noli associated RESU\_INIT.*

**CRITERION**

**=**

**/**

**“RELATIVE”**

**[DEFECT]**

**/**

**“ABSOLUTE”**

*Criterion used to seek the moment specified by INST\_INIT in the associated SD evol\_noli with RESU\_INIT.*

### **5.3 Operands**

**MAILLAGE\_INIT**

**MAILLAGE\_INIT =**

*Name of the grid on which the SD evol\_noli indicated under RESU\_INIT was defined.*

#### **5.4 Operands**

**RESU\_FINAL**

**RESU\_FINAL = resu**

*Name of the SD evol\_noli definite on the new grid on which they will be transferred fields. It is also in this case the name of the outgoing concept of order CREA\_RESU. structure of data resu must exist (it will have been created for example by the order STAT\_NON\_LINE) and should contain one sequence number.*

#### **5.5 Operands**

**MAILLAGE\_FINAL**

**MAILLAGE\_FINAL =**

*Name of the structure of data grid created on the new grid on which will be to transfer the fields.*

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#### **5.6 Word**

**key**

**PERM\_CHAM**

#### **5.6.1 Operands**

## ***GROUP\_MA\_FINAL***

***GROUP\_MA\_FINAL = gma\_2***

***Name of the group of meshes of the MAILLAGE\_FINAL, place where the fields are transferred in RESU\_FINAL.***

### ***5.6.2 Operands***

#### ***GROUP\_MA\_INIT***

***GROUP\_MA\_INIT = gma\_1***

***Name of the grid on which the SD evol\_noli indicated under RESU\_INIT was defined.***

### ***5.6.3 Operand***

#### ***TRAN***

***TRAN = (tx, ty, tz)***

***Vector translation allowing to obtain GROUP\_MA\_FINAL geometrically from GROUP\_MA\_INIT.***

### ***5.6.4 Operand***

#### ***PRECISION***

***PRECISION = prec***

***Absolute precision making it possible to check the good adequacy enters the initial meshes and them final meshes, by defect the value is fixed at 10-3.***

## ***6 Operands associated with projection on a grid axisymmetric***

### ***6.1 Word***

#### ***key***

#### ***PROL\_RTZ***

***Construction of a thermal transient on an axisymmetric grid (3D) starting from the data of one thermal transient calculated on a grid 1D. The transient 1D is given in the form of one structure of data COUNTS resulting from order POST\_RELEVE\_T having the parameters following:***

***.  
the definition of the moments (“INST”),***

•  
*co-ordinates of the nodes of the grid 1D (“COOR\_X”)*

•  
*the value of the temperatures to the nodes (“TEMP”).*

*The co-ordinates of the table must necessarily have for origin the node of co-ordinate 0.*

*The values of the temperatures can possibly be prolonged regularly or interpolated linearly according to co-ordinate “COOR\_X”.*

### **6.1.1 Operands**

**MAILLAGE\_FINAL**

**MAILLAGE\_FINAL =**

*Name of the grid on which one carries out projection, the operator checks that the grid is three-dimensional.*

### **6.1.2 Operands**

**COUNT**

**COUNT =**

*Name of a structure of data COUNTS resulting from order POST\_RELEVE\_T containing it thermal transient 1D. The parameters of this table are obligatorily: “INST”, “COOR\_X” and “TEMP”.*

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### **6.1.3 Operands**

#### ***INST/LIST\_INST/PRECISION/CRITERION***

/

***INST = litps***

***List actual values.***

/

***LIST\_INST = litps***

***List realities produced by DEF1\_LIST\_REEL [U4.34.01].***

***PRECISION =***

***Precision used to seek the moment specified in the TABLE post\_ID.***

***CRITERION =***

***Criterion used to seek the moment specified in the TABLE post\_ID.***

### **6.1.4 Operands**

#### ***PROL\_DROITE and PROL\_GAUCHE***

***The projection of the transient is carried out according to co-ordinate COOR\_X considered as co-ordinate R in the cylindrical reference mark of the grid 3D. One can define using these two operands the way of prolonging the field beyond the terminals defined by the beach of variation of parameter "COOR\_X" in the table.***

***PROL\_DROITE and PROL\_GAUCHE =***

***Define the type of prolongation on the right (on the left) of the field of definition of the variable:***

.

***"CONSTANT" for a prolongation with the last (or first) value of function,***

.

***"LINEAR" for a prolongation along the first definite segment (PROL\_GAUCHE) or of the last definite segment (PROL\_DROITE),***

.

***"EXCLUDED"***

*if the extrapolation of the values apart from the field of definition of parameter is prohibited (in this case if a calculation requires a value function out of the field of definition, the code will stop in fatal error).*

### **6.1.5 Operand**

**REPERE/ORIGINE/AXE\_Z**

**LOCATE = "CYLINDRICAL"**

*The reference mark of work to project the transient is supposed to be cylindrical, the transient 1D being regarded as the radial variation of the field of temperature. The two operands following allow to carry out a change of reference mark.*

**ORIGIN = (ori1, ori2, ori3)**

*Corresponds to the position of the origin of the grid 1D compared to the origin of the grid 3D.*

**AXE\_Z = (axe1, axe2, axe3)**

*Definition of the axis of the cylindrical reference mark.*

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**7 Example**

*of use*

*Construction of a thermal transient starting from a function:*

*One defined below the principal orders used to build a concept result of evol\_ther type.*

*Definition of a list of moments.*

*lr8*

*= DEFI\_LIST\_REEL (BEGINNING*

*=*

*0.E0,*

*INTERVALLE= (\_F (JUSQU\_A=5.e-3, NOMBRE=10*

*),*

*\_F (JUSQU\_A=5.e-2, NOMBRE= 9),*

*\_F (JUSQU\_A=4.e-0, NOMBRE=79),*

*\_F (JUSQU\_A=6.e-0, NOMBRE=20),)*

)

*Definition of a function of parameter "INST".*

*fct1 = DEFI\_FONCTION*

*(NOM\_PARA = "INST"*

*VALE=*

*(*

*0.0,*

*20.0,*

*0.5,*

*25.0,*

*2.0,*

*54.0,*

*10.0,*

*134.0,)*

*PROL\_DROIT*

*= ' LINEAIRE',*

*PROL\_GAUCHE*

*= ' LINEAIRE',*

)

*Construction of a field to the nodes of function, one assigns the same function fct1 to the whole of nodes of the grid.*

*CH = AFFE\_CHAM\_NO*



*(GRID = my, SIZE = "TEMP\_F",  
AFFE  
=  
(\_F (  
ALL  
=  
"YES",  
NOM\_CMP=' TEMP',  
  
FONCTION=fct1,  
),)*

)  
...

*Creation of the concept TEMPLE result, built starting from the field with the nodes of CH function.  
One  
limit with the sequence number 20 correspondent to value 0.1. The structure of data will comprise 20  
sequence numbers from 1 to 20.*

*TEMPLE = CREA\_RESU  
(OPERATION = "AFFE",  
TYPE\_RESU = "EVOL\_THER", NOM\_CHAM = "TEMP",*

*CHAM\_GD = (\_F (CHAM\_NO = CH,*

*LIST\_INST*

=  
*lr8,*

*NUME\_FIN*

=  
*20*

,

),  
)

)

...

*END ()*

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*Date:*

01/02/05

*Author (S):*

**J. Key PELLET**

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***Macro-order MACR\_ECLA\_PG***

## ***1 Goal***

***To allow a visualization of the fields the points of Gauss without smoothing nor interpolation. The principle of this order is to burst each element of the model in as many small elements that it has points of Gauss. Each subelement then carries a constant field by mesh: the value point of Gauss.***

***Product a structure of data result and a grid.***

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***J. Key PELLET***

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## ***2 Syntax***

***MACR\_ECLA\_PG***

***(***

***# concepts produced by the macro-order:***

***RESULT***

***=***

***CO ("resu\_2") \****

***,***

***[sd\_resultat]***

## **GRID**

=

**CO (“my”) \*, [grid]**

**# operands obligatory:**

**RESU\_INIT**

=

**resu\_1, [sd\_resultat]**

**MODELE\_INIT**

=

**model, [model]**

**NOM\_CHAM**

=

**/**  
**“SIEF\_ELGA”,**

**/**  
**“VARI\_ELGA”**

**,**  
**/**  
**“SIEF\_ELGA\_DEPL”**

**,**  
**/**  
**“FLUX\_ELGA\_TEMP”**

**,**

**# optional geometrical parameters:**

**SHRINK**

=

**/HS,**

**[R8]**

***/0.9, [DEFECT]***

***TAILLE\_MIN =/MT,***

***[R8]***

***/ 0.,  
[DEFECT]***

***# possible Selection of a subset of elements to be visualized:***

***/ALL***

***=  
"YES"***

***,  
[DEFECT]***

***/  
NET***

=  
*lma*  
,  
*[l\_maille]*  
/  
*GROUP\_MA*

=  
*lgma*  
,  
*[l\_gr\_maille]*

#  
*Selection of the sequence numbers:*

/  
*TOUT\_ORDRE*

=  
*“YES”*  
, *[DEFECT]*

/  
*NUME\_ORDRE =*  
*l\_nuor*  
,  
*[l\_I]*  
/  
*LISTE\_ORDRE*

=  
*l\_numo*  
,  
*[listis]*

/  
/  
*INST*

=  
*l\_inst*  
,  
[*l\_R*]  
/  
*LIST\_INST*  
=  
*l\_inst*  
,  
[*listr8*]

/ *PRECISION* =  
/*prec*,  
/  
*1.0E-3*,  
[*DEFECT*]  
/  
*CRITERION*  
=  
/  
“*RELATIVE*”,  
[*DEFECT*]  
/  
“*ABSOLUTE*”  
,

)

\*



*Syntactically, the concepts produced by the order must be obligatorily written:*

*CO (“xxxx”)*

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*Titrate:*

*Macro-order MACR\_ECLA\_PG*

*Date:*

*01/02/05*

*Author (S):*

*J. Key PELLET*

*:*

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### *3 Operands*

#### *3.1 General*

*The order transforms SD\_resultat (and its subjacent grid) into a news SD\_resultat and a new grid.*

*The meshes of the initial grid are burst in smaller meshes: 1 mesh by point of Gauss. These new meshes all are disjoined (i.e they are not connected between them).*

*The value of a field on a point of Gauss is then assigned to all the nodes of the small mesh which he is associated.*

*SD\_resultat produced is thus a little particular because the fields (which keep their original name) are actually fields with the nodes!*

*Such a structure of data is intended above all for a visualization (after IMPR\_RESU). But one can also consider other postprocessings: POST\_RELEVE, PROJ\_CHAMP,...*

#### *3.2 Operands*

*RESU\_INIT*

*RESU\_INIT: resu\_1*

*Name of the result post-to treat*

### **3.3 Operands**

#### **MODELE\_INIT**

**MODELE\_INIT: Mo**

*Name of the model associated with the resu\_1 result.*

### **3.4 Operand**

#### **NOM\_CHAMP**

**NOM\_CHAM:**

*Reference symbol of (or of) the fields post-to be treated.*

#### **Note:**

*One treats only the fields by elements with the points of integration (standard ELGA)*

### **3.5 Operand**

#### **SHRINK**

**SHRINK = HS**

*Homothetic factor of reduction allowing to ensure nonthe interpenetration of the meshes.*

**SHRINK: 0,9**

**SHRINK: 0,5**

**Not Gauss**

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**3.6 Operand****TAILLE\_MIN** $TAILLE\_MIN = MT$ 

*This makes it possible to fix the minimal size on a side of an element. If this size is not reached, one proceed to a geometrical transformation (affinity along the too small side). The interest is of to be able to display results on very stretched elements (like the elements of joint). By defect, MT is worth 0. : the geometry of the elements is not modified.*

**3.7 Operand****RESULT** $RESULT = CO ("resu\_2")$ 

*Name of the SD result defined on the new grid on which the fields will be transferred.*

**3.8 Operand****GRID** $GRID = CO ("my")$ 

*my is the name of the grid associated with resu\_2. This name is necessary for visualization (order IMPR\_RESU).*

**3.9 Operands****ALL/GROUP\_MA/MESH** $/ALL = "YES",$  $[DEFECT]$ 

*This key word makes it possible to carry out the operation on all the meshes of the grid.*

 $/GROUP\_MA = l\gamma,$ 

*This key word makes it possible to carry out the operation on a list of groups of meshes of the grid.*

/

**NET**

=

*lma,*

*This key word makes it possible to carry out the operation on a list of meshes of the grid.*

### **3.10 Operands**

**TOUT\_ORDRE/NUME\_ORDRE/LIST\_ORDRE/INST/  
LIST\_INST/PRECISION/CRITERION**

*Selection in a structure of data result [U4.71.00].*

## **4 Example**

### **4.1 Visualization of a field of result at the points of Gauss on some groups of meshes**

**MACR\_ECLA\_PG (  
RESU\_INIT = U2, MODELE= MO, GROUP\_MA = (“G1”, “G7”),  
NOM\_CHAM= (“SIEF\_ELGA”, “VARI\_ELGA”),  
RESULT**

**=  
CO (“U2B”),**

**GRID = CO (“MA2B”),)**

**IMPR\_RESU (FORMAT=' IDEAS', UNITE=38,**

**RESU**

**=  
\_F (  
GRID = MA2B,  
RESULT = U2B**

**, ),  
)**

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***Author (S):***

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***Organization (S): EDF-R & D /AMA, SINETICS, Industrie/CNPE EDF-Pole of Tricastin***

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***Operator DEFI\_OBSTACLE***

***1 Goal***

***To define the geometry of the places of shocks of a telegraphic structure. These places are defined in a plan***

***perpendicular with the structure modelled by beams POU\_D\_T and POU\_D\_E. It is then used by***

*DYNA\_TRAN\_MODAL [U4.53.21] for the study of the response of a structure whose displacements are limited by the presence of this obstacle. One can also define the initial section of a structure which one will study progressive wear. In this last case, the concept will be used by MODI\_OBSTACLE [U4.44.22].*

*Product a concept of the obstacle type.  
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## *2 Syntax*

*obstacle = DEFI\_OBSTACLE*

*(  
/  
TYPE  
=  
/  
"CIRCLE",  
[DEFECT]  
/  
"PLAN\_Y",*

/

**“PLAN\_Z”,**

/

**“BI\_CERCLE”,**

/

**“BI\_CERC\_INT”,**

/

**“BI\_PLAN\_Y”,**

/

**“BI\_PLAN\_Z”,**

/

**“DISCRETE”,**

/

**“CRAYON\_900”,**

/

**“CRAYON\_1300”,**

/

**“GUID\_A\_CARTE\_900”,**

/

**“GUID\_A\_GCONT\_900”,**

/

**“GUID\_A\_GCOMB\_900”,**

/

**“GUID\_B\_CARTE\_900”,**

/

**“GUID\_B\_GCONT\_900”,**

/

**“GUID\_B\_GCOMB\_900”,**

/

**“GUID\_C\_CARTE\_900”,**

/

**“GUID\_C\_GCONT\_900”,**

/

**“GUID\_C\_GCOMB\_900”,**

/

**“GUID\_D\_CARTE\_900”**,

/

**“GUID\_D\_GCONT\_900”**,

/

**“GUID\_D\_GCOMB\_900”**,

/

**“GUID\_E\_CARTE\_900”**,

/

**“GUID\_E\_GCONT\_900”**,

/

**“GUID\_E\_GCOMB\_900”**,

/

**“GUID\_F\_CARTE\_900”**,

/

**“GUID\_F\_GCONT\_900”**,

/

**“GUID\_F\_GCOMB\_900”**,

/

**“GUID\_A\_CARSP\_900”**,

/

**“GUID\_B\_CARSP\_900”**,

/

**“GUID\_C\_CARSP\_900”**,

/

**“GUID\_D\_CARSP\_900”**,

/

**“GUID\_E\_CARSP\_900”**,

/

**“GUID\_F\_CARSP\_900”**,

/



**“GUID\_A\_CARTE\_1300”,**

/

**“GUID\_A\_GCONT\_1300”,**

/

**“GUID\_A\_GCOMB\_1300”,**

/

**“GUID\_B\_CARTE\_1300”,**

/

**“GUID\_B\_GCONT\_1300”,**

/

**“GUID\_B\_GCOMB\_1300”,**

/

**“GUID\_C\_CARTE\_1300”,**

/

**“GUID\_C\_GCONT\_1300”,**

/

**“GUID\_C\_GCOMB\_1300”,**

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**“GUID\_D\_CARTE\_1300”,**

/

**“GUID\_D\_GCONT\_1300”,**

/

**“GUID\_D\_GCOMB\_1300”,**

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**“GUID\_E\_CARTE\_1300”,**

/

**“GUID\_E\_GCONT\_1300”,**

/

**“GUID\_E\_GCOMB\_1300”,**

/

**“GUID\_F\_CARTE\_1300”,**

/

**“GUID\_F\_GCONT\_1300”,**

/

**“GUID\_F\_GCOMB\_1300”,**

/

**“GUID\_A\_CARSP\_1300”,**

/

**“GUID\_B\_CARSP\_1300”,**

/

**“GUID\_C\_CARSP\_1300”,**

/

**“GUID\_D\_CARSP\_1300”,**

/

**“GUID\_E\_CARSP\_1300”,**

/

**“GUID\_F\_CARSP\_1300”,**

**VALE**

=

***thetar, [l\_R]***

**VERIF = “FIRM”,**

**);**

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**3 Operands**

**3.1 Operand**

***TYPE***

**/**

***TYPE = typ***

***The STANDARD operand makes it possible to give:***

**.**

***the form wraps play in the connection of shock by a text among the following:***

***PLAN\_Y, PLAN\_Z, CIRCLE, DISCRETE, BI\_PLAN\_Y, BI\_PLAN\_Z, BI\_CERCLE and BI\_CERC\_INT;***

**.**

***the initial section of structures such as pencils CRAYON\_\* and the guides***

***GUID\_\*\_\*\_\* of control rods of the REFERENCE MARKS 900 and 1300 MW.***

***The obstacles of the type PLAN\_Y, PLAN\_Z, CIRCLE and DISCRETE define the geometry of places of shock enters a mobile structure and an indeformable obstacle. They are traced below [Figure 3.1-a] according to the selected type.***

***Zloc***

***Zloc***

***Zloc***

***play***

***play***

***Yloc***

**Yloc**  
**Yloc**  
**play**  
**PLAN\_Y**  
**PLAN\_Z**  
**RING**

**Appear 3.1-a**

**The value of the play and the local reference mark (Xloc, Yloc, Zloc) will be defined in the moment of the use**

**obstacle (see operator DYNA\_TRAN\_MODAL [U4.53.21]). The origin of this reference mark being its place of the telegraphic structure considered.**

**In the case of the STANDARD obstacle = "DISCRETE", it is necessary to specify the curve defining it**

**contour and play simultaneously, using key word VALE.**

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**Types BI\_PLAN\_Y, BI\_PLAN\_Z, BI\_CERCLE and BI\_CERC\_INT make it possible to define them possible places of contact of the telegraphic structure between two nodes NO1 and pertaining NO2 each one with a mobile structure. Geometries of the connections of plane contact on plan (or ring on circle) are described on the figure [Figure 3.1-b] below.**

**Zloc**

**Zloc**

**N01**  
**N01**  
**N02**  
**D1**  
**D1**  
**D2**  
**Yloc**  
**play**  
**Yloc**  
**D2**  
**N02**  
**play**  
**BI\_PLAN\_Y**  
**BI\_PLAN\_Z**  
**N02**  
**Zloc**  
**play**  
**R2**  
**NO2**  
**R1**  
**N01**  
**R2**  
**Zloc**  
**R1**  
**NO1**  
**Yloc**  
**Yloc**  
**BI\_CERCLE**  
**BI\_CERC\_INT**

**Appear 3.1-b**

*The value thicknesses of matter surrounding the nodes of shock (D1 and D2 for one obstacle of the type BI\_PLAN\_\*, R1 and R2 for an obstacle of the type BI\_CERCLE or BI\_CERC\_INT) as well as the local reference mark (Xloc, Yloc, Zloc) are defined in the moment of the use of the obstacle, i.e. in operator DYNA\_TRAN\_MODAL [U4.53.21].*

*Several initial forms, in particular for the study of the vibrations of the bunches of order, are defined. They correspond with the pencil of the various bunches of order and from their guidance.*

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***The STANDARD operand then makes it possible to define the geometry of a pencil of control rod nine of type REFERENCE MARK 900MW: `CRAYON\_900' or of type REP1300MW: "CRAYON\_1300";***

***and that of the various parts of a guidance of bunch nine: type starting with GUID (GUID\_\*\_\*\_\*). The three indications which follow GUID respectively make it possible to define:***

**.**

***the type of pencil of bunch - of A with F - which is inside (the channel of guidance is different for each type of pencil);***

**.**

***the part of the guidance to which the obstacle belongs: CHART if discontinuous guidance; GCONT if continuous guidance; GCOMB if guidance combustible; CARSP if chart with play increased;***

**.**

***and the type of engine: 900 if REFERENCE MARK 900MW or 1300 if REFERENCE MARK 1300MW.***

### **3.2 Operands**

**VALE/VERIF**

**VALE = thetar**

***In the case of the DISCRETE obstacle it is necessary to specify the curve defining contour and the play at the same time, using key word VALE.***

***thetar is the list of realities making it possible to describe the contour of the obstacle of the DISCRETE type in***

*polar co-ordinates. One describes the obstacle like a curve planes into polar while giving couples of values, the first being the angle in degrees of 0 with 360°, the second the ray [Figure 3.2-a].*

**VALE**  
**= ( 0.0, 0.00086,**  
**30.0,**  
**0.00086,**  
**90.0,**  
**0.001,**  
**150.0,**  
**0.001,**  
**210.0,**  
**0.001,**  
**270.0,**  
**0.001,**  
**330.0,**  
**0.001,**  
**360.0,**  
**0.00086,)**

*Appear 3.2-a*

**VERIF = "FIRM"**

*Key word allowing to check if the curve given into polar is well closed.*

**4 Phase**  
**of execution**

*It is checked that the number of values behind VALE is even and that the curve defined in co-ordinates polar is well closed (operand VERIF = "FIRM").*

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*Organization (S): EDF-R & D /AMA*

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***Operator MODI\_OBSTACLE***

***1 Goal***

***To calculate the obstacles in the systems guidance-tube, after wear.***

*The concept result of MODI\_OBSTACLE is of obstacle type. It is expressed in co-ordinates polar, it is of the same type as that of DEFI\_OBSTACLE with “DISCRETE” keyword and sound use is the same one. This form called figure of play is usable in the operator DYNA\_TRAN\_MODAL under the key word OBSTACLE.*

*This calculation can intervene following a calculation of dynamics with DYNA\_TRAN\_MODAL. One calculates initially the volumes used with operator POST\_USURE. TABL\_USURE resulting from POST\_USURE contains the volumes used during dynamic calculation. MODI\_OBSTACLE uses TABL\_USURE to calculate the new figure of play after wear.*

*The use of the empirically given laws specific starting from the experience feedback on control rods currently limits the use of this option to the specific case of it component.*

*Product a concept result of the obstacle type.*

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*2 Syntax*

*figure1 = MODI\_OBSTACLE*

*[obstacle]*

(

## ***GUIDE***

=

***guid,***  
***[obstacle]***

## ***/PENCIL***

=

***pencil, [obstacle]***

/

## ***R\_MOBILE***

=

***rcray,***  
***[R]***

## ***OBSTACLE***

=

***figure0,***  
***[obstacle]***

***/BORING***

=

***bore,***

***[R]***

/

***V\_USUR\_OBST =***

***vusob,***

***[l\_R]***

***V\_USUR\_TUBE***

***= vustu,***

***[l\_R]***

/

***TABL\_USURE***

=

***tabuse, [tabl\_post\_usur]***

***INST***

=

***inst,***

**[R]**

**INFORMATION**

=

/1,

**[DEFECT]**

/2,

);

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**3 Operands**

**3.1 Operand**

**GUIDE**

**The obligatory keyword *GUIDE* makes it possible to define guidance used. This guidance was defined in**

**DEFI\_OBSTACLE.**

*It is of “DISCRETE” type or “GUID\_\*\_\*\_\*” if option TABL\_USURE is not used.*

*It is obligatorily of type “GUID\_\*\_\*\_\*” if one uses option TABL\_USURE (the removal of preset forms of wear is valid only starting from the new antagonists).*

*“GUID\_\*\_\*\_\*” contains the type of chart, the type of stage, the rays and the thicknesses of guidance. By defect, it provides also the pencil adapted to the guide.*

*“GUID\_\*\_\*\_\*” can take the values indicated exhaustively in the list below.*

**“GUID\_A\_CARTE\_900”**

**“GUID\_D\_CARTE\_900”**

**“GUID\_A\_GCONT\_900”**

**“GUID\_D\_GCONT\_900”**

**“GUID\_A\_GCOMB\_900”**

**“GUID\_D\_GCOMB\_900”**

**“GUID\_B\_CARTE\_900”**

**“GUID\_E\_CARTE\_900”**

**“GUID\_B\_GCONT\_900”**

**“GUID\_E\_GCONT\_900”**

**“GUID\_B\_GCOMB\_900”**

**“GUID\_E\_GCOMB\_900”**

**“GUID\_C\_CARTE\_900”**

**“GUID\_F\_CARTE\_900”**

**“GUID\_C\_GCONT\_900”**

**“GUID\_F\_GCONT\_900”**

**“GUID\_C\_GCOMB\_900”**

**“GUID\_F\_GCOMB\_900”**

**“GUID\_A\_CARTE\_1300”**

**“GUID\_D\_CARTE\_1300”**

**“GUID\_A\_CAR11\_1300”**

**“GUID\_A\_GCONT\_1300”**

**“GUID\_D\_GCONT\_1300”**

**“GUID\_B\_CAR11\_1300”**

**“GUID\_A\_GCOMB\_1300”**

**“GUID\_D\_GCOMB\_1300”**

**“GUID\_C\_CAR11\_1300”**

**“GUID\_B\_CARTE\_1300”**

**“GUID\_E\_CARTE\_1300”**

**“GUID\_D\_CAR11\_1300”**

**“GUID\_B\_GCONT\_1300”**

**“GUID\_E\_GCONT\_1300”**

“GUID\_E\_CAR11\_1300”  
“GUID\_B\_GCOMB\_1300”  
“GUID\_E\_GCOMB\_1300”  
“GUID\_F\_CAR11\_1300”  
“GUID\_C\_CARTE\_1300”  
“GUID\_F\_CARTE\_1300”

“GUID\_C\_GCONT\_1300”  
“GUID\_F\_GCONT\_1300”  
“GUID\_C\_GCOMB\_1300”  
“GUID\_F\_GCOMB\_1300”

### **3.2 Operand**

#### **PENCIL/R\_MOBILE**

*Useless operand when one uses a guide “GUID\_\*\_\*\_\*”, the definition of the pencil (900 or 1300MW) then is already informed by defect.*

*The keywords “PENCIL” or “R\_MOBILE” are thus optional (of type PRESENT-ABSENT). They allow to define the mobile structure of which it is necessary to hold account in the definition of the figure of play.*

*For pencil, the type results from DEFI\_OBSTACLE.*

*It is of “DISCRETE” type or “CRAYON\_900” or “CRAYON\_1300” if the option is not used  
TABL\_USURE.*

*It is obligatorily of type “CRAYON\_900” or “CRAYON\_1300” if option TABL\_USURE is used because the removal of the preset forms of wear is valid only starting from the new antagonists.*

*For rcray, indicate the ray of the pencil in meter.*

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### **3.3 Operand OBSTACLE**

*The optional keyword OBSTACLE makes it possible to introduce the initial figure of play figure0 from which one calculates the obstacle figure1 result.*

*If figure1 = MODI\_OBSTACLE (reuse = figure1, the obstacle figure0 is modified at exit of MODI\_OBSTACLE.*

### **3.4 Operand BORING**

*The optional keyword BORING applies to the tube. It makes it possible to give the ratio thickness used on initial thickness which sets off an alarm. The release of alarm corresponds to one boring of the tube.*

### **3.5 Operands V\_USUR\_OBST and V\_USUR\_TUBE**

*Keywords V\_USUR\_OBST and V\_USUR\_TUBE make it possible the user to give volumes used to apply respectively to the obstacle and the tube. vusob and vustu are lists of volumes used by angular sector. They have the same structure as the lists of worn volumes resulting from POST\_USURE.*

*These key words are used only to carry out calculations of test using MODI\_OBSTACLE. At the time use of MODI\_OBSTACLE following a dynamic calculation, one more often uses TABL\_USURE.*

### **3.6 Operands TABL\_USURE and INST**

*tabuse is a table of wear defined by POST\_USURE. It contains the volumes used on the guide and on the pencil by angular sectors and for various dates.*

*MODI\_OBSTACLE reads the volumes used at the moment inst and applies these volumes to the guide and to pencil according to precise profiles'. These profiles result from the experience feedback.*



*These rules are valid only starting from new obstacles. I.e. the guide and the pencil used must be defined by “GUID\_\*\_\*\_\*” (and “CRAYON\_\*”) in DEFI\_OBSTACLE.*

*In the case of the use of option INST of TABL\_USURE several times of continuation, it is necessary to take care of  
to control well the dates and cumulated moments preserved in table TABL\_USURE.*

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## **4 Example of use**

*An example of use is the vibratory calculation of a bunch in a guide of bunch.  
The step indicated is then followed [Figure 4-a].*

### **DEFI\_OBSTACLE**

*Initialization of calculation, one enters the geometry of*

*“GUID\_A\_CARTE\_900”  
problem*

### **DYNA\_TRAN\_MODAL**

*The first dynamic calculation,  
on the initial geometry*

## **POST\_USURE**

*Calculation of the volumes used starting from dynamic calculation:*

*V obst and V tube.*

*(depend on the date, written by angular sector.)*

## **MODI\_OBSTACLE**

*Calculation of the worn obstacles  
starting from V obst and V tubes*

*and of the initial geometries*

*Not boring*

*Boring*

*The pencil is changed*

## **POST\_USURE**

*Dynamic **DYNA\_TRAN\_MODAL** the 2nd calculation,  
bored. V tube is given to  
Tube\_neuf*

*on the worn geometry  
zero.*

## **MODI\_OBSTACLE**

*Calculation of the worn obstacles*

## **POST\_USURE**

*Calculation of worn volumes **DYNA\_TRAN\_MODAL** the 2nd dynamic calculation,*

*V'*  
*on worn guide and pencil*

*obst and V' tube.*

*nine*

***POST\_USURE***

*Calculation of worn volumes:*

*Calculation of the obstacles*

*V' obst and V' tube.*

***MODI\_OBSTACLE***

*used*

*from*

*Calculation of the worn obstacles*

*V' obst and V' tube*

*from*

*Not boring*

*and of the geometries*

*V' obst and V' tube*

*initial*

*and of the initial geometries.*

***MODI\_OBSTACLE***

*Boring*

...

...

*Not boring*

*Boring*

...

...

***Appear 4-a: Example of calculation using MODI\_OBSTACLE***

*Instruction manual*

*U4.4- booklet: Modeling*

*HT-66/05/004/A*

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*Version*

*7.4*

*Titrate:*

*Operator MODI\_OBSTACLE*

*Date:*

*02/02/05*

*Author (S):*

***S. LAMARCHE, D. BOSSELUT, G. DEVESA Key***

*:*

*U4.44.22-C Page*

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*Version*

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*Titrate:*

*Operator* ***DEFI\_SPEC\_TURB***

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*27/01/05*

*Author (S):*

***A. Key ADOBES***

*:*

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*Organization (S): EDF-R & D /MFTT*

***Instruction manual***

***U4.4- booklet: Modeling***

***Document: U4.44.31***

***Operator DEFI\_SPEC\_TURB***

## ***1 Goal***

***To define a spectrum of turbulent excitation. Various types of spectra are available:***

- for the “beams of tubes under transverse flow”, spectra of the type “length of correlation”,***
- for established uniform flows, parallel with plane or cylindrical structures circulars, spectra of turbulence of boundary layer,***
- spectrum of excitation defined by its decomposition on a family of functions of form in providing a matrix interspectrale and a list of associated functions of form. concepts *tabl\_intsp* and function must then be generated upstream,***
- preset spectrum of turbulence, identified on model GRAPPE1 or GRAPPE2,***
- spectrum of excitation associated with one or more forces and specific moments while providing a matrix interspectrale of excitations (concept *tabl\_intsp* having to be generated upstream), the list of the nodes of application of these excitations, the nature of the excitation applied in each one of these nodes (force or moment) and directions of application of the excitations thus defined.***

***Product a concept of the spectrum type.***

***Instruction manual***

***U4.4- booklet: Modeling HT-66/05/004/A***

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***Code\_Aster ®***

***Version***

***7.4***

***Titrate:***

***Operator DEF1\_SPEC\_TURB***

***Date:***

***27/01/05***

***Author (S):***

***A. Key ADOBES***

***:***

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## ***2 Syntax***

***spe [spectrum] = DEF1\_SPEC\_TURB (***

/  
*SPEC\_LONG\_COR\_1:*  
*\_F (*

*LONG\_COR*  
*=*  
*lc*  
*, [R]*

*PROF\_VITE\_FLUI = profv*  
*, [function, formula]*

*VISC\_CINE*  
*=*  
*eps*  
*,*  
*[R]*

*),*  
  
*/*  
*SPEC\_LONG\_COR\_2*  
*=*  
*\_F (*

*LONG\_COR*

=

*lc*

, [R]

*PROF\_VITE\_FLUI = profv*

, [function, formula]

*/FREQ\_COUP*

= 0.1

[DEFECT]

*PHI0 =*

*1.5D-3*

[DEFECT]

*BETA =*

*2.7*

,

[DEFECT]

/

*FREQ\_COUP*

=

*frc*

[R]



*PHI0*

=

*phi0*

[R]

*BETA*

=

*beta,*

[R]

),

/  
*SPEC\_LONG\_COR\_3 =*  
*\_F (*

*LONG\_COR*

=

*lc*  
*, [R]*

*PROF\_VITE\_FLUI = profv*  
*, [function, formula]*

*/FREQ\_COUP*  
*=*  
*0.2*  
*[DEFECT]*

*PHIO\_1*  
*=*  
*5.D-3*  
*[DEFECT]*

*BETA\_1*  
*=*  
*0.5 [DEFECT]*

*PHI0\_2*

=

*4.D-5*

*[DEFECT]*

*BETA\_2*

=

*3.5*

,

*[DEFECT]*

/

*FREQ\_COUP*

=

*frc*

*[R]*

*PHI0\_1*

=

*phi01*

*[R]*

*BETA\_1*

=

*beta1*

[R]

*PHI0\_2*

=

*phi02*

[R]

*BETA\_2*

=

*beta2,*

[R]

),

/  
*SPEC\_LONG\_COR\_4 =*  
*\_F (*

*LONG\_COR*

=

*lc*

, [R]

*PROF\_VITE\_FLUI = profv*

, [function, formula]

*TAUX\_VIDE*

=

*TV*

, [R]

*/BETA = 2.*

[DEFECT]

*GAMMA*

=

4. ,

[DEFECT]

/  
*BETA*

=

*beta*

[R]

*GAMMA*

=

*gamma,*

[R]

),

/  
*SPEC\_CORR\_CONV\_1:*  
*\_F (*

*LONG\_COR\_1 = lc1*

,

[R]

$LONG\_COR\_2 = lc2$

,  
[R]

$VITE\_FLUI$

=  
 $vflui$   
,[R]

$FREQ\_COUP$

=  
 $FC$   
,[R]

$K = /5.8D-3$

[DEFECT]

/  
K,

[R]

*D\_FLUI*

=

*dhyd*

,

[R]

*RHO\_FLUI*

=

*rho\_f*

, [R]

*COEF\_VITE\_FLUI\_A*

=

*alpha*

, [R]

*COEF\_VITE\_FLUI\_O*

=

*beta*

,

[R]

*METHOD =/"GENERAL"*

[DEFECT]



/  
"CORCOS"  
/  
"AU\_YANG"  
,

),  
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*Operator* ***DEFI\_SPEC\_TURB***

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/  
*SPEC\_CORR\_CONV\_2* =  
*\_F* (

*FUNCTION*

=  
*fonc*  
,  
[*function, formula*]

*VITE\_FLUI*

=  
*vflui*  
, [R]

*FREQ\_COUP*

=  
*FC*  
, [R]

*COEF\_VITE\_FLUI\_A*

=  
*alpha*  
, [R]

*COEF\_VITE\_FLUI\_O*

=  
*beta*  
,  
[R]

*METHOD* =/"GENERAL"  
[DEFECT]  
/  
"CORCOS"  
/  
"AU\_YANG"  
,

),

/  
*SPEC\_FONC\_FORME* =  
\_F (

/INTE\_SPEC  
=  
*int\_spec*  
,  
[tbl\_intsp]  
FUNCTION  
=  
*l\_fonc*  
,  
[l\_fonction]

/  
*GRAPPE\_1* =/"DEBIT\_180"  
/  
"DEBIT\_300"  
,

*NODE*  
=  
*No*  
, [*node*]

*CARA\_ELEM*  
=  
*will cara*  
,  
[*cara\_elem*]

*MODEL*  
=  
*model*  
,  
[*model*]

),  
  
/  
*SPEC\_EXCI\_POINT* =  
*\_F* (

*/INTE\_SPEC*  
= *int\_spec*  
,  
*[tabl\_intsp]*  
*NATURE*  
=  
*l\_nat*  
, *[l\_TXM]*  
*ENG* =  
*l\_theta*  
,  
*[l\_R]*  
*NODE*  
=  
*l\_no*  
,  
*[l\_noeud]*

/  
*GRAPPE\_2* =/"ASC\_CEN"  
/  
"ASC\_EXC"  
/  
"DES\_CEN"  
/

*“DES\_EXC”*

,  
*RHO\_FLUI*

=

*rho\_f*

, [*R*]

*NODE*

=

*No*

, [*l\_noeud*]

*CARA\_ELEM*

=

*will cara*

,

[*cara\_elem*]

*MODEL*

=

*model*

,

[*model*]

),

*TITRATE = title*

, [*TXM*]

);  
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*Operator* **DEFI\_SPEC\_TURB**

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### **3 Operands**

#### **3.1 Key words**

**SPEC\_LONG\_COR\_n**

*The definition of a spectrum of excitation of the type “length of correlation” can be done only by one only occurrence of one of the key words SPEC\_LONG\_COR\_n factors, corresponding to a zone of the tube*

*defined beforehand by the function indicated in operand PROF\_VITE\_FLUI of the order DEFI\_FLUI\_STRU [U4.25.01]. Profile speed associated with this zone, pointed out here under the operand*

*PROF\_VITE\_FLUI, must be identical to that indicated in DEFI\_FLUI\_STRU [U4.25.01]. The use spectra of excitation of the type “length of correlation” is limited to the configuration “beam of tubes under transverse flow” (key word factor FAISCEAU\_TRANS of the operator DEFI\_FLUI\_STRU [U4.25.01]).*

*To carry out a calculation with several zones of excitation, it is necessary to define as many spectra as there is*

*zones. The contributions of the various spectra can be then added when the excitation is projected on modal basis by order PROJ\_SPEC\_BASE [U4.63.14]. However, it is not possible in this order to combine spectra of the type "length of correlation" with spectra of another type (SPEC\_CORR\_CONV\_n, SPEC\_FONC\_FORME or SPEC\_EXCI\_POINT).*

*The four spectra of the type "length of correlation" have values defined by defect. The definition new coefficients is delicate, in particular with regard to the model 3 for which it exist conditions of connection between the lines determined by the coefficients.*

*The general analytical form of models 1 to 4 is as follows:*

*- S*

*2 - S*

*S (S*

*1*

*1, S, F*

*2*

*R) = S (F R) .exp*

*C*

*with:*

*S (S, S, F*

*interspectre adimensional of turbulence between two points of X-coordinates*

*1*

*2*

*R)*

*curvilinear S, S*

*1*

*2 ;*

*S (F*

*autospectre of turbulence;*

*R)*



-  $S$

2 -

$S$

*exp*

1

*function of space correlation and  $C$  length of correlation.*

$C$

*The spectrum is defined according to a reduced frequency  $Fr$  (a Strouhal number). For a tube under transverse flow, the  $Fr$  expression is as follows:*

$F$ .  $E$

$D$

$F R =$

$G$

$V$

*$F$  is the dimensioned frequency, of the diameter external of the tube and  $Vg$  transverse speed average of the fluid along the structure, which will be recovered in operator  $PROJ\_SPEC\_BASE$  [U4.63.14] via the concept [melasflu] produced by operator  $CALC\_FLUI\_STRU$  [U4.66.02].*

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### ***3.1.1 Analytical expression of the spectra of the type SPEC\_LONG\_COR\_1***

***/SPEC\_LONG\_COR\_1***

***Key word factor corresponding to the first model of spectrum with length of correlation.***

***LONG\_COR = lc***

***Length of correlation.***

***PROF\_VITE\_FLUI = profv***

***Name of the profile speed corresponding to the zone where is applied the turbulent excitation.***

***VISC\_CINE***

***=***

***eps***

***Kinematic viscosity of the fluid.***

***S (F***

***0***

***R) =***

2

*F* 2

*F* 2

*R*

2

*R*

1-

+ 4

*F*

*F*

*rc*

*rc*

*with: =*

0

0 (*Re*) polynomial of the 5th degree.

= (*Re*)

= (*Re*)

*F*

=

*rc*

0 2

.

*If 1.5.104 < Re 5.104:*

4

-

4

-

8

-

2

12

-  
**3**  
**0 = 13. 10. [2042**  
.  
**- 14 10. Re - 9.8.1 10. Re + 119**  
**. 7 10**  
**. Re**  
**17**  
-  
**4**  
**-22**  
**5**  
**- 3595**  
.  
**10**  
**. Re + 34 69**  
.  
**10**  
**. Re]**

**If Re > 5.104:**  
**0 = 386075**  
.

**If Re 3.5 104**  
**= 0 7**  
.  
**= 3**  
**If not if 3.5.104 < Re 5.5 104**  
**= 0 3**  
.  
**= 4**  
**If not**  
**= 0 6**  
.  
**= 4**

**3.1.2 Analytical expression of the spectra of the type SPEC\_LONG\_COR\_2**

/  
**SPEC\_LONG\_COR\_2**

***Key word factor corresponding to the second model of spectrum with length of correlation.***

***LONG\_COR = lc***

***Length of correlation.***

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***PROF\_VITE\_FLUI***

***=***

***profv***

***Name of the profile speed corresponding to the zone where is applied the turbulent excitation.***

***/FREQ\_COUP***

***=***

***frc***

***Reduced frequency of cut.***

***PHI0***

***=***

***phi0***

***BETA***

***=***

***beta***

***Coefficients of the spectrum.***

**Note:**

**If the user informs one of these operands, it must obligatorily inform the two others, in order to have coherent values.  
If the user does not inform any of the three operands, the default values are used.**

**S (F  
0  
R) =  
F  
R  
1+ F  
rc**

**The values of the default settings are:  
-3**

**F  
0 = 15  
. 10, = 2 7  
. , rc = 01.**

**3.1.3 Analytical expression of the spectra of the type SPEC\_LONG\_COR\_3**

**/  
SPEC\_LONG\_COR\_3**

**Key word factor corresponding to the third model of spectrum with length of correlation.**

**LONG\_COR  
=  
lc**

**Length of correlation.**

**PROF\_VITE\_FLUI  
=  
profv**

**Name of the profile speed corresponding to the zone where is applied the turbulent excitation.**

**/FREQ\_COUP**

=  
*frc*

*Reduced frequency of cut.*

*PHI0\_1*

=

*phi01*

*BETA\_1*

=

*beta1*

*PHI0\_2*

=

*phi02*

*BETA\_2*

=

*beta2*

*Coefficients of the spectrum.*

*Note:*

*The five operands must be used simultaneously. If one is informed, the others must be it also.*

*The default values are used when the user did not inform any of the five operands.*

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*Author (S):*

*A. Key* **ADOBES**

*:*

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0  
0  
= F  
S (F  
0  
rc  
R)  
( )  
=

F  
with  
=  
where  
= 0 2  
.  
R

(frc)  
frc

If F F  
-3  
R  
rc  
0 = 5 10  
= 05.  
If not

5  
0 =  
-  
4 10  
= 35.

### **3.1.4 Analytical expression of the spectra of the type SPEC\_LONG\_COR\_4**

/  
**SPEC\_LONG\_COR\_4**



***Key word factor corresponding to the fourth model of spectrum with length of correlation.***

***LONG\_COR = lc***

***Length of correlation.***

***PROF\_VITE\_FLUI = profv***

***Name of the profile speed corresponding to the zone where is applied the turbulent excitation.***

***TAUX\_VIDE***

***=***

***TV***

***Rate of vacuum (diphasic flow).***

***/BETA***

***=***

***beta***

***GAMMA = gamma***

***Coefficients of the spectrum.***

***Note:***

***If the user informs one of these two operands, it must obligatorily to inform the other.***

***If none of the two operands is indicated, values by defect are used.***

***1***

***10***

***=***

***S (F***

***0***

***-2***

***6 8***

***. 1***

***0***

***R) =***

**0**

**(with**

**F**

**R) (v)**

**0 5**

**.**

**1 5**

**.**

**2 5**

**.**

**3 5**

**= .**

**To v -.**

**B v + C. v -.**

**D .v**

**v the rate of vacuum indicates;**

**To = 24 042**

**.**

**; B = -50 421**

**.**

**; C = 63 483**

**.**

**; D = 33 284**

**.**

**.**

**The default values of the exhibitors are = 2 and = 4.**

**NR F E (xi)**

**=**

**v is the volume throughput: v**

**m × V =**

**× V**

**NR N**

**i = NR D**

**where V indicates the speed of the fluid for which the study of interaction**

**fluid-structure was carried out and NR N the number of points taken into account on**

**the excited length. The speed of the fluid will be recovered in the operator**

**PROJ\_SPEC\_BASE [U4.63.14] via the concept [melasflu] produced by operator CALC\_FLUI\_STRU [U4.66.02].**

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**Operator DEFI\_SPEC\_TURB**

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**Author (S):**

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**:**

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**3.2 Key words**

**SPEC\_CORR\_CONV\_n**

**The key words factors SPEC\_CORR\_CONV\_1 and SPEC\_CORR\_CONV\_2 make it possible to define respectively spectra of turbulence of boundary layer and a function of the frequency unspecified.**

**Theoretical precise details:**

**· Dans le cas d'une structure plane soumise à un écoulement turbulent parallèle, si l'on souhaite connaître la réponse spectrale à cette excitation, le modèle de corrélation de CORCOS introduit une fonction de corrélation entre deux items  $X$  et  $X$  sur la structure plane, de la forme**

**(**

**-**

**-**

**-**

**,  $X$ ,  $X$ )**

**$X X$**

**$y y$**

**( $X X$ )**

***R***  
***= exp -***  
***×***  
***-***

***exp***  
***\****  
***1***

***cos***  
***2***

***×***

***U.a.***

***1***

***1 =***  
***ave***  
***CKL = 0 1***  
***, ×***

***KL***  
***U.a.***

***In the basic model of CORCOS, one has***

***1***

***2 = with kT = 0.5,5×***

***kT***  
***U.a.***

***X is the axis parallel with the flow.***

*y is the axis perpendicular to the flow.*

*U.a. is the convective speed of the swirls. It is allowed that it represents between 60 and 70% of speed of the fluid. By defect, one takes it equal to 65% speed of the fluid.*

*· Dans le cas d'une structure cylindrique soumise à un écoulement axial, le modèle de corrélation de AU YANG introduit une fonction de corrélation entre deux points définies par:*

(  
-  
-  
-  
-  
-  
-  
, X, X)  
X X  
(X X)  
R  
R (  
)  
R  
= exp -  
-

cos  
× exp  
cos

×

*U.a.*

×

*U.a.*

*- and correspond to the angular positions of the two points of the cylinder to correlate,*

-  
*X and X indicate the dimensions of the points to be correlated,*

-  
*R is the ray of the cylinder,*

- *U.a. is the axial convective speed of the swirls: it is equal to the product of the coefficient of axial speed by the speed of the fluid,*

- *U.a. is convective speed orthoradiale swirls: it is equal to the product of coefficient speed orthoradiale by the speed of the fluid,*

-  
*and are the lengths of correlation according to the axis and the direction orthoradiale respectively.*

· *The GENERAL correlation is a function of the type*

*X - X*

*X - X*

*R (, X, X) = exp -*

*cos*

×

*U.a.*

-  
*X and X are the vectors locating the positions of the two points to be correlated,*

- *U.a. is the convective speed of the swirls,*

-  
*is the length of correlation.*

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**Author (S):**

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### **3.2.1 Definition of a spectrum of turbulence of boundary layer**

**/**

**SPEC\_CORR\_CONV\_1**

**Key word factor corresponding to the first model of spectrum of pressure with length of correlation and speed of convection of the swirls in the fluid.**

**LONG\_COR\_1 = lc1**

**First length of correlation (along the axis parallel with the flow) for the method AU-YANG. Length of correlation of the GENERAL method.**

**LONG\_COR\_2 = lc2**

**Second length of correlation for the method of AU\_YANG.**

**VITE\_FLUI**

**=**

**vflui**

**Speed of the fluid skirting the studied structure.**

**FREQ\_COUP**

**=**

**FC**

**Cut-off frequency of the spectrum. In the case of the method of CORCOS, one uses**

**U**

**value  $F C = 10$**

**(see notations below) by defect.**

**D**

**K = K**

**Constant giving the amplitude of the spectrum of pressure.**

*By defect, K is worth 5,8 103 in units IF.*

*D\_FLUI = dhyd*

*Hydraulic diameter entering the expression of the amplitude of the spectrum of pressure.*

*RHO\_FLUI = rho\_f*

*Density of the fluid.*

*COEF\_VITE\_FLUI\_A*

=

*alpha*

*Coefficient the convective speed of the swirls in the axial direction (direction of the flow) for the methods of CORCOS, AU\_YANG.*

*COEF\_VITE\_FLUI\_O*

=

*beta*

*Coefficient the convective speed of the swirls in the direction orthoradiale with roll, for the method of AU\_YANG.*

*METHOD*

=

*“GENERAL” or “CORCOS” or “AU\_YANG”*

*Method of correlation determined by the type of the structure which one wants to study them vibrations generated by turbulence.*

*By defect, the GENERAL method is used.*

*Note:*

*In the case of the method of CORCOS, one uses for LONG\_COR\_1 and LONG\_COR\_2 the lengths of correlation of the basic model (see [§3.2]).*

*The spectrum of pressure used is of the type S*

*2*

*2*

*2*

*3*

*p () = K (U) D if F F C and 0 for F > F C.*

*K indicates the constant of the model, well informed under the operand K. For the model of CORCOS, K*

*is in experiments given and is worth K =*



-  
5 8 10 3 s1 2 m3 2

,  
;  
*is the density of the fluid, well informed under operand **RHO\_FLUI**;  
U is the speed of the fluid, well informed under operand **VITE\_FLUI**;  
D is the hydraulic diameter, well informed under operand **D\_FLUI**.*

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---

**Code\_Aster** ®

*Version*

7.4

*Titrate:*

*Operator **DEFI\_SPEC\_TURB***

*Date:*

27/01/05

*Author (S):*

**A. Key ADOBES**

:

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### ***3.2.2 Definition of a spectrum of turbulence of a function of the frequency unspecified***

/  
***SPEC\_CORR\_CONV\_2***

*Key word factor allowing to define a spectrum of unspecified pressure function of frequency.*

***FUNCTION***

=

***fonc***

*Concept of the function type defining the spectrum of pressure according to frequency, produced by one of operators **DEFI\_FONCTION** [U4.31.02], **CALC\_FONCTION** [U4.32.04] or **CALC\_FONC\_INTERP** [U4.32.01].*

***VITE\_FLUI***

=  
*vflui*

*Speed of the fluid skirting the studied structure.*

*FREQ\_COUP*  
=  
*FC*

*Frequency cut-off beyond which the function defining the spectrum of pressure is regarded as null.*

*COEF\_VITE\_FLUI\_A = alpha*

*Coefficient the convective speed of the swirls in the axial direction (direction of the flow).*

*METHOD*  
=  
*“CORCOS”*

*Method of correlation for the structures of the type plates. Lengths of correlation reserves are the lengths of the model of CORCOS per defect (see [§3.2]).*

### **3.3 Key word**

***SPEC\_FONC\_FORME***

/  
*SPEC\_FONC\_FORME*

*Key word factor allowing to define a spectrum of excitation by its decomposition on one family of functions of form.*

*/INTE\_SPEC*  
=  
*int\_spec*

*Concept of the tabl\_intsp type defining a matrix interspectrale excitation. It concept can be produced by operator LIRE\_INTE\_SPEC [U4.36.01] after reading matrix interspectrale on external file.*

*FUNCTION = l\_fonc*

*List concepts of the function type defining the family of functions of form*

*associated.*

/  
*GRAPPE\_1 = "DEBIT\_180" or "DEBIT\_300"*

*Two possible choices corresponding to the flows for which excitation GRAPPE1 was identified.*

*NODE*

=  
*No*

*Node of application of the excitation.*

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***CARA\_ELEM***

=

*will cara*

*Concept of the cara\_elem type produces by operator AFFE\_CARA\_ELEM [U4.42.01], defines geometrical characteristics assigned to the elements of the structure.*

*The geometrical characteristics are necessary to the estimate of the diameter hydraulics. Moreover, the concept of the cara\_elem type brings relative information with the orientations of the elements.*

***MODEL = model***

*Concept of the model type produced by operator AFFE\_MODELE [U4.41.01], defines them types of elements assigned to the meshes of the structure.*

**Note:**

*1) The length of application  $L$  is characterized in an intrinsic way by field of definition of the functions of form associated with the excitation. The zone of application is centered around the node of application.*

*2) The turbulent excitation being able to be developed in a way correlated in both orthogonal directions with the axis of the telegraphic structure (axis  $\mathbf{X}$ ), functions of form are a priori vectors with two components (according to  $\mathbf{y}$  and  $\mathbf{Z}$ ).*

*One will thus inform, by convention, these functions about the interval  $(0; 2L)$ , them fields  $(0; L)$  and  $(L; 2L)$  being respectively associated with the directions  $\mathbf{y}$  and  $\mathbf{Z}$ .*

**3.4 Key word**

**SPEC\_EXCI\_POINT**

/  
SPEC\_EXCI\_POINT

*Key word factor allowing to define a spectrum of excitation associated with one or more forces and specific moments.*

/INTE\_SPEC  
=  
int\_spec

*Concept of the tabl\_intsp type defining a matrix interspectrale excitations specific. This concept can be produced by operator LIRE\_INTE\_SPEC [U4.56.01] after reading of the matrix interspectrale on external file.*

NATURE  
=  
l\_nat

*List arguments of the text type defining the nature of the excitation of each one of nodes of application. The licit arguments are "FORCE" or "MOMENT".*

ENG  
=  
l\_theta

*List angles defining the directions of the vectors forces and moments in each node of application (see diagram).*

**Z**  
**P**  
**RF**

y  
*Node of application*  
*X (neutral fibre)*

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*The vector force is directed in the plan **P** orthogonal with neutral fibre. In this plan, the azimuth gives the direction of the vector. The angles must be given in **degrees**.*

**NODE**  
=  
*l\_no*

*List nodes of application of the specific excitations.*

**Note:**

*The matrix interspectrale has as a dimension the number of forces and moments specific applied. The diagonal terms of this matrix characterize them autospectres of these excitations.*

*Lists defining the nodes of application, the nature and the direction of imposed excitations must thus be ordered in accordance with the structure matrix interspectrale of excitations.*

/

**GRAPPE\_2**

=

“ASC\_CEN” or “ASC\_EXC” or “DES\_CEN” or “DES\_EXC”

*Four possible choices corresponding to the various experimental configurations for which excitation GRAPPE2 was identified:*

- Ascending flow stem of Centered order,
- Ascending flow stem of Offset order,
- flow Descending stem from Centered order,
- flow Descending stem from Offset order.

*Excitation GRAPPE2 is characterized by a specific force and a moment applied in the same node, in a homogeneous way in the two directions orthogonal with the axis of the telegraphic structure.*

**RHO\_FLUI**

=

*rho\_f*

*Density of the fluid surrounding the structure.*

**NODE**

=

*No*

*Node of application of excitation GRAPPE2.*

**Note:**

*When one resorts to a preset spectrum GRAPPE2, the list of nodes waited under the operand **NODE** is reduced to only one element (only one node of application).*

**CARA\_ELEM**

=

*will cara*

*Concept of the cara\_elem type produces by operator AFFE\_CARA\_ELEM [U4.42.01], defines the affected geometrical characteristics in the elements of the structure. The geometrical characteristics are necessary to the estimate of the diameter hydraulics. Moreover, the concept of the cara\_elem type brings information relating to the orientations of the elements.*

*MODEL = model*

*Concept of the model type produced by operator AFFE\_MODELE [U4.41.01], defines them types of elements assigned to the meshes of the structure.*

#### **4 Bibliography**

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[2]

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Version

8.2

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Key word SOLVEUR

Date:

31/01/06

Author (S):

**J. PELLET, O. BOITEAU** Key

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Organization (S): EDF-R & D /AMA, SINETICS

***Instruction manual  
U4.5- booklet: Methods of resolution  
Document: U4.50.01***

***Key word SOLVEUR***

### ***1 Goal***

***To choose the mode of storage of the matrices and the algorithm of resolution. This key word factor is found in a certain number of orders leading to the resolution of linear systems. For algorithms of resolution it makes it possible to choose between “traditional” factorization of type “GAUSS” (“LDLT”), multi-frontal factorization (“MULT\_FRONT” or “MUMPS”), combined gradient packaged ILU (K) (“GCPC”) or solver FETI by decomposition of fields (“FETI”).***

***For each type of solver, certain optional numerical parameters are accessible and are described here. By defect, it is the solver “MULT\_FRONT” who is used. Solver “FETI”, as for him, is still in phase of development, it is thus not advised to use it without preliminary councils of the team of development.***

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**2 Syntax**

**SOLVEUR = \_F (**

**# “multi-frontal” Factorization of the type:**

**/**  
**METHOD**  
**=**  
**“MULT\_FRONT”**  
**,**  
**[DEFECT]**

**# Parameter numerical**

**RENUM**  
**=**  
**/**  
**“MONGREL”**  
**,**  
**[DEFECT]**

**/“MANDELEVIUM”,**

*/“MDA”,*

*# functional Parameters*

*STOP\_SINGULIER =/“YES”*

*, [DEFECT]*

*/*

*“NOT”*

*,*

*NPREC*

*=*

*/*

*8*

*,*

*[DEFECT]*

*/*

*nprec*

*,*

*[I]*

*# Factorization “traditional” of Gauss type:*

*/*

*METHOD*

*=*

*“LDLT”,*

*# Parameter numerical*

**RENUM**

=

/

**“RCMK”**

,

**[DEFECT]**

/

**“WITHOUT”**

,

**# functional Parameters**

**STOP\_SINGULIER =/“YES”**

**, [DEFECT]**

/

**“NOT”**

,

**NPREC**

=

/

**8**

,

**[DEFECT]**

/

**nprec**

,

**[I]**

**# “multi-frontal” Factorization of the type with MUMPS:**

/

**METHOD**

=

**“MUMPS”**,

**TYPE\_RESOL =/“CAR”**

**, [DEFECT]**

**/**

**“NONSYM”**

**,**

**/**

**“SYMGEN”**

**,**

**/**

**“SYMDEF”**

**,**

**-6**

**RESI\_RELA**

**=**

**/**

**10**

**,**

**[DEFECT]**

**/**

**resi**

**,**

**[R]**

**PCENT\_PIVOT**

**=**

**/**

**20**

**,**

**[DEFECT]**

**/**

*pcpiv,*  
*[R]*

*# iterative Method of the combined gradient:*

*/*  
*METHOD*  
*=*  
*“GCPC”,*

*# Parameters numerical*

*PRE\_COND*  
*=*  
*“LDLT\_INC”*  
*,*  
*[DEFECT]*

*NIVE\_REPLISSAGE*  
*= /*  
*0*  
*,*  
*[DEFECT]*  
*/*  
*niv*  
*,*

*# functional Parameters*

*NMAX\_ITER*  
*=*  
*/*  
*0*

,  
**[DEFECT]**  
/  
*niter,*  
**[I]**  
**-6**

**RESI\_REL**

=  
/  
**10**

,  
**[DEFECT]**  
/  
*resi*  
,  
**[R]**

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*# Method of decomposition of fields FETI:*

/

**METHOD**

=

**“FETI”**,

*# functional Parameters*

**PARTITION**

=

*sdfeti*

**NMAX\_ITER**

=

/

0

,

**[DEFECT]**

/

*niter,*

*[I]*

*-6*

*RESI\_RELA*

*=*

*/*

*10*

*,*

*[DEFECT]*

*/*

*resi*

*,*

*[R]*

*# Parameters of the problem of interface*

*PRE\_COND*

*=*

*/*

*“LUMPE”*

*, [DEFECT]*

*/“WITHOUT”,*

*SCALING =/*



*“MULT”*

,  
*[DEFECT]*

/  
*“WITHOUT”*

,

*TYPE\_REORTHO\_DD=*

/  
*“GSM”,*  
*[DEFECT]*

/  
*“GS”*

,

/  
*“IGSM”*

,

/  
*“WITHOUT”*

,

*NB\_REORTHO\_DD*

= /  
*0*

,  
*[DEFECT]*

/  
*nb\_reortho,*  
*[I]*

*# Parameters of the local problems*

*RENUM*

=  
/

*“MONGREL”*

,  
*[DEFECT]*

*/“MANDELEVIUM”,*

*/“MDA”,*

*STOP\_SINGULIER =/“YES”*

*, [DEFECT]*

*/*

*“NOT”*

*,*

*NPREC*

*=*

*/*

*8*

*,*

*[DEFECT]*

*/*

*nprec*

,  
*[I]*

*# Parameters of tests, various*

*VERIF\_SDFETI*

=  
/“YES”

,  
*[DEFECT]*  
/“NOT”

,  
-6

*TEST\_CONTINU*

= /10 ,  
*[DEFECT]*

*/test\_continu, [R]*

*STOCKAGE\_GI*

=  
/“CAL”

,  
*[DEFECT]*

/“YES”,  
/“NOT”,

*INFO\_FETI*

=  
/“FFFFFFFFFFFF”,  
[DEFECT]  
/info\_feti,  
[K9]

*# Parameter for parallelism*

*NB\_SD\_PROCO* =/  
0  
,  
[DEFECT]  
/  
nb\_sdproc0,  
[I]

*# Parameter for accelerations (problem of the multiples type second members)*

*ACCELERATION\_SM*

=  
/“YES”  
,  
[DEFECT]  
/“NOT”  
,

*NB\_REORTHO\_INST*

=  
/0  
,  
[DEFECT]

/nb\_reortho\_inst,  
[I]

*# Parameter common to all the solveurs*

*SYME =/  
"NOT"  
,  
[DEFECT]*

*/"YES",*

),  
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### **3 Operands**

#### **3.1 Operand**

##### **METHOD**

**METHOD =**

*This key word makes it possible to choose the method of resolution of the linear systems:*

*/"MULT\_FRONT" direct Solveur of type "multi-frontal". Matric storage is "MORSE" (defect)*

*and thus proscribed any swivelling. This method is paralleled in memory divided (OpenMP) and can be carried out on several processors (via small the Astk interface Options Options of launching). The initial matrix is stored in only one object JEVEUX and its factorized is distributed on several, therefore can be discharged partially and automatically on disc.*

*/"LDLT"*

*Direct Solvor with factorization of Crout per blocks (without swivelling). matric storage is "line of sky" or "SKYLINE". There is a pagination completely skeletal memory (the matrix is broken up in blocks managed in memory independently and discharged on disc progressively) which makes it possible to pass from large case but which pay by accesses expensive discs.*

## ***/“MUMPS”***

***Direct Solvor of type “multi-frontal” with swivelling. This solvor is obtained while “connecting” on library MUMPS developed by CERFACS-ENSEEIH-Parallab (see lower copyright). For Code\_Aster, its interest principal resides in its capacity to swivel lines and/or columns of the matrix during factorization in the event of small pivot.***

***This possibility is useful (even essential) for the models leading to positive nondefinite matrices (except conditions to limits); for example, “mixed” elements having ddls of the type “Lagrange” (incompressible elements...).***

***By means of computer, this solvor poses two problems: he requires one compiler fortran90 and it are necessary to share the memory between JEVEUX and library MUMPS (use of the button “mem\_aster” of small the OPTIONS ASTK).***

## ***/“GCPC”***

***Iterative Solvor of gradient type combined with prepacking ILU (K). The storage of the matrix is then “MORSE”. The initial matrix and its factorized incomplete are stored, each one, in only one object JEVEUX.***

## ***/“FETI”***

***Solvor by decomposition of fields of the type FETI: combined gradient packaged projected (GCPPC) for the problem of interface and solvor direct multi-frontal for the inversions of the local matrices of rigidity. Local problems being reversed by multi-frontal “the MULT\_FRONT”, their associated matrices, local and factorized matrices of rigidity, are treated like such (cf above). This method is paralleled in distributed memory (MPI).***

***The default values of the other key words are then taken automatically according to selected method.***

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***Robustness***  
***Memory***  
***CPU***  
***Parameter setting***  
***Small standard Case***  
***(Very) large***  
***(RAM/Disque)***  
***case***  
***(<106***  
***case***  
***(<103***  
***DDL)***  
***(>106 DDL)***  
***DDL)***  
***MULT\_FRONT***  
***Good***  
***RAM: weak***  
***Good***  
***Nothing to make***  
***not***  
***yes***  
***Yes and rather***  
***DEFECT***  
***Disc: important***  
***with the version***  
***parallel***  
***LDLT***  
***Good***  
***Because of***  
***Expensive***  
***Nothing to make***  
***yes***



*not*  
*not*  
*pagination one can*  
*to modulate the distribution*  
*RAM/disque*  
*MUMPS*  
*Very good*  
*RAM: important*  
*Good*  
*Nothing to make*  
*yes*  
*yes*  
*not*  
*Disc: weak*  
*GCPC*  
*Very*  
*Very variable according to*  
*Very*  
*To adapt to*  
*yes Yes*  
*so Rather not*  
*variable*  
*the level of*  
*variable*  
*individually*  
*thermics or*

*prepacking*  
*according to*  
*Pb mechanics*  
*level of*  
*well*  
*précondi*  
*conditioned*  
*tionnement*  
*FETI*  
*Rather good*  
*RAM: weak*  
*Good*  
*To adapt to*  
*not*  
*Yes with with*  
*Yes with with*

*Disc:*  
*individually*  
*less 104 DDL minus 104 DDL*  
*important in*  
*by under*  
*by under*  
*sequential, weaker*  
*field and one*  
*field*  
*in parallel.*  
*interface*  
*and with one*  
*proportion*  
*interface*  
*reasonable by*  
*proportion*  
*report/ratio with*  
*reasonable by*  
*cut*  
*report/ratio with*  
*problem*  
*cut*  
*(<10%)*  
*problem*  
*(<10%)*  
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### 3.2

#### **METHOD: "MULT\_FRONT"**

*RENUM =*

*This argument makes it possible to renumber the nodes of the model:*

*/"MANDELEVIUM"*

*("Degree Minimum") this classification of the nodes minimizes the filling of stamp during its factorization.*

*/"MDA"*

*("Approximate Degree Minimum") this classification is in theory less optimal than "MANDELEVIUM" with regard to the filling but it is more economic with to calculate. It is however preferable with "MANDELEVIUM" for the large models (50 000 ddls).*

*/"MONGREL" Another method of classification based on an encased dissection. This method (defect) is not possible that on the waiter of calculation dedicated to the project Aster (Alpha Waiter TRU64) except installing oneself the achievable MONGREL. On this machine, it is the most effective method (in time CPU and memory).*

*STOP\_SINGULIER = "YES" (defect)/"NOT"*

*When at the end of factorization, one notes that a diagonal term of became very small (compared to what it was before factorization D), it is that the matrix is (probably) almost singular.*

*D*

*That is to say  $N = \log$ , this report/ratio magnitude indicates that on an equation (at least) one lost N of significant figures.*

*If  $N > nprec$  (key word NPREC below), one considers that the matrix is singular. If the user indicated: STOP\_SINGULIER = "YES", the code stops then in FATAL ERROR, if not the execution continues with emission of an alarm.*

**Note:**

*Any important loss of significant figures during a factorization is an indicator of one badly posed problem. Several causes are possible (nonexhaustive list):*

.  
*boundary conditions insufficient of blocking of the structure,*

.  
*redundant linear relations,*

.  
*very heterogeneous numerical data (too large terms of penalization),...*

*NPREC = nprec (défaut=8)*

*It is the number which is used to determine if the matrix is singular (or not) (cf key word STOP\_SINGULIER above).*

### **3.3**

#### **METHOD: “LDLT”**

*RENUM =*

*This argument makes it possible to renumber if it is wished the nodes of the model:*

*“WITHOUT”*

*One keeps the initial order given in the file of grid,*

*“RCMK”*

*“Reverse Cuthill-MacKee”, this algorithm of renumerotation is often effective (defect) to reduce the place necessary to storage “line of sky” of the assembled matrix and to reduce time necessary to the factorization of the matrix.*

*STOP\_SINGULIER*

*See [§3.2].*

*NPREC*

*See [§3.2].*

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### **3.4**

#### **METHOD: "MUMPS"**

##### **3.4.1 General**

*Solvor MUMPS developed by CERFACS-ENSEEIH-Parallab is a direct solver of type multi-frontal paralleled (MPI) and robust because it makes it possible to swivel the lines and columns of the matrix during numerical factorization.*

*Although he is a direct solver, its use in Code\_Aster is connected more with the iterative solver GCPC: one cannot use it in the operator modal nor in conjunction of the key word STOP\_SINGULIER='DECOUPE'.*

*The reason is that MUMPS (called by Code\_Aster) does not give information on the quality of factorization (as MULT\_FRONT and LDLT do it: to see key word NPREC). One thus does not know to determine if a matrix is "close" to the singularity during its factorization.*

##### **3.4.2 TYPE\_RESOL**

*This key word makes it possible to choose the type of resolution MUMPS:*

*"NONSYM" must be selected for the nonsymmetrical matrices.*

*"SYMGEN" must be selected for the positive nondefinite symmetrical matrices. It is the case more general in Code\_Aster because of dualisation of the boundary conditions by coefficients of Lagrange.*

*"SYMDEF" can be selected for the positive definite symmetrical matrices. There is no swivelling.*

*If the user leaves the default value ("CAR"), the code will not choose "NONSYM" for the matrices symmetrical and "SYMGEN" for the symmetrical matrices.*

*It is not interdict to choose "NONSYM" for a symmetrical matrix. That will probably double it*

*cost of calculation but this option gives to MUMPS more possibilities of swivelling while breaking initial symmetry.*

### **3.4.3 RESI\_RELA**

*This key word makes it possible to choose the precision awaited for the resolution. This value is the relative residue acceptable maximum (1.d-6 by defect). If this precision is not reached, the code stops in fatal error.*

### **3.4.4 PCENT\_PIVOT**

*This key word makes it possible to choose a percentage of memory that MUMPS will hold at the beginning of calculation for its swivellings. The default value is 20% which corresponds to a number of swivellings reasonable. If for example MUMPS estimates at 100 the place necessary to a factorization without swivelling, it will allocate actually 120. Thereafter, if the number of swivellings is more important than envisaged, the place allocated memory will be insufficient and the code will stop in fatal error while requiring to increase PCENT\_PIVOT. For certain calculations, it is necessary "to push" PCENT\_PIVOT up to 500! what wants to say that the overcost of the swivelling is 500%.*

### **3.4.5 COPYRIGHT**

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*Instruction manual*

*U4.5- booklet: Methods of resolution*

*HT-62/06/004/A*

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**Code\_Aster** ®

Version

8.2

Titrate:

Key word SOLVEUR

*Date:*

*31/01/06*

*Author (S):*

*J. PELLET, O. BOITEAU Key*

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*[1] P.R. Amestoy, I.S. Duff and J. there. The Excellent one (1998), Multifrontal parallel distributed symmetric and unsymmetric solvers,*

*in Comput. Methods in Appl. Mech. Eng., 184, 501-520 (2000).  
Year early version appeared have has Technical Report ENSEEIHT-IRIT (1998)  
and is available At <http://www.enseeiht.fr/apo/MUMPS/>.*

*[2] P.R. Amestoy, I.S. Duff, J. Koster and J. there. The Excellent one,  
With fully asynchronous multifrontal solver using distributed dynamic  
scheduling, SIAM Newspaper of Matrix Analysis and Applications,  
Flight 23, No 1, pp 15-41 (2001).  
Year early version appeared have has Technical Report ENSEEIHT-IRIT,  
RT/APO/99/2 (1999) and is available At  
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### **3.5** **METHOD: "GCPC"**

*PRE\_COND = "LDLT\_INC" (defect)*

*Method of prepacking: the matrix of prepacking is obtained by one  
incomplete decomposition **LDLT** of the assembled matrix.*

*NIVE\_REMPLISSAGE  
= / 0  
(defect)  
/  
niv*

*The matrix of prepacking (**P**) used to accelerate the convergence of the gradient  
combined by factorizing in a more or less complete way the initial matrix (**A**) is obtained.  
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*If niv = 0*

*P has same storage that A. factorization is incomplete because one does not use for calculations that the terms which one can store in A.P thus represents an approximation (poor) of AI; its storage is thus more reasonable.*

*If niv = 1*

*One stores in P in addition to the terms which had their place in initial storage, them "downward" of first generation of the initial terms. Indeed during factorization, one null term in A can become nonnull in P. One obtains thus the filling of level 1.*

*If niv = 2,...*

*The same process is taken again: the matrix P filled on the level niv-1 creates the terms of stamp P on the level niv.*

*The larger niv is, the closer the matrix P is to AI and thus more the combined gradient converge quickly (in iteration count). On the other hand, more niv is the great more storage of P becomes bulky (in memory and on disc) and more the iterations are expensive in CPU. The first tests showed (roughly) that the size of P was worth:*

*.  
1\*taille (A) for niv = 0*

*.  
3,5\*taille (A) for niv = 1*

*.  
7,5\*taille (A) for niv = 2*

*Our experiment of this key word is still limited and we advise to use the value by defect (niv = 0). If niv = 0 does not allow the gradient combined to converge, one will test successively the values niv = 1, 2, 3...*

*NMAX\_ITER*

*= niter*

*(défaut=0)*

*Maximum iteration count of the iterative algorithm of resolution. If niter = the 0 then number*

*maximum of iterations is calculated as follows:*

*niter = nequ/2 where nequ is the number of equations of the system.*

*RESI\_RELA*

*= resi*

*(défaut=10-6)*

*Criterion of convergence of the algorithm: it is a relative criterion on the residue:*

*rm resi*

***B***

***R***

*with*

*residue*

*is*

*iteration m*

*m*

***B***

*member*

*second*

*is*

*and*

*euclidienn*

*normalizes*

***E***

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**3.6**

***METHOD: "FETI"***

*PARTITION = sdfeti*

*Name user of object SD\_FETI describing partitioning in under-fields. It is generated by a call preliminary to operator DEF1\_PART\_FETI [U4.23.05].*

***Appear 3.6-a: Example of structure (zone of mixture of a circuit RRA) partitionnée in 10 under-fields***

*NMAX\_ITER*

*= niter*

**(défaut=0)**

*Maximum iteration count of the GCPPC solving the problem of interface. If  $niter = 0$  then it numbers maximum iterations is calculated as follows:*

*$niter = \max(nbi/100, 10)$  where  $nbi$  the number of unknown factors of the problem of interface.*

**RESI\_RELA = resi (défaut=10-6)**

*Criterion of convergence of the algorithm: it is a relative criterion on the projected residue of the problem of interface*

**Prm resi**

**B**

**R**

*with*

*residue*

*is*

*iteration  $m$*

*$m$*

***P*** *the operator projection*

*of*

**B**

*member*

*second*

*is*

*and*

*euclidienn*

*normalizes*

*E*

*PRE\_COND*

=

*This argument makes it possible to choose the type of preconditionnor for the GCPPC:*

*“WITHOUT”*

*No prepacking.*

*“LUMPE” lumpé Prepacking.*

*(defect)*

*Normally the lumpé preconditionnor leads to a profit in iterations and CPU, without overcost memory.*

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*SCALING*

=

*This argument makes it possible to choose the type of scaling (put on the scale) adoptee for preconditionnor. It is thus taken into account only if PRE\_COND is different from “WITHOUT”.*

*“WITHOUT”*

*No the phase of scaling.*

“MULT”

*Scaling by the multiplicity of the nodes of interface.*

**(defect)**

*Normally the phase of scaling leads to a profit in iterations and CPU, without overcost memory. Especially when partitioning produces many assemblage points (points belonging to more than two under-fields).*

TYPE\_REORTHO\_DD

=

*This argument makes it possible to choose the type of reorthogonalisation of the directions of descent (to the centre*

*of a resolution of system linear or between various resolutions cf ACCELERATION\_SM). It is related to parameter NB\_REORTHO\_DD.*

“WITHOUT”

*No the reorthogonalisation of the methods of descent.*

“GS”

*Réorthogonalisation of Gram-Schmidt.*

“GSM”

*Réorthogonalisation of Modified Gram-Schmidt.*

**(defect)**

“IGSM”

*Réorthogonalisation of Iterative Modified Gram-Schmidt.*

*This phase makes it possible to fight against the propensity of the directions of descent of the GCPPC to lose*

*their orthogonality. In theory, IGSM is better than GSM which is him even higher than GS. In practical, the best compromise “overcost calculation/quality of orthogonality” is often carried out by GSM.*

NB\_REORTHO\_DD = nb\_reortho (**défaut=0**)

*A number of initial directions of descent used in the phase of reorthogonalisation. In principle, more it is large, better is convergence, but greater east also the overcost calculation and memory. It is thus necessary to find a compromise between these elements.*

*If nb\_reortho = 0 then this number is calculated as follows:*

*nb\_reortho = max (niter/10,5) where niter the maximum number of definite iterations above.*

RENUM

*See [§3.2].*

## *STOP\_SINGULIER*

*See [§3.2].*

## *NPREC*

*See [§3.2].*

*VERIF\_SDFETI = “YES” (defect)/“NOT”*

*One enters the inconsistencies in term of name of model and of names of loading, enters the parameter setting of the operator calling the key word SOLVEUR and that provides to the operator partitioning which remains stored in the SD\_FETI. It is necessary that the names of models are identical and that the list of the loadings of the appealing operator is included in that of DEFI\_PART\_OPS. If it is not the case and if VERIF\_SDFETI = “YES”, one stops in ERREUR\_FATALE, if not an ALARM is emitted.*

## *TEST\_CONTINU*

*= test\_continu*

*(défaut=10-6)*

*Criterion of the test of continuity to the interface: it is a relative criterion on the values (nonnull) of unknown factors with the interface. If one is in top of the criterion, it y' has emission of an ALARM.*

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*STOCKAGE\_GI = "CAL" (defect)/"YES"/"NOT"*

*When the number of under-fields increases, an object becomes prominent, it is **GI** the matrix traces of the rigid modes of body on the interface. It is used in the phase of projection, i.e.  $10 + \text{nombre\_itérations\_FETI} * 4$ . To allow the user to adapt it compromise "cuts memory/time CPU", its storage is skeletal:*

- If STOCKAGE\_GI = "YES", it is calculated and stored once for all. That require more memory but less time calculation when one makes use of it.*
- If STOCKAGE\_GI = "NOT", it is the reverse, it is recomputed with each time that is necessary.*
- If STOCKAGE\_GI = "CAL", the choice "YES" or "NOT" will be calculated automatically. If the size of the matrix is lower than the average size of the local matrices of rigidity, one store ("YES"), if not, one recomputes ("NOT").*

*INFO\_FETI = info\_feti (défaut=' FFFFFFFFFF')*

*Its pre, character string allowing to parameterize postings of algorithm FETI and postprocessings as well as its tests of coherence. This monitoring is independent of the key word INFORMATION. Being often very verbeux and sometimes expensive in memory and CPU, it must be used of*

*preference on small cases and rather for activities of developments.*

- If INFO\_FETI (1: 1) = ' You: general unfolding of the algorithm.*
- If INFO\_FETI (2: 2) = ' You: contents of the structures of data except CHAM\_NO and MATR\_ASSE.*
- If INFO\_FETI (3: 3) = ' You: contents of the structures of data CHAM\_NO and MATR\_ASSE.*
- If INFO\_FETI (4: 4) = ' You: posting of intermediate variables.*
- If INFO\_FETI (5: 5) = ' You: details of the routines of assemblies.*
- If INFO\_FETI (6: 6) = "You: tests of validity of the modes of rigid bodies.*
- If INFO\_FETI (7: 7) = "You: test of the definite-positivity of the operator of interface. One calculate then the  $n_{\text{max\_freq}} = \min(n_{\text{bi}} - 2, n_{\text{b\_reortho}})$  eigenvalues via the algorithm IRAM [R5.01.01] while projecting on a space of size  $\text{dim\_sous\_espace} = \min(n_{\text{bi}}, n_{\text{iter}})$ . Option sells by auction only into sequential.*
- If INFO\_FETI (8: 8) = "You: test of orthogonalities of the GCPPC.*
- If INFO\_FETI (9: 9) = "You: profiling (time CPU + system) of the various stages of resolution of the problem of interface FETI, the GCPPC, (projection, operator FETI, reorthogonalisation, restartings...).*
- If INFO\_FETI (10: 10) = "You: postings dedicated to parallelism MPI.*
- If INFO\_FETI (11: 11) = "You: general postings (size of the interface, the matrices of rigidity local and their factorized, a total number of rigid modes...) and profiling stages upstreams of solvor FETI (time CPU + system of the phases of calculations*



*elementary, of assemblies, factorizations symbolic system and numerical) detailed by under-field or by processor.*

*NB\_SD\_PROC0 = nb\_sdproc0 (défaut=0)*

*Parameter used in parallel mode MPI, allowing to allot a number of under-fields arbitrary with processor 0 (the “Master”). This number can thus be lower than that which would be to him*

*allotted by the automatic procedure of distribution “under-fields/processors”. That allows to relieve it, in CPU and memory capacity, compared to the other processors because it must to manage additional stages and potentially bulky objects JEVEUX (phase of reorthogonalisation, projections of the coarse problem...).*

*It is active only if it is licit:  $nb\_sdproc0 > 0$  and  $nb\_sdproc0 < nbsd - nbproc + 1$  ( $nbproc$ , a number of processors and  $nbsd$ , a number of under-fields).*

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**ACCELERATION\_SM**

=

*This argument makes it possible to activate the phase of acceleration of a problem with multiple second members (for example, a calculation of elasticity with thermal loadings depending on time). When it is activated, the GCPPC of solver FETI will not start its process in on the basis of zero, but on the contrary will be based on information a priori, that of the directions of descent stored with the nb\_reortho\_inst not of previous times. One thus will gain much in iteration count and thus in CPU, by conceding little in memory enough (if the interface is weak in front of the size of the problem).*

“YES”

*Activated acceleration if the conditions are met (see low).*

**(defect)**

“NOT”

*Decontaminated acceleration.*

*This argument is related to parameter NB\_REORTHO\_INST and is activated only if the problem is one succession of linear systems to second members different and if the reorthogonalisation from directions of descent, within each step of time, is activated (TYPE\_REORTHO\_DD different from “WITHOUT”).*

**NB\_REORTHO\_INST = nb\_reortho\_inst (défaut=0)**

*With a step of time given, it is the number of steps of previous times which one will use them directions of descent for the procedure of acceleration. In theory, more it is large, better is convergence, but greater east also the overcost calculation and memory. One thus should be found compromise between these elements.*

If  $nb\_reortho\_inst = 0$  then this number is calculated as follows:

$$nb\_reortho\_inst = \max(nb\_pas\_temps/5, 5)$$

where  $nb\_pas\_temps$  is the number of steps of time of the problem.

And if, with the step of time  $num\_pas\_temps$ ,  $nb\_reortho\_inst$  is higher than the number of steps of previous times available (e.g. to the 5<sup>ième</sup> not of time one can use only the 4 steps of former times) one dynamically fixes it at this value:

$$nb\_reortho\_inst = num\_pas\_temps - 1.$$

### 3.7 Word

key

**SYME**

*SYME*

=

/“YES”

/

“NOT”

If the matrix of linear system **A** is not-symmetrical, the key word **SYME** = “YES” allows to symmetrize this matrix before the resolution of the system. The matrix then is replaced by

1

$A' = ($

$T$

**WITH** + **A**).

2

#### **Caution:**

The symmetrization of matrix **A** thus results in solving another problem that that which one seeks to solve! Actually, this possibility (**SYME** = “YES”) is useful only in non-linear orders (like **STAT\_NON\_LINE** for example), for which convergence towards the solution is obtained by successive iterations. Each reiterated is obtained by “estimate” and one checks then that it is “solution”. In this case, a light error on reiterated does not prevent from converging towards the good solution. The interest of this key word is of

to save time at the time of the resolution of the linear systems. The whole is to know if does symmetrization disturb much (or not) the solution of the linear system? One can quote (by example) the case of the models 3D (or hull) with following pressure for which symmetrization saves much time.

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## **4 Examples**

### **4.1**

**Solvor by defect**

*There is nothing to write! But one can also write: SOLVEUR=\_F ()*

### **4.2 Gradient**

**combined**

*One wants to use the combined gradient. It is thought that convergence will be more effective if one authorizes*

*a more thorough prepacking (NIVE\_REMPLISSAGE=1).*

*SOLVEUR=\_F (METHOD = ' GCPC', NIVE\_REMPLISSAGE=1,)*

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***Key word SENSITIVITY***

***1 Goal***

***Calculations of sensitivity of a result compared to a parameter are controlled by the insertion of the key word***

***SENSITIVITY in the order which produces the result. It is thus detailed in this document, in specifying the limits of validity. Indeed sensitivities of all the results compared to all them parameters all are not available!***

***Generally, for a creation of result, that means that one wants to calculate the derivative of usual result compared to the indicated parameters. It is what occurs for the operators principal***

***THER\_LINEAIRE,***

***THER\_NON\_LINE,***

**MECA\_STATIQUE,**  
**MODE\_ITER\_SIMULT,**  
**MODE\_ITER\_INV, STAT\_NON\_LINE, DYNA\_LINE\_HARM, DYNA\_LINE\_TRAN,**  
**DYNA\_NON\_LINE** or  
*for the operators of enrichment of results **CALC\_G\_THETA\_T, CALC\_ELEM, CALC\_NO** and **NORM\_MODE.***

*For a postprocessing of results, that means that one is not interested in the result in itself but with its derivative compared to the indicated parameters. It is what occurs for the operators **IMPR\_RESU, POST\_RELEVE\_T, RECU\_CHAMP, EXTR\_RESU** and **TEST\_RESU.***

*The sizes given in the list associated with the key word **SENSITIVITY** are of two types:*

- of the significant parameters, **para\_sensi,***
- of the fields **theta, theta\_geom,** for Lagrangian derivations.*

**Note:**

*One will refer to the document [U2.08.02] for a general note on calculations of sensitivity. The theoretical bases of these calculations of sensitivity are described in:*

*[R4.03.01]: Sensitivity of the thermomechanical fields to a variation of the field*

*[R4.03.02]: Calculation of sensitivity in thermics*

*[R4.03.03]: Calculation of sensitivity in mechanics*

*[R4.03.04]: Calculation of sensitivity in dynamics*

*[R4.03.07]: Calculation of sensitivity in postprocessings*

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## 2 Syntax

***(SENSITIVITY***

***=***

***(ps1, ps2,...)***

***[l\_para\_sensi]***

***(theta1,***

***theta2,***

***...)***

***[l\_theta\_geom)***

***)***

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### 3 Operand

***SENSITIVITY***

***SENSITIVITY =***

***This key word makes it possible to choose the parameters by report/ratio to which one derives the result.***

***They are significant parameters, defined by order DEFI\_PARA\_SENSI (cf document [U4.31.04]):***

*ps1,  
ps2,... [l\_para\_sensi]*

*That can also be fields theta in the case of derivation compared to the field geometrical:*

*theta1, theta2,... [l\_theta\_geom]*

*The key word SENSITIVITY can be followed of 1 or several names of parameters. Their order is indifferent. On the other hand, the key word itself can be present only once in order.*

#### **4 Convention of drafting**

*We will review the three types of operators who accept the key word SENSITIVITY: main line operator, of enrichment, postprocessing.*

*Main line operator: it is an operator who carries out the resolution of the problem and creates one new structure of result. They are the THER\_LINEAIRE, MECA\_STATIQUE, etc In it case, the insertion of the key word SENSITIVITY means that Code\_Aster will calculate the result usual, but also each one of derived from this result compared to each one of parameters transmitted by the key word.*

*Operator of enrichment: it is an operator who starting from the principal result (temperature, displacement,...) product of the secondary results (flow, forced,...). They are them operators CALC\_ELEM and CALC\_NO for example. In this case, the insertion of the key word SENSITIVITY means that Code\_Aster will calculate the derivative of the secondary result by report/ratio with each parameter transmitted by the key word.*

*Operator of postprocessing: it is an operator who does not make calculation but which puts in form a result to make it available to the user. They are the operators POST\_RELEVE\_T, IMPR\_RESU for example. In this case, the insertion of the key word SENSITIVITY means that Code\_Aster will exploit the derivative of the result compared to each parameter transmitted by the key word. Attention, only these derivative are exploited.*

*In the continuation of this document, we will enumerate the operators concerned with the sensitivity.  
By*



*convention, only the operators mentioned hereafter are concerned. In the same way, for an operator given, only the types of derivations mentioned are accessible.*

*Unless otherwise specified, all the derivative accessible are it for all the types of elements, for all types of model and as well in hover as in transient.*

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*5*

*In a main line operator*

*5.1 General*

*The main line operator calculates the principal result and his derivative.*

*Example:*

```
reth = THER_LINEAIRE  
(MODEL = model,  
CHAM_MATER = chmat,  
EXCIT = (...),  
SENSITIVITY = (ps1, ps2));
```

*This sequence will solve a linear problem of thermics and will produce the structure of result reth. This structure contains the field of temperature TEMP. Moreover, there will be calculation of derived from*

*the temperature compared to ps1 and of derived from the temperature compared to ps2. These derivative*

*have same nature as the temperature: they are represented in the shape of fields to the nodes. These fields are then easy to handle like the usual field of temperature: extraction of values, impressions, etc*

*In a subjacent way, there is creation of as many structures of results of sensitivities asked. Their names are established automatically by the program. They do not have to be known explicitly because one will always accèdera with information by a couple (name of standard result, name parameter of sensitivity). Each field which makes one of these structures of results the derivative of this field compared to the parameter of sensitivity concerned will contain.*

*Example:*

*The field TEMP of the structure reth of the evol\_ther type contains the field of temperature with nodes of standard calculation. The field TEMP of the structure of the evol\_ther type known by the couple (reth, ps1) the field with the nodes of the derivative partial of the temperature will contain compared to*  
*T*

*ps1,*  
*. The same rule applies to all the fields which will be calculated by enrichment.*  
*1*  
*PS*

## *5.2 Operator*

### *THER\_LINEAIRE*

#### *5.2.1 By*

*ameters*  
*sensitive*

*It is possible to derive the field from temperature compared to a significant parameter when it was used to define:*

*.  
a condition of imposed temperature,*

*.  
a loading:*

*- source,  
- flow,  
-*

*coefficient of exchange and outside temperature,*

-  
*coefficient of walls exchange,*

*a material:*

- *conductivity*

*thermics*

,  
- *heat*

*voluminal*

*CP.*

*Note:*

*Derivations in the problems of linear thermics in hull are not available.*

*One will look at the test [V1.01.151] for an example of sensitivity in linear thermics.*

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*5.2.2 Derivation*

*Lagrangian*

*Derivation known as “Lagrangian” makes it possible to calculate the sensitivity of the field of temperature*

*position of the edge of the field. That is not possible that for modelings “PLAN” and “AXIS”.*

*The edge by report/ratio to which one wishes to derive the temperature must be rectilinear, parallel to the axis of*

*y. The matter must be “on the right” of this edge.*

*y*

*Edge*

*Matter*

*The designation of this edge is made by the data of a field “theta”:*

*SENSITIVITY = (theta)*

*This field is defined by operator CALC\_THETA, by using option THETA\_BANDE to give position of the edge cf [U4.82.02].*

*Note:*

*There is no checking of coherence between the data of the X-coordinate of the edge in definition of the field theta and the position of the edge such as it is defined in the grid. One will look at the test [V7.01.101] for an example of Lagrangian derivation in thermics.*

*5.3 Operator*

*THER\_NON\_LINE*

*It is possible to derive the field from temperature compared to a significant parameter when it was used to define:*

•  
*a condition of imposed temperature,*

•  
*a loading:*

- *source,*

-  
*linear and nonlinear flow,*

- *emissivity,*

- *temperature*

*with*

*the infinite one,*

-  
*coefficient of exchange and outside temperature,*

-  
*coefficient of walls exchange,*

•  
*a material:*

- *conductivity*

*thermics*

,  
- *heat*

*voluminal*

*CP.*

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***Derivation is available for the isoparametric finite elements and following modelings:  
PLAN, PLAN\_DIAG, AXIS, AXIS\_DIAG, 3D and 3D\_DIAG.***

***Note:***

***One will look at the test [V1.01.154] for an example of sensitivity in non-linear thermics.***

## ***5.4 Operator MECA\_STATIQUE***

### ***5.4.1 Parameters sensitive***

***It is possible to derive the field from displacement compared to a significant parameter when it was used to define:***

- a condition of imposed displacement (DDL\_IMPO or FACE\_IMPO),***
- a loading:***
  - a pressure distributed,***
  - a force nodal or distributed linear,***
- a material:***
  - Young modulus for an isotropic, orthotropic elastic law or isotropic-transverse.***
  - Poisson's ratio***

***The functionality of derivation is available in 2D and 3D, isothermal continuous medium, POU\_D\_E.***

***Note:***

***One will look at the test [V1.01.144] for an example of sensitivity in static mechanics.***

### ***5.4.2 Derivations Lagrangian***

***Derivation known as “Lagrangian” applies under the same conditions as for the operator of linear thermics. Only additional restriction: the elements must be degree 2.***

***Note:***

*One will look at the test [V7.01.101] for an example of Lagrangian derivation in mechanics.*

## **5.5 Operator**

**MODE\_ITER\_SIMULT and MODE\_ITER\_INV**

*It is possible to derive the clean, real or complex modes, compared to a significant parameter when it was used to define:*

.

*a condition of imposed displacement,*

.

*a material (available in 2D and 3D, continuous medium, POU\_D\_E):*

*- module*

*of Young,*

-

*Poisson's ratio.*

*The functionality of derivation of the clean modes is not available for the multiple modes.*

**Note:**

*One will look at the test [V1.01.188] for an example of sensitivity of clean modes.*

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## **5.6 Operator**

### **STAT\_NON\_LINE**

*It is possible to derive the field from displacement, constraints and internal variables by report/ratio with a significant parameter when it was used to define:*

- 
- a condition of imposed displacement (DDL\_IMPO or FACE\_IMPO),*
- 
- a condition of the Neumann type:*
  - 
  - a pressure distributed,*
  - 
  - a force nodal or distributed linear,*
  - 
  - a material:*
    - *module of Young*
    - 
    - Poisson's ratio*
    - *limit of elasticity*
    - 
    - slope of the traction diagram after the elastic limit*

*The functionality of derivation is available only for one elastic or elastoplastic structure (Von Mises or Drucker-Prager) with isotropic linear work hardening, in 2D and 3D, continuous medium isotherm, POU\_D\_E (only on the Young modulus and the Poisson's ratio). It available in 2D is not forced plane.*

*Note:*

*One will look at the test [V1.01.181] for an example of sensitivity in static mechanics non-linear.*

## **5.7 Operator**

### **DYNA\_LINE\_HARM**

*It is possible to derive the field from displacement compared to a significant parameter when it was used to define:*

- *a condition of imposed displacement,*
- *a loading:*



- *force nodal,*  
-  
*force distributed linear, surface or voluminal,*  
- *pressure distributed.*

·  
*a material (available in 2D and 3D, continuous medium, POU\_D\_E):*

-  
*Young modulus for an isotropic, orthotropic elastic law or isotropic-transverse,*  
-  
*Poisson's ratio.*

*Note:*

*One will look at the test [V1.01.158] for an example of sensitivity in linear dynamics harmonic.*

## *5.8 Operator DYNA\_LINE\_TRAN*

*It is possible to derive the field from displacement compared to a significant parameter when it was used to define:*

· *a condition of imposed displacement,*  
· *a loading:*  
- *force nodal,*  
-  
*force distributed linear, surface or voluminal,*  
- *pressure distributed,*

·  
*a material (available in 2D and 3D, medium continuous, POU\_D\_E, inalienable for the diagram of integration clarifies with step of adaptive time):*

-  
*Young modulus for an isotropic, orthotropic elastic law or isotropic-transverse,*  
-  
*Poisson's ratio.*

*Note:*

*One will look at the test [V1.01.171] for an example of sensitivity in linear dynamics transient.*

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***5.9 Operator***

***DYNA\_NON\_LINE***

***It is possible to derive the fields from displacement, speed and acceleration compared to one significant parameter when it was used to define:***

***.***

***a condition of the Neumann type:***

***-***

***a pressure distributed,***

***-***

***a force nodal or distributed linear,***

***.***

***a material:***

***- module***

***of Young,***

***-***

***Poisson's ratio,***

***- limit***

***of elasticity,***

***-***

***slope of the traction diagram after the elastic limit.***

***The functionality of derivation is available only for one elastic or elastoplastic structure (Von Mises) with isotropic linear work hardening, in 2D and 3D, continuous medium, POU\_D\_E (only on the Young modulus and the Poisson's ratio). It available in 2D is not forced plane.***

***Note:***

***One will look at the test [V1.01.174] for an example of sensitivity in non-linear dynamics.***

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## **6 In an operator of enrichment**

### **6.1 General**

**The operator of enrichment calculates secondary results starting from the principal result.**

**Example:**

```
reth = CALC_ELEM  
(RESULT = reth,  
MODEL = model,  
EXCIT = (...),  
OPTION = ("FLUX_ELGA_TEMP"),  
SENSITIVITY = (ps1, ps2)),
```

**This sequence will enrich the structure of reth results by calculating the derivative by the heat flux with**

**points of Gauss compared to ps1 and that compared to ps2.**

**These derivative have same nature as flow: they are fields at the points of Gauss. These fields are then easy to handle like the field of usual flow: extraction of values, impressions, etc**

**Note:**

*For making such an enrichment, it is necessary that the derivative of the principal field (temperature, displacement,...) was calculated.*

*The arrangement of the various derived fields is done according to the rule described with [5.1].*

## **6.2 Operator CALC\_ELEM**

**The operator of enrichment calculates secondary results starting from the principal result.**

### **6.2.1 Parameters sensitive**

**In or not linear linear thermics:**

•  
**FLUX\_ELGA\_TEMP: derived from the heat flow.**

**In static mechanics:**

•  
**EPSI\_ELGA\_DEPL: derived from the deformations,**  
•  
**SIEF\_ELGA\_DEPL: derived from the constraints.**

**In transitory linear dynamics:**

•  
**\*\*\*\* \_ \*\*\*\* \_DEPL: derived from the strains or the stresses.**

### **6.2.2 Derivation Lagrangian**

**In linear thermics:**

•  
**DETE\_ELNO\_DLTE: derived eulérienne from the temperature.**

**In static mechanics:**

•  
**DEDE\_ELNO\_DLDE: derived eulérienne from the temperature,**  
•  
**SIEF\_ELGA\_DEPL: Lagrangian derivative of the constraints,**  
•  
**DESI\_ELNO\_DLSI: derived eulérienne from the constraints.**

## **6.3 Operator CALC\_NO**

**There is no particular restriction: as from the moment when the derivative by element was calculated, its projection on the nodes is possible.**

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**6.4 Operator**

**NORM\_MODE**

**It is a question here of multiplying the derivative of the clean vector by a coefficient depend on the standard asked by the user.**

**6.5 Operator**

**CALC\_G\_THETA\_T**

**The rate of refund of energy can be derived. The field of validity is that of the derivation of fields of displacements and associated constraints.**

**It is possible to derive the rate of refund from energy compared to a significant parameter when it has summer used to define:**

.

**a loading:**

-

**a force distributed linear (2D) or surface (3D),**

- a voluminal force (2D or 3D),
- a pressure distributed on the lips of the crack,
- a nodal force,
- a material:
- Young modulus for an isotropic elastic law.

### Limitations:

- It is not possible to derive the rate of refund from energy compared to a condition from imposed displacement because the term corresponding in G is not established.
- The functionality of derivation is available in 2D and 3D, medium continuous.

The result is a table, like the rate of standard refund.

### Example:

`ga = CALC_G_THETA_T (...  
SENSITIVITY = (ps1, ps2)),`

This sequence will produce the derivative of the rate of refund `ga` compared to the significant parameter `ps1`.

The exploitation of this derivative will be done by providing the couple (`ga`, `ps1`); for example, for one impression one will use usual order `IMPR_TABLE`.

### Note:

*One will look at the test [V7.02.101] for an example of sensitivity in breaking process.*

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**In an operator of postprocessing**

## **7.1 General**

**The operator of postprocessing formats the derivatives of the results.**

**IMPR\_RESU (RESU = \_F (GRID = email,  
RESULT = reth,  
NOM\_CHAM = "TEMP"  
SENSITIVITY = (ps1, ps2)) ),**

**This sequence will print the derivative of the field of temperature contained in the reth result compared to ps1 and ps2. Attention, that will not print the standard temperature.**

**One notes in these orders that the name of the structure of results which contains the derivative never appears in light. The structure is always known by the couple (name of standard result, name of the significant parameter). It is what is described with [§5.1].**

## **7.2 Operators concerned**

**The postprocessing of derivations of the results is possible with the following operators:**

.

**IMPR\_RESU: impression of structures of results,**

.

**IMPR\_TABLE: impression of tables,**

.

**POST\_RELEVE\_T: extraction of values,**

.

**TEST\_RESU: comparison of values,**

.

**EXTR\_RESU: extraction of results,**



•  
**CREA\_CHAMP: creation of a field.**

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***Titrate:***

***Operator MECA\_STATIQUE***

***Date:***

***31/01/06***

***Author (S):***

***J. Key PELLET***

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***Operator MECA\_STATIQUE***

## ***1 Goal***

***To solve a problem of static mechanics linear.***

***This operator allows to solve is:***

***.  
a linear static mechanical problem with superposition of various conditions with limits and of various loadings,  
.***

***a thermomechanical analysis for a given list of moments.***

***-  
in this case the mechanical characteristics of materials can depend on temperature: the concept of the `cham_mater` type must then be defined starting from functions (Cf operator `DEFI_MATERIAU` [U4.43.01] operand `ELAS_FO`),  
-***

***the loading of dilation can be given only if one defined the coefficient of dilation and the temperature of reference (cf operators `DEFI_MATERIAU` [U4.43.01] and `AFFE_MATERIAU` [U4.43.03]).***

***The concept produced by this operator is of `evol_elas` type containing one or more fields of displacements at the various moments of calculation.***

***In the case of the static mechanical analysis, one assigns the sequence number 0 (moment 0) to the field solution.***

***Product a structure of data of the `evol_elas` type.***

***When a calculation of sensitivity of the result compared to a parameter is required, there is production of as many structures of data of the `evol_elas` type than of definite parameters of sensitivity.***

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## ***2 Syntax***

***mestat [evol\_elas] = MECA\_STATIQUE***  
***, reuse = mestat,***

***(***  
***MODEL***  
***=***  
***Mo***  
***,***  
***[model]***

***/***  
***CHAM\_MATER***  
***=***  
***chmat***  
***,***  
***[cham\_mater]***

/  
**CARA\_ELEM**  
=  
**carac**  
,  
[*cara\_elem*]

**EXCIT**  
= (**\_F (LOAD = tank**  
,/[*char\_meca*]  
/  
[*char\_cine\_meca*]

**FONC\_MULT=**  
**fmult**  
,/[*function*]  
/[*formula*]

),)

**/INST**  
=

/  
*tps*  
,  
**[R]**

/  
0.  
,  
**[DEFECT]**

**/LIST\_INST**  
=  
/  
*litps*  
,  
**[litr8]**

**INST\_FIN = tf,**

**SOLVEUR = (... to see [U4.50.01]),**

**SENSITIVITY**  
=

(... to see [U4.50.02]),

**OPTION**

=  
/  
“SIEF\_ELGA\_DEPL”, [DEFECT]

/  
“WITHOUT”,

**INFORMATION**

=  
/  
1,  
[DEFECT]

/  
2,

**TITRATE**

= title,  
[I\_K80]

);  
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### **3 Operands**

**3.1 Operands**  
**MODEL/CHAM\_MATER/CARA\_ELEM**

**One provides the arguments allowing to calculate the matrix of rigidity (and the second member):**

**MODEL = Mo,**

**Name of the model whose elements are the subject of mechanical calculation.**

**CHAM\_MATER = chmat,**

**Name of the material field.**

**CARA\_ELEM**  
**= carac,**

**Name of the characteristics of the structural elements (beam, hull, discrete,...) if they are used in the model.**



## **3.2 Word**

**key**

**EXCIT and operands INST/LIST\_INST**

*One defines here the boundary conditions and the loadings.*

**EXCIT**

=

*This key word factor makes it possible to define several concepts of the type charges, one by occurrence;*

*solution is calculated by superimposing the effects of the various loads applied.*

### **3.2.1 Operands**

**CHARGE/FONC\_MULT**

**CHARGE = tank,**

*Name of a concept of the char\_meca type produces by AFFE\_CHAR\_MECA or AFFE\_CHAR\_MECA\_F [U4.44.01] starting from the model Mo. Only one occurrence must make reference to the temperature (load with TEMP\_CALCULEE).*

*One can also give the name of a “kinematic load” (standard char\_cine\_meca) result of operators AFFE\_CHAR\_CINE and AFFE\_CHAR\_CINE\_F [U4.44.03].*

**FONC\_MULT = fmult,**

*Name of a concept of the function type (or formulates) which makes it possible to define for each moment of calculation a multiplying coefficient applied to the load tank.*

*For a thermal loading of origin (dilation) defined by TEMP\_CALCULEE in order AFFE\_CHAR\_MECA [U4.44.01] the field of temperature is not multiplied by fmult.*

*fmult is a function of time: by defect it is a constant function which is worth 1.*

### **3.2.2 Operands**

**INST/LIST\_INST**

**/INST = tps,**

*Key word used to carry out calculation at only one moment tps with the temperature correspondent at this moment.*

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**/LIST\_INST = litps,**

**INST\_FIN = tf,**

**The list litps produced by DEFI\_LIST\_REEL [U4.34.01] defines the moments for which one ask for the calculation of a thermomechanical evolution.**

**Key word INST\_FIN makes it possible to calculate only the moments former or equal to tf.**

**This key word (INST\_FIN) compound with the key word “reuse” (order réentrante) allows to split a long thermomechanical transient.**

**One will make for example:**

**resu = MECA\_STATIQUE (...**

**LIST\_INST = linst, INST\_FIN = 10. ,...)**

**MECA\_STATIQUE (reuse = resu, LIST\_INST = linst, INST\_FIN = 20. ,...)**

**MECA\_STATIQUE (reuse = resu, LIST\_INST = linst, INST\_FIN = 30. ,...)**

**3.3**

**Key word factor SOLVEUR**

**See [U4.50.01].**

### **3.4 Word**

*key*

**SENSITIVITY**

*Activate the calculation of derived from the field of displacement compared to a parameter of the problem.*

*See [U4.50.02].*

### **3.5 Operand**

**OPTION**

**OPTION =/“WITHOUT”**

**/“SIEF\_ELGA\_DEPL”**

*By defect order MECA\_STATIQUE calculates the constraints at the points of Gauss (or efforts generalized for the elements of structure).*

*The other options of postprocessing will be calculated a posteriori by order CALC\_ELEM [U4.81.01].*

*If the user indicates OPTION = “WITHOUT”, these constraints will not be calculated and the structure*

*data produced will be less bulky.*

### **3.6 Operand**

**INFORMATION**

**INFORMATION = 1,**

*Print the principal characteristics of the linear systems to solve: a number of unknown factors, cut matrix.*

### **3.7 Operand**

**TITRATE**

**TITRATE = titr,**

*Titrate that one wants to give to the result [U4.03.01].*

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## ***Operator MECA\_STATIQUE***

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***Examples of calculations***

***4.1***

***Static calculation with superposition of 2 loading cases***

***mest1 = MECA\_STATIQUE (***

***MODEL = Mo, CHAM\_MATER = chmat,***

***CARA\_ELEM***

***=***

***carac,***

***EXCIT = (\_F (LOAD = ch1, FONC\_MULT = COS),***

***\_F (***  
***CHARGE***

***:***

***ch2***

***),), )***

***4.2***

***Thermoelastic calculation at various moments***

***ch\_temp = AFFE\_CHAR\_MECA (***  
***... TEMP\_CALCULEE = evoth... ) );***

***mest2 = MECA\_STATIQUE (***

***MODEL = Mo, CHAM\_MATER = chmat,***

```
EXCIT  
=  
(_F (  
CHARGE  
=  
ch_temp  
),
```

```
_F (LOAD = bloq),),  
LIST_INST  
=  
litps  
)
```

### 4.3 *Sensitivity to an imposed displacement*

```
psx= DEFI_PARA_SENSI (VALE=7.0)  
psy= DEFI_PARA_SENSI (VALE=3.0)
```

```
ch=AFFE_CHAR_MECA_F (MODELE=mo,  
FACE_IMPO=_F (GROUP_MA=' BORD_SUP', DX=psx, DY=psy))
```

```
mest3 = MECA_STATIQUE (  
  
MODEL = Mo, CHAM_MATER = chmat,  
EXCIT  
=  
_F (  
CHARGE  
=  
CH  
)
```

```
SENSIBILITE= (psx, psychiatrist),)
```

*This calculation will produce the structure of data mest3 of the evol\_elas type, containing the field of displacement penny sle name "DEPL". It will produce two other structures of data of the type evol\_elas. The first will contain under the name of field "DEPL", the field of derived from displacement compared to the parameter psx. The second will contain the derivative compared to psychological parameter.*

*The name of these 2 structures is created automatically by the code and remains unknown to the user. The access to their contents (impression, test, post\_releve,...) is done by calling upon the order corresponding with the name of the principal structure, mest3, and the name of the significant parameter concerned (psx or psychiatrist).*

## **5 Remark**

*For certain studies in linear elasticity for which characteristics of rigidity of structure are independent of the thermal history and the boundary conditions kinematics independent of the other loads, one can determine the deformations for several cases of loading by using MACRO\_ELAS\_MULT [U4.51.02].*

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*Titrate:*

*Macro order MACRO\_ELAS\_MULT*

*Date:*

11/02/05

*Author (S):*

**X. DESROCHES, L. VIVAN** *Key*

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***Macro order MACRO\_ELAS\_MULT***

***1 Goal***



*To calculate linear static answers for various loading cases or modes of Fourier.*

*It is supposed that the conditions kinematics (blockings of the structure) and the characteristics of materials are invariant for all the loading cases, which makes it possible to have the same matrix of rigidity.*

*The structure of data produced is of mult\_elas type for the multicas of load or fourier\_elas for calculations of Fourier.*

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*X. DESROCHES, L. VIVAN Key*

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*2 Syntax*

*resu = MACRO\_ELAS\_MULT*

*(*

*reuse*

*=*

*resu,*

*MODEL*

*=*

*Mo,*

*[model]*

**CHAM\_MATER = *chmat*,**  
**[*cham\_mater*]**

**CARA\_ELEM**  
**=**  
***carac*,**  
**[*cara\_elem*]**

**NUME\_DDL = *naked*,**  
**[*nume\_ddl*]**

**/CHAR\_MECA\_GLOBAL**  
**=**  
***lchmg*,**  
**[*l\_char\_meca*]**

**/**  
**CHAR\_CINE\_GLOBAL**  
**=**  
***lchcg*,**  
**[*l\_char\_cine*]**

**/**  
**LIAISON\_DISCRET**  
**=**  
***“YES”*,**

**CAS\_CHARGE=\_F**  
**(**

**/NOM\_CAS = *moncas*, [*kN*]**

**/**

**MODE\_FOURIER**

=

**mode,**

**[I]**

**TYPE\_MODE**

=

/

**“SYME”, [DEFECT]**

/

**“ANTI”,**

/

**“ALL”,**

**/CHAR\_MECA**

**= lcharm, [l\_char\_meca]**

/

**CHAR\_CINE**

=

**lcharc, [l\_char\_cine\_meca]**

/

**VECT\_ASSE**

=

**chdep,**  
**[cham\_no\_depl\_r]**

**OPTION**

=

**option, [l\_Kn]**

**NUME\_COUCHE**

=

/

1,

**[DEFECT]**

/

**nume,**

**[I]**

**NIVE\_COUCHE =/"MOY",**

**[DEFECT]**

/

**"SUP",**

/  
“INF”,

***SOUS\_TITRE = soustitre, [l\_Kn]***

)

***SOLVEUR***  
***=\_F (), [U4.50.01]***

***TITRATE***  
***= title,***  
***[l\_Kn]***

)

***resu is a structure of data RESULT of the type:***

***mult\_elas if key word NOM\_CAS is present,***  
***fourier\_elas if key word MODE\_FOURIER is present.***

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**Version**

**7.4**

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**Macro order *MACRO\_ELAS\_MULT***

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**3 Operands**

**3.1 Operands**

***MODEL/CHAM\_MATER/CARA\_ELEM***

***One provides the arguments allowing to calculate the matrix of rigidity (and second members).***

***MODEL***

***= Mo,***

***Name of the model whose elements are the subject of mechanical calculation.***

***CHAM\_MATER = chmat,***

***Name of the material field.***

***CARA\_ELEM***

***= carac,***

***Name of the characteristics of the structural elements (beam, hull, discrete,...) if they are used in the model.***

**3.2 Operand**

***NUME\_DDL***

***NUME\_DDL = naked,***

***Key word used to name classification for a later use or to use one***

*existing classification. If no name is provided, a classification is created temporarily for each call to MACRO\_ELAS\_MULT.*

### **3.3 Operands**

**CHAR\_MECA\_GLOBAL/CHAR\_CINE\_GLOBAL/  
LIAISON\_DISCRET**

**/CHAR\_MECA\_GLOBAL**  
**= lchmg,**

*Key word defining the boundary conditions mechanical of blocking of the structure. These conditions are the same ones for all the loading cases. They are defined by AFFE\_CHAR\_MECA or AFFE\_CHAR\_MECA\_F [U4.44.01].*

**/**  
**CHAR\_CINE\_GLOBAL**  
**= lchcg,**

*Key word defining the conditions kinematics of blocking (eliminated) of the structure.*

*These conditions are the same ones for all the loading cases. They are defined by AFFE\_CHAR\_CINE or AFFE\_CHAR\_CINE\_F [U4.44.03].*

**/LIAISON\_DISCRET = "YES",**

*This key word is simply used to say that there are not mechanical conditions or kinematics of blocking of the structure.*

### **3.4 Word**

**key**

**CAS\_CHARGE**

*Key word factor allowing to define a loading case.*

*For each occurrence of the key word factor, one builds a second member (except if one uses VECT\_ASSE (in which case the second member is already assembled)) and one résoud the linear system.*

#### **3.4.1 Operand**

**NOM\_CAS**

**NOM\_CAS = moncas,**

*Character string, is used as variable of access to the structure of data result.*

**Note:**

*Each case is named by the user and the concept of sequence number does not exist.*

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**3.4.2 Operands**

**MODE\_FOURIER/TYPE\_MODE**

*MODE\_FOURIER*

*= mode,*

*Positive or null entirety indicating the harmonic of FOURIER on whom one calculates the matrix elementary of rigidity and the elementary vector.*

*TYPE\_MODE*

*= standard,*

*The type of the harmonic will be symmetrical (“SYME”), or antisymmetric (“ANTI”) or symmetrical and antisymmetric (“ALL”) (cf the note of use Fourier [U2.01.07]).*

**3.4.3 Operands**

**CHAR\_MECA/CHAR\_CINE/VECT\_ASSE**

*CHAR\_MECA*

*= lcharm,*



List concepts of the *char\_meca* type produces by *AFFE\_CHAR\_MECA* [U4.44.01] or *AFFE\_CHAR\_MECA\_F* [U4.44.01] starting from the model *Mo*.

*CHAR\_CINE*  
= *lcharc*,

List concepts of the *char\_cine\_meca* type produces by *AFFE\_CHAR\_CINE* [U4.44.03] from model *Mo*.

*VECT\_ASSE*  
= *chdep*,

Concept of the *cham\_no\_depl\_r* type representing the second member of the linear system with to solve.

### 3.4.4 Operands

#### ***OPTION/NUME\_COUCHE/NIVE\_COUCHE***

One asks, if it is wished, of the options of calculation of postprocessing starting from displacements. One can not request these options from this stage of the study to analyze the solution in displacement ; then, in a later work, to supplement the concept produced by using order *CALC\_ELEM* [U4.81.01] or *CALC\_NO* [U4.81.02] orders it.

*OPTION*  
= *option*,

The significance of the options is given in orders *CALC\_ELEM* [U4.81.01] and *CALC\_NO* [U4.81.02].

When the model contains elements of hull, one will be able to specify, if necessary, for calculation of certain options:

*NUME\_COUCHE* = *nume*,

In the case of a multi-layer material, value ranging between 1 and number it layers, necessary to specify the layer where one wishes to carry out elementary calculation. By convention layer 1 is the sub-base. By defect the number of layer is 1 for a full-course element of hull.

*NIVE\_COUCHE* = *nive*,

For the *nume* layer defined by *NUME\_COUCHE*, allows to specify the level in the thickness where one wants to carry out elementary calculation:

*Lower ordered “INF” of the layer (lower skin),  
Higher ordered “SUP” of the layer (higher skin),  
Average ordered “MOY” of the layer (average layer).  
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### **3.4.5 Operand**

**SOUS\_TITRE**

*SOUS\_TITRE = soustitre,*

*Under title which one wants to give to the field result displacement.*

### **3.5 Word**

**key**

**SOLVEUR [U4.50.01]**

*This key word makes it possible to choose the method of resolution of the linear systems. Let us recall that, in the case of the multicases of loads, only one factorization is made for each call to MACRO\_ELAS\_MULT and a resolution for each loading case.*

### **3.6 Operand**

**TITRATE**

*See [U4.03.01].*

#### **4 Examples**

***One will be able to refer to test SSSL14 A [V3.01.014].***

***% definition of the boundary conditions of blocking***

***bloqu = AFFE\_CHAR\_MECA (model MODELE=,***

***DDL\_IMPO= (\_F (TOUT=' OUI'***

***,***

***DZ=0.***

***),***

***\_F (GROUP\_NO= ("A", "B"), DX=0., DY=0.,),))***

***% definition of 4 loadings***

***charg1***

***=***

***AFFE\_CHAR\_MECA (model MODELE=,***

***FORCE\_POUTRE=\_F (GROUP\_MA= "D2", FY= P))***

***charg2***

***=***

***AFFE\_CHAR\_MECA (model MODELE=,***

***FORCE\_NODALE=\_F (GROUP\_NO= “It, FY= F1))***

***charg3***

***=***

***AFFE\_CHAR\_MECA (model MODELE=,***

***FORCE\_NODALE=\_F (GROUP\_NO= “Of, FX= F2))***

***charg4***

***=***

***AFFE\_CHAR\_MECA (model MODELE=,***

***FORCE\_NODALE=\_F (GROUP\_NO= “Of, MZ= M))***

***statics***

***=***

***MACRO\_ELAS\_MULT***

***(***

***MODEL***

***=***

***model,***

***CHAM\_MATER =***

***ch\_mater,***

***CARA\_ELEM***

***=***

***cara\_ele,***

***CHAR\_MECA\_GLOBAL***

***=***

***bloqu,***

***% one gives a name in order to recover concept NUME\_DDL***

***NUME\_DDL***

=  
*nu\_ddl,*  
*CAS\_CHARGE=\_F*  
*(NOM\_CAS = "load number 1",*  
*CHAR\_MECA*

=  
*charg1,*  
*OPTION*

=  
(  
*"SIEF\_ELGA\_DEPL", "REAC\_NODA"),*  
*SOUS\_TITRE=' charges*  
*set out again*  
*vertical*  
*on*  
*DC',*

),

)  
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**% second series of loading case**

**statique=**

**MACRO\_ELAS\_MULT**

**(**

**reuse**

**=**

**statics,**

**MODEL**

**=**

**model,**

**CHAM\_MATER =**

**ch\_mater,**

**CARA\_ELEM**

**=**

**cara\_ele,**

**CHAR\_MECA\_GLOBAL**

**= bloqu,**

**% one gives concept NUME\_DDL calculated previously**

**NUME\_DDL**

**=**

**nu\_ddl,**

**CAS\_CHARGE= (\_F (NOM\_CAS = "load number 2",**

**CHAR\_MECA**

**=**

**charg2,**

**OPTION**

=  
(  
"SIEF\_ELGA\_DEPL", "REAC\_NODA"  
)  
SOUS\_TITRE=  
*'force*  
*specific*  
*vertical*  
*in*  
*It,*

),  
  
*\_F*  
(  
NOM\_CAS

= 'load  
number  
3',  
CHAR\_MECA  
=charg3,  
OPTION

=(  
"SIEF\_ELGA\_DEPL", "REAC\_NODA"  
)  
SOUS\_TITRE='forces  
*specific horizontal in It,*

```
),  
_F  
(  
NOM_CAS  
  
=  
'load  
number  
4',  
CHAR_MECA  
=  
charg4,  
OPTION  
  
=  
(  
"SIEF_ELGA_DEPL", "REAC_NODA"  
),  
SOUS_TITRE=  
'moment  
in  
It,  
),),  
  
)
```

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**8.2**

**Titrant:**

**Operator STAT\_NON\_LINE**

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**:**

**31/01/06**

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**Mr. Key ABBAS**

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**Document: U4.51.03**

**Operator STAT\_NON\_LINE**

**1 Goal**

**To calculate the mechanical evolution or coupled thermo-hydro-mechanics, into quasi-static, of a**

**structure  
into nonlinear.**

**Nonthe linearity is related either to the behavior of material (for example plastic), or with the geometry (for example in great displacements). To have details on the method of resolution employed, one will refer to the reference material [R5.03.01].**

**The evolution can be studied in several successive work (réentrant concept), that is to say in continuation (it last calculated moment is the initial moment of following calculation), that is to say in recovery on the basis of one moment former.**

**If time necessary to carry out calculation is not sufficient, the program stops, but them already calculated results are safeguarded if a data base were defined in the profile of study of the user. Product a structure of data of the evol\_noli type.**

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matters**

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***Mr. Key ABBAS***

***:***

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***2 Syntax***

***statnl [evol\_noli] = STAT\_NON\_LINE***

***(reuse***

***= statnl, [evol\_noli]***

***MODEL***

***= Mo,***

***[model]***

***CHAM\_MATER***

***=***

***chmat,***

***[cham\_mater]***

***CARA\_ELEM***

***=***

***carac,***

***[cara\_elem]***

***EXCIT = \_F (***

***CHARGE***

***=***

***chi,***

***[char\_meca]***

***FONC\_MULT***

***= f<sub>i</sub>,***

***[function/formula]***

***TYPE\_CHARGE***

***=***

***/***

***“FIXE\_CSTE”***

***[DEFECT]***

***/***

***“FIXE\_PILLO”***

/  
“*SUIV*”  
/  
“*DIDI*”

),

*SOUS\_STRUC = \_F (*

*CAS\_CHARGE*  
=  
*chi,*

*[char\_meca]*

/  
*ALL*  
=

“*YES*”,  
*[DEFECT]*  
/  
*NET*

=  
*lma,*  
*[l\_maille]*

),

*/ COMP\_INCR = \_F (see the document [U4.51.11]),*



**/COMP\_ELAS**

**=\_F**

*(see the document [U4.51.11]),*

**VARI\_COMM**

**=\_F**

**(**

**/**

**IRRA**

**=**

*will irra*

*[evol\_varc]*

**/**

**CORROSION**

**=**

*corro*

*[evol\_varc]*

**),**

**ETAT\_INIT**

**=\_F**

**(**

**/**

**/**

**SIGM**

**=**

*sig,*

*[cham\_elem\_SIEF\_R]*  
*[carte\_SIEF\_R]*  
/  
*VARI*  
=  
*vain,*  
*[cham\_elem\_VARI\_R]*

/

*DEPL*  
=  
*depl,*  
*[cham\_no\_DEPL\_R]*

*/ VARI\_NON\_LOCAL*  
=  
*vanolo, [cham\_no\_VANL\_R]*

/

*EVOL\_NOLI*  
=  
*evol,*  
*[evol\_noli]*

*/NUME\_ORDRE=*  
*nuini,*  
*[I]*  
/  
*INST*  
=  
*instini,*  
*[R]*

***PRECISION***

=

/

***1.0E-3,***

***[DEFECT]***

/

***prec, [R]***

***CRITERION =/***

***“RELATIVE”,***

***[DEFECT]***

/

***“ABSOLUTE”,***

***NUME\_DIDI***

=

***nudidi, [I]***

***INST\_ETAT\_INIT***

=

***istetaini***

***[R]***

),

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*INCREMENT*

= *\_F*

(

*LIST\_INST*

=

*litps,*

*[listr8]*

*EVOLUTION*

=

/

*“CHRONOLOGICAL”,*

*[DEFECT]*

/

*“RETROGRESSES”,*

/

*“WITHOUT”,*

*/NUME\_INST\_INIT*

=

*nuini,*

*[I]*

/

*INST\_INIT*

=

*instini,*

*[R]*

*/NUME\_INST\_FIN*

=

*nufin,*

*[I]*

/

*INST\_FIN*

= *instfin,*

*[R]*

*PRECISION*

=

/

*1.0E-3,*

*[DEFECT]*

/

*prec, [R]*

*SUBD\_PAS*

= /

*1,*

*[DEFECT]*

/

*subpas,*

*[I]*

*SUBD\_PAS\_MINI*

=

*submini,*

*[R]*

*COEF\_SUBD\_PAS\_1*

= /

*1.,*

*[DEFECT]*

/

*coefsub, [R]*

*OPTI\_LIST\_INST*

=

/

*“INCR\_MAXI”,*

*[DEFECT]*

*NOM\_CHAM*

= *nomch,*

*[KN]*

*NOM\_CMP*

=

*nomcmp, [kN]*

*VALE*

=

*valley*

*[R]*

)

*NEWTON*  
=*\_F* (

*PREDICTION*

=

/

*“TANGENT”*,

*[DEFECT]*

/

*“ELASTIC”*,

/

*“EXTRAPOL”*,

/

*“DEPL\_CALCULE”*,

*EVOL\_NOLI*

=

*evol\_noli, [evol\_noli]*

*STAMP*

=

/

*“TANGENT”*,

*[DEFECT]*

/

*“ELASTIC”*

*REAC\_INCR*

=

/

1,

[DEFECT]

/

MF,

[I]

*REAC\_ITER*

=

/

0,

[DEFECT]

/

it,

[I]

*REAC\_ITER\_ELAS*

=

/

0,

[DEFECT]

/

it,

[I]

*PAS\_MINI\_ELAS*

=

/

0,

[DEFECT]

/

pasmini, [R]

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*RECH\_LINEAIRE =\_F (*

*RESI\_LINE\_RELA*

=

/

*1.E-1,*

*[DEFECT]*

/

*reslin,*

*[R]*

*ITER\_LINE\_MAXI*

=

/

*3*

*[DEFECT]*

/

*itelin*

*[I]*

*PAS\_MINI\_CRIT*

=

/

0.

[DEFECT]

/

*pmicri*

[R]

*ITER\_LINE\_CRIT*

=

/

20

[DEFECT]

/

*itelic*

[I]

*RHO\_MIN*

=

/

1.E-2 [DEFECT]

/

*rmin*

[R]

*RHO\_MAX*

=

/

1.E+1 [DEFECT]

/

*rmax*

[R]

*RHO\_EXCL*

= /  
*9.E-3 [DEFECT]*  
/  
*rexc*  
*[R]*  
,

*PARM\_THETA*  
=  
/  
*1.,*  
*[DEFECT]*  
/  
*theta,*  
*[R]*

*PILOTING =\_F (*

*TYPE*  
=  
/  
*“DDL\_IMPO”,*  
/  
*“LONG\_ARC”,*

*/“ANA\_LIM”,*  
/  
*“DEFORMATION”,*  
/  
*“PRED\_ELAS”,*

*/ALL =*

*“YES”,  
[DEFECT]  
/  
GROUP\_MA  
= lgrma,  
[l\_gr\_maille]  
/  
NET  
  
=  
lma,  
[l\_maille]*

*/NODE  
=  
No,  
[node]  
/  
GROUP\_NO  
= grno,  
[gr\_noeud]*

*NOM\_CMP = nomcmp, [kN]*

*COEF\_MULT  
=  
/  
1.,  
[DEFECT]  
/  
cmult,  
[R]*

*ETA\_PILO\_R\_MAX*

=

*etarmax,*

*[R]*

*ETA\_PILO\_R\_MIN*

=

*etarmin,*

*[R]*

*ETA\_PILO\_MAX*

=

*etamax, [R]*

*ETA\_PILO\_MIN*

=

*etamin*

*[R]*

*PROJ\_BORNES*

=

/

*“YES” [DEFECT]*

*/“NOT”*

*SELECTION*

=

/  
“NORM\_INCR\_DEPL”,  
[DEFECT]

/  
“ANGL\_INCR\_DEPL”,  
/  
“RESIDUE”,

),

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*SOLVEUR =\_F (see the document [U4.50.01]*

),

*CONVERGENCE =\_F (*

*/RESI\_GLOB\_RELA*

=

*1.E-6,*

*[DEFECT]*

*/ RESI\_GLOB\_MAXI*

=

*resmax,*

*[R]*

*/ RESI\_GLOB\_RELA*

=

*resrel,*

*[R]*

*/ RESI\_REFE\_RELA*

=

*resref,*

*[R]*

*SIGM\_REFE*

=

*sigref, [R]*

*EPSI\_REFE*

=

*sigref, [R]*

*FLUX\_THER\_REFE*

=

*sigref, [R]*

*FLUX\_HYD1\_REFE*

=

*sigref, [R]*

*FLUX\_HYD2\_REFE*

=

*sigref, [R]*

*ITER\_GLOB\_ELAS*

=

/

25,

*[DEFECT]*

/

*maxelas, [I]*

*ITER\_GLOB\_MAXI*



=  
/  
10,  
[DEFECT]  
/  
maglob,  
[I]

STOP  
=  
"YES",  
[DEFECT]  
/  
"NOT",

RESI\_INTE\_RELA  
=  
/  
1.E-6,  
[DEFECT]  
/  
resint,  
[R]

ITER\_INTE\_MAXI  
=  
/  
10,  
[DEFECT]

/  
*iteint*,  
[I]

*ITER\_INTE\_PAS*

=  
/  
0,  
[DEFECT]  
/  
*itepas*,  
[I]

*RESO\_INTE*

=  
/  
"IMPLICIT",  
[DEFECT]  
/  
"RUNGE\_KUTTA\_2",  
/  
"RUNGE\_KUTTA\_4",

),

*CRIT\_FLAMB*

=\_F (

*NB\_FREQ* =/  
3,

*[DEFECT]*

/

*nbfreq,*

*[I]*

*CHAR\_CRIT*

=

/

*(-10,10),*

*[DEFECT]*

/

*intcc,*

*),*

*SENSITIVITY (see the document [U4.50.02]),*

*FILING*

= *\_F*

(

*/LIST\_INST*

=

*list\_r8,*

*[listr8]*

/

*INST*

=

*l\_r8,*

*[R]*

/

*PAS\_ARCH*

= *npas,*

*[I]*

*PRECISION*

=

/

*1.E-3,*  
*[DEFECT]*  
*/*  
*prec, [R]*

*/ARCH\_ETAT\_INIT*  
*=*  
*“YES”,*  
*/*  
*NUME\_INIT*  
*=*  
*nuinit, [I]*

*DETR\_NUME\_SUIV*  
*=*  
*“YES”,*  
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*CHAM\_EXCLU*

=

/

“DEPL”,

/

“SIEF\_ELGA”,

/

“VARI\_ELGA”,

/

“VARI\_NON\_LOCAL”,

/

“LANL\_ELGA”,

),

*POSTING*

=\_F

(

*/LIST\_INST*

=

*list\_r8,*

*[listr8]*

/

*INST*

=

*l\_r8,*

*[R]*

/

*PAS\_ARCH*

= *npas,*

*[I]*

*UNIT =*

*/unit*

[I]

*LONG\_R*

= /

12

[DEFECT]

/

*long\_r*

[I]

*PREC\_R =*

/ 5

[DEFECT]

/

*prec\_r*

[I]

*LONG\_I =*

/ 6

[DEFECT]

/

long\_i

[I]

NOM\_COLONNE

=

/

“STANDARD”,

/

“MINIMUM”,

/

“ITER\_NEWT”,

/

“INCR\_TPS”,

/

“RESI\_RELA”,

/

“RELA\_NOEU”,

/

“RESI\_MAXI”,

/

“MAXI\_NOEU”,

/

“RESI\_REFE”,

/

“REFE\_NOEU”,

/

“RELI\_ITER”,

/

“RELI\_COEF”,

/  
“PILO\_PARA”,  
/  
“LAGR\_ECAR”,  
/  
“LAGR\_INCR”,  
/  
“LAGR\_ITER”,  
/  
“MATR\_ASSE”,  
/  
“ITER\_DEBO”,  
/  
“CTCD\_ITER”,  
/  
“CTCD\_INFO”,  
/  
“CTCD\_GEOM”,

/  
“CTCD\_NOEU”,  
/  
“CTCC\_CONT”,  
/  
“CTCC\_FROT”,  
/  
“CTCC\_GEOM”,

*INFO\_RESIDU*

=  
“YES”,  
[DEFECT]

“NOT”

),

*OBSERVATION =\_F (see the document [U4.53.01]),*



*LAGR\_NON\_LOCAL =\_F (*

*ITER\_PRIM\_MAXI*

*=*

*/*

*10,*

*[DEFECT]*

*/*

*iterprimmax,*

*[I]*

*RESI\_PRIM\_ABSO = resiprimab,*

*[R]*

*ITER\_DUAL\_MAXI*

*=*

*/*

*50,*

*[DEFECT]*

*/*

*iterdmax,*

*[I]*

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*RESI\_DUAL\_ABSO*

=

*residabso, [R]*

*R*

=

/

*1000. [DEFECT]*

/

*rho*

*[R]*

),

*SOLV\_NON\_LOCAL =\_F (*

*to see the document [U4.50.01]*

),

*INFORMATION*

=

/

*1,*

*[DEFECT]*

/ 2,

*TITRATE*

=

*tx [kN]*

);

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### ***3 Operands***

#### ***3.1 Operands***

***MODEL/CHAM\_MATER/CARA\_ELEM***

***MODEL = Mo***

***CHAM\_MATER = chmat***

***CARA\_ELEM = carac***

***These key words make it possible to inform:***

- the name of the model (Mo) whose elements are the subject of mechanical calculation,***
- the name of the material field (chmat) affected on the grid. Attention, all meshes model must be associated a material (if not fatal error with message little***

*clarify),*

*· the name of the characteristics (carac) of the elements of hull, beam, pipe, bars, cable, and discrete elements affected on the model Mo. Obviously, this key word is optional: if the model does not contain such elements, it is not useful; on the other hand, if the model contains such elements, it is obligatory.*

### **3.2 Word**

*key*

**EXCIT**

**EXCIT:**

*This key word factor makes it possible to describe with each occurrence a load (requests and conditions with the limits), and possibly a multiplying coefficient and/or a type of load.*

#### **3.2.1 Operands**

**CHARGE**

**CHARGE: chi**

*CH is the mechanical loading (possibly comprising the evolution of a field of I temperature) specified with the ième occurrence of EXCIT.*

*One and only one load can comprise the evolution of a field of temperature, which will have previously be defined thanks to key word TEMP\_CALCULEE of the order AFFE\_CHAR\_MECA.*

**Caution:**

*In a thermomechanical calculation, if the initial temperature is different from the temperature of reference (given in operator AFFE\_MATERIAU), the field of deformation associated with the initial moment can be incompatible and thus lead to a state of stresses and variables interns associated not no one. If one uses a relation of behavior incremental (key word factor COMP\_INCR) and if one explicitly does not define a state of stresses and variables interns initial (associate with a field of initial temperature different from the temperature from reference), the internal variable and stress field calculated to the first increment account will hold that only variation in temperature enters the initial moment and the first moment, and not of the possible constraints of compatibility associated with the initial temperature. To take this initial state hopes some, it should be given explicitly, for example thanks to key words SIGM, DEPL, VARI and VARI\_NON\_LOCAL in ETAT\_INIT. To avoid such situations which can lead to miscalculations, it is worth to better begin a calculation while considering than it is necessary to start from a virgin state.*

**Caution:**

*If one carries out a calculation into axisymmetric and that one imposes nodal forces, these efforts must be divided by  $2*\text{Pi}$  (one works on a sector of 1 radian) compared to real loadings. In the same way, if one wishes to calculate the resultant of the efforts, the result is to multiply by  $2*\text{Pi}$  to have the total resultant on the complete structure. In the same way in plane constraints or in plane deformation, one works on a thickness unit: efforts (on the thickness) applied must be divided by the thickness, the real efforts are obtained by multiplying by the thickness the efforts “of calculation”.*

**Caution:**

*The loadings resulting from AFFE\_CHAR\_CINE are not usable with STAT\_NON\_LINE.*

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### **3.2.2 Operand**

**FONC\_MULT**

**FONC\_MULT: fi**

*F is the multiplying function of the time of the loading specified with the ième occurrence of I*

*EXCIT.*

*The loading and the boundary conditions for N occurrences of the key word factor EXCIT are:*

*N*

*CH =*

*F CH**I**I**i=1**For the conditions of Dirichlet, of course, only the specified value is multiplied by F.**I**By defect:  $f_i = 1$ .***Note:***The field of temperature is not multiplied by F.**I*

### **3.2.3 Operand**

#### **TYPE\_CHARGE**

**TYPE\_CHARGE: *tchi****By defect, tchi is worth “FIXE\_CSTE”: that corresponds to a loading applied to initial geometry and not controlled. It can however be a function, and, in particular, to depend on time.**If tchi is worth “FIXE\_PILO”, the loading is always fixed (independent of the geometry) but will be controlled thanks to the key word PILOTING [§3.11]. The loads controllable must result AFPE\_CHAR\_MECA or AFPE\_CHAR\_MECA\_F and not to be affected key word FONC\_MULT. One cannot control the loadings of gravity, the centrifugal force, the forces of Laplace, thermal loadings or of initial or anelastic deformations, and conditions of connection.**If tch is worth**I**“SUIV”, the loading is known as “follower”, i.e. it depends on the value on unknown factors: for example, pressure, being a loading applying in the normal direction with a structure, depends on the geometry brought up to date of this one, and thus on displacements. One**following loading is revalued with each iteration of the algorithm of resolution. A loading fix is revalued only at each new moment, and only if chi depends on time (defined in AFPE\_CHAR\_MECA\_F and parameterized by the moment).**Currently the loadings which can be qualified “SUIV” are the loading of gravity for the element of CABLE\_POULIE, the pressure for modelings 3D, 3D\_SI, D\_PLAN, D\_PLAN\_SI, AXIS, AXIS\_SI, C\_PLAN, C\_PLAN\_SI and for all modelings THM (3D\_HHM, 3D\_HM, 3D\_JOINT\_CT, 3D\_THH, 3D\_THHM, 3D\_THM, AXIS\_HHM, AXIS\_HM, AXIS\_THH, AXIS\_THHM, AXIS\_THM, D\_PLAN\_HHM, D\_PLAN\_HM, D\_PLAN\_THH,*

*D\_PLAN\_THHM, D\_PLAN\_THM) and the centrifugal force in great displacements (key word ROTATION in AFFE\_CHAR\_MECA).*

*If tchi is worth "DIDI then" the conditions of Dirichlet (imposed displacements, conditions linear) will apply to the increment of displacement as from the moment given under ETAT\_INIT/NUME\_DIDI (by defect the moment of resumption of calculation) and not on displacement total. For example for an imposed displacement (key word DDL\_IMPO of AFFE\_CHAR\_MECA) condition will be form:  $U - U = D$*

*0  
where u0 is the displacement defined by NUME\_DIDI and  
not:  $U = D$ .*

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### **3.3 Key word SOUS\_STRUC**

*For more precision concerning the use of substructures (elastic linear) in one nonlinear structure, one will refer to documentation [U2.07.02]*

### **SOUS\_STRUC**

*This key word factor makes it possible to specify which are the loadings to be used for substructures. In its absence, the loadings on under structures are null.*

*These loadings are added to the loadings “finite elements” which can be applied to remain model.*

***CAS\_CHARGE = nocas***

*nocas is the name of the loading case to be used. See operator MACR\_ELEM\_STAT [U4.62.01].*

***/ALL = “YES”***

*This key word makes it possible to affect the loading nocas to all under structures of model.*

***/MESH = l\_mail***

*This key word factor makes it possible to assign the loading nocas only to some substructures.*

### ***3.4 Key words***

***COMP\_INCR and COMP\_ELAS***

*The syntax of these key words common to several orders is described in the document [U4.51.11].*

### ***3.5 Word***

***key***

***VARI\_COMM***

***VARI\_COMM***

***:***

*Variables of orders which control the laws of behavior (as well as temperature).*

#### ***3.5.1 Operand***

***IRRA & CORROSION***

***/IRRA***

***:***

***irr***



*Exposure fields.*

**/CORROSION**

**: corro**

*Fields of corrosion.*

**3.6 Word**

**key**

**ETAT\_INIT**

**ETAT\_INIT:**

*Initial State of reference selected. By defect, all the fields are identically null. This initial state can be defined either by specifying each field of the initial state, or in extraction since one concept of the preexistent evol\_noli type.*

*The data of an initial state does not have a direction (and is not thus taken into account) only for the part of field treated in incremental behavior (COMP\_INCR); if the behavior is elastic (COMP\_ELAS) that does not have any incidence.*

***If one wants to take into account an initial state in elasticity, it is key word ELAS located under COMP\_INCR which should be used.***

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**Note:**

*If the user specified that the concept result is réentrant (by the reserved word reuse), key word ETAT\_INIT is obligatory.*

**3.6.1 Operands****SIGM/VARI/DEPL/VARI\_NON\_LOCAL**// **SIGM**

=

**sig**/ **VARI**= **vain**/ **DEPL**= **depl**/ **VARI\_NON\_LOCAL = vanolo**

*Respectively, stress fields at the points of Gauss, variables intern at the points of Gauss, of displacements to the nodes and nonlocal variables to the nodes (for models not buildings) taken in an initial state. If one of these fields is not specified, it is taken null by defect. They*

*can for example be resulting from order CREA\_CHAMP, or be read in one file with format I-DEAS by order LIRE\_RESU (attention format MED only reads fields with the nodes).*

**3.6.2 Operands****EVOL\_NOLI**

/

**EVOL\_NOLI**

:

**evol**

*Name of the concept of the evol\_noli type from where will be extracted the initial state.*

### 3.6.3 Operand

**NUME\_ORDRE/INST/NUME\_DIDI**

**/NUME\_ORDRE**

= *nuini*

/

**INST**

=

***instini***

*Extraction of the initial mechanical state in evol starting from the number of filing NUME\_ORDRE or of the moment of filing INST to carry out the continuation of calculation. If NUME\_ORDRE or INST are not filled, the last filed number is taken existing in evol.*

**NUME\_DIDI: nudidi**

*In the case of loadings of the differential type DIRICHLET (“DIDI”), one gives under NUME\_DIDI the number of filing of the mechanical state (displacement) which is used as reference for the application of these boundary conditions (cf [§3.2.2]). By defect one takes the definite mechanical state under NUME\_ORDRE or INST.*

### 3.6.4 Operand

**INST\_ETAT\_INIT**

**INST\_ETAT\_INIT: istetaini**

*One can associate a value of moment istetaini in this initial state.*

*By defect:*

- *when the initial state is defined by the data of the fields, it does not have there an associated moment.*
- *when the state is given by a concept evol\_noli, it acts of the moment in the precedent calculation (istetaini = instini).*

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***With - Simple example (by defect)***

*LIST1 = DEFI\_LIST\_REEL (  
=0 BEGINNING.,*

*INTERVAL =\_F (UNTIL = 4. , A =4 NUMBER)),*

*U = STAT\_NON\_LINE (INCREMENT =\_F (LIST\_INST =LIST1)) ,*

*LIST2 = DEFI\_LIST\_REEL (  
=4 BEGINNING.,*

*INTERVAL =\_F (UNTIL = 10. , A =6 NUMBER)),*

*U = STAT\_NON\_LINE*

*(reuse=U,*

*INCREMENT*

*=\_F (LIST\_INST*

*=LIST2),*

*ETAT\_INIT*

=\_F (EVOL\_NOLI  
=U))

1<sup>er</sup> STAT\_NON\_LINE: carry out calculation for the moments 1, 2, 3 and 4s.

2<sup>nd</sup> STAT\_NON\_LINE: carry out calculation for the moments 5, 6, 7, 8, 9 and 10s, the initial state corresponding to time 4s.

**B - Example to show the interest of INST\_ETAT\_INIT (two different lists of moments)**

LIST1 = DEFI\_LIST\_REEL (  
=0 BEGINNING.,

INTERVAL =\_F (UNTIL = 10. , A =10 NUMBER)),

U = STAT\_NON\_LINE (INCREMENT =\_F (LIST\_INST =LIST1)) ,

LIST2 = DEFI\_LIST\_REEL (  
=20 BEGINNING.,

INTERVAL =\_F (UNTIL = 30. , A =10 NUMBER)),

U = STAT\_NON\_LINE  
(reuse=U  
INCREMENT  
=\_F (LIST\_INST  
=LIST2),  
ETAT\_INIT  
=\_F (EVOL\_NOLI  
=U,

*INST\_ETAT\_INIT*

=  
20.))

,

*1èr STAT\_NON\_LINE: carry out the calculation of moments 1 with 10s.*

*2nd STAT\_NON\_LINE: carry out the calculation of moments 21 with 30s, the initial state corresponding to the moment*

*t=10s of 1èr STAT\_NON\_LINE (by defect INST=10.). This initial state corresponds for this 2nd STAT\_NON\_LINE at the moment t=20s. (INST\_ETAT\_INIT=20.).*

***C - Example to show the interest of INST\_ETAT\_INIT (practical when the cyclic one is made)***

*LIST1 = DEFI\_LIST\_REEL (  
=0 BEGINNING.,*

*INTERVAL =\_F (UNTIL = 10. , A =10 NUMBER)),*

*U1 = STAT\_NON\_LINE (INCREMENT =\_F (  
LIST\_INST =LIST1)),*

*U2 = STAT\_NON\_LINE (INCREMENT =\_F (  
LIST\_INST =LIST1),*

*ETAT\_INIT  
=\_F (  
EVOL\_NOLI  
=U1,*

*INST\_ETAT\_INIT*

=  
0.))

,

*1èr STAT\_NON\_LINE: carry out the calculation of moments 1 with 10s.*

*2nd STAT\_NON\_LINE: carry out the calculation of moments 1 with 10s, the initial state corresponding to the moment*

*t=10s of 1<sup>er</sup> STAT\_NON\_LINE (by defect INST=10.). This initial state corresponds for this 2nd STAT\_NON\_LINE at the moment t=0s. (INST\_ETAT\_INIT: 0.).*

### **3.6.5 Operand**

#### **PRECISION/CRITERION**

*Cf [U4.71.00].*

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### **3.7 Word**

*key*

**INCREMENT**

**INCREMENT:**

*Defines the intervals of time taken in the incremental method.*

*The moments thus defined have physical direction only for relations of behavior where time intervenes explicitly (viscoelastic or viscoplastic for example). In the others cases, they allow only indicer the increments of load and to parameterize the evolution of one possible field of temperature.*

#### **3.7.1 Operands**

**LIST\_INST/EVOLUTION**

**LIST\_INST: *litps***

*The moments of calculation are those defined in the concept *litps* by operator *DEFI\_LIST\_REEL* [U4.34.01].*

**EVOLUTION**

**: /“CHRONOLOGICAL”**

**[DEFECT]**

/



**“RETROGRESSES”**

/

**“WITHOUT”**

The “**CHRONOLOGICAL**” key word makes it possible to check if the list of moments given by the user is

strictly increasing (so not an error message is transmitted).

The “**RETROGRADE**” key word makes it possible to reverse the list of moments given by the user and of

to check that after this operation, it is well strictly decreasing.

There is no checking when one specifies an evolution “**WITHOUT**”.

**3.7.2 Operands**

**NUME\_INST\_INIT/INST\_INIT/NUME\_INST\_FIN/INST\_FIN**

/

**NUME\_INST\_INIT = nuini**

/

**INST\_INIT**

**= instini**

The initial moment of the calculation (which thus (Re) is not calculated) is indicated either by its value (**INST\_INIT**), that is to say by its sequence number in the list of moments litps (**NUME\_INST\_INIT**).

To be able to reach by value, it is necessary that the list is ordered (**EVOLUTION: “CHRONOLOGICAL”** or “**RETROGRESSES**”).

In the absence of key words **INST\_INIT** or **NUME\_INST\_INIT**, the defect is calculated following manner:

- if an initial state is specified (operand **ETAT\_INIT**) and if it defines one moment corresponding (by **EVOL\_NOLI** or **INST\_ETAT\_INIT**) then the initial moment is that defined by the initial state,
- if there is no initial state (operand **ETAT\_INIT**) or that it does not define a moment corresponding (the fields are given in **ETAT\_INIT** without specifying **INST\_ETAT\_INIT**), then one takes the first moment of the list of moments litps (**NUME\_INST\_INIT: 0**), or the last when the evolution is retrograde.
- In the event of filing (see keyword **FILING**), the initial moment in continuation is its last step filed and not that defined in **INST\_INIT**.

/  
**NUME\_INST\_FIN**

=  
**nufin**

/  
**INST\_FIN**

=  
**instfin**

*The final moment (last calculated step) is indicated same manner that the initial moment (either NUME\_INST\_FIN, is INST\_FIN), except that it is not possible to refer to the moment initial state.*

**Caution:** with an evolution RETROGRAGE, INST\_INIT > INST\_FIN.

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***With - Simple example (by defect)***

***LIST = DEFI\_LIST\_REEL (=0 BEGINNING.,***

*INTERVAL = \_F (JUSQU'À= 10. , A =10 NUMBER)),*

*U = STAT\_NON\_LINE (  
INCREMENT = \_F (LIST\_INST =LIST,  
INST\_FIN  
=4.))*

*,  
U = STAT\_NON\_LINE (  
reuse=U,  
INCREMENT  
= \_F  
(  
LIST\_INST  
=LIST),  
ETAT\_INIT  
= \_F  
(EVOL\_NOLI  
: U))*

*1èr STAT\_NON\_LINE: carry out calculation for the moments 1, 2, 3 and 4s.*

*2nd STAT\_NON\_LINE: carry out calculation for the moments 5, 6, 7, 8, 9 and 10s, the initial state corresponding to time 4s. (by defect INST\_INIT=INST\_ETAT\_INIT=INST=4.).*

***B - Example to show the interest of INST\_INIT***

*LIST = DEFI\_LIST\_REEL (=0 BEGINNING.,*

*INTERVAL = \_F (UNTIL = 10. , A =10 NUMBER)),*

*U = STAT\_NON\_LINE  
(INCREMENT = \_F (LIST\_INST = LIST,  
INST\_FIN*

=  
4.))

,  
  
*U = STAT\_NON\_LINE*  
*(reuse = U,*  
*INCREMENT*  
*=\_F*  
*(*  
*LIST\_INST*  
*=LIST,*

,  
  
*INST\_INIT =8.),*  
*ETAT\_INIT*  
*=\_F*  
*(*  
*EVOL\_NOLI*  
*=U))*

*1èr STAT\_NON\_LINE: carry out the calculation of moments 1 with 4s.*

*2nd STAT\_NON\_LINE: carry out calculation for moments 9 and 10s (does not do anything for t=5, 6, 7 and 8s),*

*the initial state corresponding to time t=4s (by defect INST=4.).*

### **3.7.3 Operand PRECISION**

**PRECISION:** *prec* cf [U4.71.00]

### **3.7.4 Operand**

**SUBD\_PAS/SUBD\_PAS\_MINI/COEF\_SUBD\_PAS\_1**

**SUBD\_PAS**

=  
**subpas**  
**SUBD\_PAS\_MINI = submini**  
**COEF\_SUBD\_PAS\_1**

**= coefsub**

*Allows to carry out an automatic recutting of the step of time when the algorithm of Newton do not converge.*

*The step of time is redécoupé in subpas under step. By defect there is no recutting (subd\_pas: 1). The automatic subdivision stops when the new steps created are more small that SUBD\_PAS\_MINI. The new steps created are of identical size, except the first who is equal to this size multiplied by COEF\_SUBD\_PAS\_1 (by defect 1). This allows best to take into account the problems of discharge of the structure (change of tangent matrix) without using the elastic matrix (PREDICTION: "ELASTIC" or STAMPS: "ELASTIC" under the operand NEWTON).*

*When a step of time was redécoupé several times (let us call N the number of times where one has proceeded to a subdivision of the same step), the following step is automatically subdivided (n-1) time, this to avoid, in the event of convergence difficult to try a step of too important time.*

**Notice concerning the key word CUTS OUT under SOLVEUR:**

*During elastoplastic calculation of buckling, it can happen that the tangent matrix of the system that is to say singular during iterations of Newton. By redécoupant the step of time, one can to pass these hard points. Under operand SOLVEUR, the key word CUTS OUT under STOP\_SINGULIER is used to manage these hard points. It is then necessary to inform the words keys relating to recutting so that the method CUTTING is activated.*

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### 3.7.5 Operand

#### ***OPTI\_LIST\_INST/NOM\_CHAM/NOM\_CMP/VALE***

***OPTI\_LIST\_INST =***

***“INCR\_MAXI”***

***[DEFECT]***

***NOM\_CHAM***

***=***

***“TEMP”***

***[DEFECT]***

***NOM\_CMP =***

***“TEMP”***

***[DEFECT]***

***VALE =***

#### ***vale***

*These operands have interest only when a thermomechanical calculation is carried out. Allows to create if need be a new list of mechanical step of time so that, between each increment of time, the increment of temperature is lower than a value given by the user and indicated by key word VALE.*

*The creation of this new list is done in the following way:*

- Liste of moments initial in mechanics:  $T_i$*
- Thermal Liste of moments:*
- Nouvelle final list of moments mechanical to create if need be:  $T_f$*
- One inserts between each interval of the basic list mechanical  $T_i$ , the thermal moments include in this interval. One then recovers for each interval a list of moments =*  
*[0, 1, 2, NR]*

*· Construction of the list final  $T_f$*

*- Initialization:  $F = 0$*

*- 1st Test:*

*If  $T(J) - T(F) > \text{value}$  with  $T(T)$  the temperature at time  $T$  and  $F$  the last moment inserted in the new  $T_f$  list, then one keeps in the new list  $T_f$ , the moment*

*$j-1$*

*- 2nd Test:*

*If  $T(J) - T(j-1) > \text{value}$  then one redécoupe uniformly this interval in way to satisfy the condition on the increment of temperature.*

***Example:*** *IF  $T() = [T(1) = 20^\circ\text{C}, T(2) = 30^\circ\text{C}, T(3) = 55^\circ\text{C}, T(4) = 65^\circ\text{C}]$  with  $VALE = 15^\circ\text{C}$*

*Initialization:  $F = 1$*

*Interval 1:*

*1st Test = 2nd Test:  $T(2) - T(1) = 10^{\circ}\text{C} < 15$  thus one  $T_f = [1]$*

*Interval 2:*

*1st Test:  $T(3) - T(F) = 35^{\circ}\text{C} > 15$  thus one has  $T_f = [1, 2]$  and  $F = 2$*

*2nd Test:  $T(3) - T(2) = 25^{\circ}\text{C} > 15$  thus one  $T_f = [1, 2, T3]$  such as  $T(T3) = 42.5^{\circ}\text{C}, 3]$  and  $F = 3$*

*Interval 3:*

*1st Test = 2nd Test:  $T(4) - T(3) = 10^{\circ}\text{C} < 15^{\circ}\text{C}$*

*from where the following final list:*

*$T_f = [1, 2, T3]$  such as  $T(T3) = 42.5^{\circ}\text{C}, 3, 4]$*

### **3.8 Word**

**key**

**NEWTON**

**NEWTON**

:

*Specify the characteristics of the method of resolution of the nonlinear incremental problem (method of NEWTON-RAPHSON).*

#### **3.8.1 Operand**

**PREDICTION**

**PREDICTION**

=

**/“TANGENT”**

**/“ELASTIC”**

**/“EXTRAPOL”**

**/“DEPL\_CALCULE”**

*The purpose of the phase of prediction (cf [R5.03.01]) is to calculate an estimate of the field of displacements in order to allow the method of NEWTON more quickly to converge.*

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*When the key word misses, it is the tangent matrix of speed (option RIGI\_MECA\_TANG in the file .mess) which is used if one chose for the method of NEWTON one STAMP: "TANGENT", and it is the elastic matrix (option RIGI\_MECA in the file .mess) who is used if MATRIX were chosen: "ELASTIC".*

***/"TANGENT"***

*One uses the tangent matrix of the problem of speed (option RIGI\_MECA\_TANG in the file .mess).*

***/"ELASTIC"***

*The elastic matrix is used (option RIGI\_MECA in the file .mess).*

***/"EXTRAPOL"***

*One calculates the estimate of the increment of displacement starting from the total increment obtained like solution with the step of previous time (balanced by the report/ratio of the steps of time). One projects this estimate on the whole of the fields kinematically acceptable (i.e satisfying them boundary conditions of DIRICHLET) according to the standard given by the elastic matrix, which must thus to be calculated. This functionality is interesting in the case of the use of diagrams of explicit integration local of type RUNGE-KUTTA which does not provide a tangent matrix: in this case the method of NEWTON uses an elastic matrix, but the iteration count necessary can be high. The use of extrapolation can improve the performances.*

***/"DEPL\_CALCULE"***

*Allows to propose like displacement for the prediction with each step of time, it displacement given by a mechanical history specified under key word EVOL\_NOLI ([§3.8.3]).*

**Utility:**

*· let us suppose that one carries out the first calculation with a coarse grid. One wishes to carry it out even calculation but on a finer grid. One can suppose that the solution in displacement for this second calculation is not distant from that of the first calculation and thus only one good prediction of displacement for this second calculation is the projection of displacements of calculation*



*l* on the nodes of the new grid (the projection of displacements on the new grid must be realized beforehand with operator *PROJ\_CHAMP* [U4.72.05]). This key word allows to carry out this mode of prediction.

· that makes it possible to reduce the place memory and to preserve these results for a continuation later. For a large calculation, one can store only displacements with all their moments with formats *IDEAS* or *MED* in *IMPR\_RESU*. If one wants to recompute the constraints and internal variables, one makes a *LIRE\_RESU* with the adequate format then one uses *DEPL\_CALCULE* with *ITER\_GLOB\_MAXI: 0* (only one iteration is carried out) and *STOP: NOT* (there is not convergence, one does not check balance). It is however necessary for reasons of syntax to give a loading (to avoid the loadings dirichlet which impose one linear resolution) as well as a criterion of convergence, even if this information is not takings into account.

### **3.8.2 Operand STAMP**

**STAMP =**

**/**  
**“TANGENT”**

**REAC\_INCR**

**=**  
**/**  
**1**  
**[DEFECT]**

**/MF**

**REAC\_ITER**

**=**  
**/**  
**0**  
**[DEFECT]**

*/it*

*The matrix used for the total iterations of the method is the tangent matrix [R5.03.01] who is revalued all MF increments of time (MF positive or null) and all the it iterations of NEWTON for an increment of time given (precisely to the iterations of number it, 2it, 3it...). Thus with the first iteration of NEWTON, one reassembles the tangent matrix only if it I is worth: if not one keeps the matrix used in the phase of prediction. By convention if it is worth 0 the matrix is not revalued during all the step of time.*

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**PAS\_MINI\_ELAS**

=

/

**0.**

**[DEFECT]**

/

***pasmini [R]***

***REAC\_ITER\_ELAS =/  
0  
[DEFECT]  
/  
it  
[I]***

*Allows to pass from the tangent matrix to the matrix of discharge (i.e by considering that not linearities do not evolve/move) when the step of time is or becomes (by recutting) lower than pasmini. This matrix of discharge is the elastic matrix for the models of behavior of plastic type; for the models of damage it is identified with the secant matrix. As convergence with the elastic matrix is slower than that with the matrix tangent, key word ITER\_GLOB\_ELAS under the key word factor CONVERGENCE makes it possible to define an iteration count maximum specific to the use of the matrix elastic and different from that associated the use of the tangent matrix.*

*One can define a frequency of reactualization of the matrix of discharge with the key word REAC\_ITER\_ELAS (similar of REAC\_ITER). If the matrix of discharge does not depend on the state of deformation, to take REAC\_ITER\_ELAS = 0 (since it will be the same one during iterations).*

***Utility:***

*This option can be useful when the automatic recutting of the step of time (cf [§ 3.7.4]) converge a calculation is not enough to make. For example, in the case of lenitive laws, the matrix tangent can become singular and it is thus to better use the elastic matrix to converge.*

***“ELASTIC”***

*The matrix used corresponds to the elastic design: it is evaluated only once at the moment initial, at the beginning of algorithm.*

*This “elastic” matrix is calculated by using the YOUNG modulus given under the key word ELAS of operator DEFI\_MATERIAU, and not the slope at the origin of the traction diagram given under the key word TRACTION (and which are useful, it, in the expression of the relation of behavior).*

### ***3.8.3 Operand EVOL\_NOLI***

***EVOL\_NOLI: evol\_noli***

*Name of the concept of the evol\_noli type which will be useful in the prediction by DEPL\_CALCULE.*

**3.9 Word****key*****RECH\_LINEAIRE******RECH\_LINEAIRE:***

*Linear research can make it possible to improve convergence of the method of Newton (Cf [R5.03.01] for more details).*

***Caution:***

*It is disadvised using linear research with deformations GREEN\_GR for modelings COQUE\_3D and in the presence of contact.*

**3.9.1 Operand*****RESI\_LINE\_RELA/ITER\_LINE\_MAXI******RESI\_LINE\_RELA =/******1.E-1 [DEFECT]******/******reslin******ITER\_LINE\_MAXI******=******/******3******[DEFECT]******/******itelin***

*They are the parameters of linear research. The maximum iteration count is given itelin to be carried out and the precision reslin to reach to carry out the convergence of linear research. It is advised not to use linear research with contact.*

*It is not necessary to specify a precision nor an iteration count very high, the practice showing that 2 or 3 iterations of linear research are sufficient. One can thus be satisfied to ask 3 iterations with the precision by defect.*

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### **3.9.2 Operand**

***PAS\_MINI\_CRIT/ITER\_LINE\_CRIT***

***PAS\_MINI\_CRIT***

=

/

**0.**

**[DEFECT]**

/

***pmicri***

**[R]**

***ITER\_LINE\_CRIT =/20***

**[DEFECT]**

/

***itelic***

**[I]**

*At the time of step of time when convergence is delicate, one can want to increase the number maximum of iterations of linear research. It is what the key words allow*

*PAS\_MINI\_CRIT and ITER\_LINE\_CRIT. When the step of time (directly fixed by the user or consequence of cuttings of step of time) becomes lower than the value pmicri, the number iterations of linear search for research passes from itelin (well informed by ITER\_LINE\_MAXI) with itelic (informed by ITER\_LINE\_MAXI)*

### **3.9.3 Operands**

**RHO\_MIN/RHO\_MAX/RHO\_EXCL**

**RHO\_MIN =/1.E-2**

**[DEFECT]**

/

**rmin**

**[R]**

**RHO\_MAX =/1.E+1**

**[DEFECT]**

/

**rmax**

**[R]**

**RHO\_EXCL**

=

/

**9.E-3**

**[DEFECT]**

/

**rexc**

**[R]**

*These key words fix interval I of linear research, in the form*

:

$I = [R \text{ min}, R \text{ max}] - [- \text{rexc}, \text{rexc}]$ .

### **3.10 Operand**

**PARAM\_THETA**

**PARAM\_THETA**

=

/

**1.****[DEFECT]**

/

**theta**

*For modelings THM, the argument theta is the parameter of the theta-method used for to solve the evolutionary equations of thermics and hydraulics (cf [R5.03.60] for more details). Its value must lie between 0 (explicit method) and 1 (method completely implicit).*

*For the laws of behavior ROUSS\_VISC, ASSE\_COMBU, ZIRC\_CYRA2 and ZIRC\_EPRI, the argument theta is used for integration of the law of behavior (for model ASSE\_COMBU, it is used to integrate the law of Lemaitre in 1D). It can take values 0.5 (semi-implicit) or 1 (implicit).*

### **3.11 Word**

**key**

**PILOTING**

#### **PILOTING:**

*When the intensity of part of the loading is not known a priori (loading known as of reference defined in AFFE\_CHAR\_MECA or AFFE\_CHAR\_MECA\_F with load of the type FIXE\_PILO), the key word PILOTING makes it possible to control this loading via a node (or node groups) on which one can impose various modes of piloting (STANDARD key word).*

#### **Caution:**

*With FIXE\_PILO, one cannot use for the loading of reference the key word FONCT\_MULT.*

#### **Caution:**

*When the loading of reference is defined by AFFE\_CHAR\_MECA\_F, this loading can to be a function of the variables of space but not of time.*

#### **Caution:**

*The key word PILOTING is interdict with the contact.*

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### ***3.11.1 STANDARD operand***

***TYPE:***

***/"DDL\_IMPO"***

***/"LONG\_ARC"***

***/"ANA\_LIM"***

***/"DEFORMATION"***

***/"PRED\_ELAS"***

***It is the type of piloting carried out. Five modes of piloting are available (cf [R5.03.80] for more details):***

***/"DDL\_IMPO"***



*Allows to impose a given value of increment of displacement (only one component I possible) in a single node No (or of a group of nodes comprising one node). With each increment of time, one seeks the amplitude of the loading of reference which will allow to satisfy the following incremental relation:*

$$C$$

$$U$$

$$(No) = T$$

$$\text{mult}$$

$$I$$

*/“LONG\_ARC”*

*Allows to control the intensity of the loading of reference by the length (X-coordinate curvilinear) of the response in displacement of a group of nodes (to be used for example when one wants to control the buckling of a test-tube). The following relation is checked:*

$$C$$

$$U = T$$

$$2$$

$$\text{mult}$$

$$\text{with } U =$$

$$\text{One, } C$$

$$N$$

$$C$$

*where N are the nodes of piloting and C the components of the displacement of the nodes considered. Even if the group of node of piloting is tiny room to only one node, it is necessary when to even use GROUP\_NO.*

*/“ANA\_LIM”*

*This mode of piloting is specific to the calculation of load limits (law NORTON\_HOFF) by approach kinematic (cf [R7.07.01] for more detail). If F indicates the loading assembled controlled, TYPE\_CHARGE = “FIXE\_PILO”, then the function of piloting is written simply:*

$$P(U) =$$

$$F U = 1$$

*Except for the calculation of limiting load, this functionality is not of interest a priori. For this mode of piloting, no other key word is to be specified.*

**Note:**

***The use of lenitive laws of behavior can lead to snap backs brutal which makes delicate the course of calculation. Two modes of piloting following cures it (cf [R5.03.80] for more detail).***

***/"DEFORMATION"***

***DEFORMATION guarantees that at least a point of Gauss of the structure sees its deformation to evolve/move in a monotonous way. The relation is checked:***

-

***C  
max (  
) = T***

***mult***

-

***Gauss***

***of  
not***

***This mode of piloting is valid for all the laws of behavior including into large deformations SIMO\_MIEHE.***

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**/“PRED\_ELAS”**

***PRED\_ELAS ensures that at least a point of Gauss of the structure left the threshold of elasticity linearized  $F_{\text{préd-élas}}$  of a  $T/C_{\text{mult}}$  quantity. The relation is checked:***

***C***  
***max (F***  
***) = T***

***mult***  
***préd - élas***  
***Gauss***

***of***  
***not***

***This mode of piloting is valid only for laws ENDO\_FRAGILE (with the version local and two nonlocal versions), ENDO\_ISOT\_BETON and ENDO\_ORTH\_BETON (with local version and the nonlocal version), BARENBLATT and BETON\_DOUBLE\_DP.***

***Attention use:***

***When one wants to use these the last two modes of piloting, it is essential to make a first STAT\_NON\_LINE without the key word PILOTING to start the problem and to obtain an initial state -***

***different from zero (if not divide check for piloting by increment of deformation). One carries out after a recovery starting from this initial state not no one and one use piloting.***

***Moreover, the resolution of the two preceding equations makes it possible to obtain the intensity of the loading***

***unknown factor. In certain cases, the solution of these equations can lead to several solutions for intensity. One then chooses always the solution which is closest to -***

***. This is why, when one***

***wants to impose an alternated loading, one is obliged with each change of sign of the loading of to carry out a first STAT\_NON\_LINE without the key word PILOTING in order to obtain an initial state -***

***of***

***traction or of compression. One carries out then a second STAT\_NON\_LINE in continuation from the preceding initial state with the key word PILOTING.***

**Note:**

***DEFORMATION and PRED\_ELAS are not available for the elements of structures.***

**3.11.2 Operands NODE/GROUP\_NO**

/  
***NODE = No***  
 /  
***GROUP\_NO***  
 =  
***grno***

***One gives the name of the node or the name of group of nodes on which one will impose it piloting. To use only with “DDL\_IMPO” or “LONG\_ARC”.***

***For “DDL\_IMPO”, if operand GROUP\_NO is used, the group of nodes in question must contain that only one node. For “LONG\_ARC”, one uses only GROUP\_NO (which can if required to contain one node).***

**3.11.3 Operands ALL/MESH/GROUP\_MA**

/  
***ALL***  
 =  
***“YES”***  
***[DEFECT]***  
 /  
***GROUP\_MA***  
 =  
***lgrma***  
 /  
***NET***  
 =  
***lma***

***One gives the meshes or groups of meshes being used to control calculation. To use only with DEFORMATION or PRED\_ELAS. Interesting to reduce the resolution of the equations of these three modes of pilotings.***

**3.11.4 Operand NOM\_CMP**

## ***NOM\_CMP***

:

***nomcmp***

***It is the name of the component (corresponding to the degree of freedom I) used for piloting (“DX” for example). To use only with “DDL\_IMPO” or “LONG\_ARC”.***

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### ***3.11.5 Operand COEF\_MULT***

***COEF\_MULT***

***: cmult***

***It is the value (noted cmult in the formula of definition) by which one multiplies the degree of freedom used for piloting. By defect, this value is worth 1. With not using with ANA\_LIM.***

***Example with DDL\_IMPO:***

***Let us suppose that one wants to know the limiting load of a structure.***

***The loading imposed on the structure is the pressure of unknown intensity (P=\*valeur of Px reference) on the group of mesh A. to find the load limits Plimite, one will control it displacement of node NO1. It is wanted that final displacement according to X of this node is equal to 2.***

***(either according to the list of moments of the steps of 0.2, or a coefficient cmult=1/0.2=5.)***

**PRESSURE = AFFE\_CHAR\_MECA (CLOSE = (GROUP\_MA =A, PX = 1.0)),**

**LIST =**

**DEFI\_LIST\_REEL (=0 BEGINNING,  
INTERVAL  
= \_F (UNTIL  
=  
10,**

**NUMBERS  
=10),**

**RESU =**

**STAT\_NON\_LINE (  
EXCIT =  
\_F (  
CHARGE = PRESSURE,  
TYPE\_CHARGE  
=  
"FIXE\_PILO"),**

**PILOTING  
= \_F (  
TYPE = "DDL\_IMPO",**

**NODE = NO1,**

**NOM\_CMP**

=  
**“DX”**,  
**COEF\_MULT**

=  
 5.))

*In the fichier.resu, the value of will be at every moment posted calculation. To know charge limit, it is enough to make  $P_{\text{limite}} = *P_x$ . (Here  $P_x$  is worth 1 thus one has the limiting load directly).*

*If one imposes on the structure a pressure  $P$  close to the limiting load without using piloting, it calculation will not converge if one is close to the limiting load.*

### **3.11.6 Operand $ETA\_PILO\_R\_MAX/ETA\_PILO\_R\_MIN$**

**$ETA\_PILO\_R\_MAX = etarmax$ ,**  
**[R]**

**$ETA\_PILO\_R\_MIN$**

=  
 **$etarmin$ ,**  
**[R]**

*These two key words make it possible to specify the interval of awaited values of piloting. principle of operation is as follows: with each iteration of Newton, if values are found of piloting in the interval  $[etar\ min, etar\ max]$ , all values of piloting apart from this interval are not considered. On the other hand, if no value of piloting is found in this interval, all the values of piloting are preserved.*

*If one does not specify values, it is - for  $etarmin$  and + for  $etarmax$ .*

*A possible use of this interval is as follows. one wishes for example, to control a pressure some share on the structure and one expects to keep this positive pressure. By fixing  $etarmin$  at 0, that make it possible to preserve only the positive values of piloting, if at least one is found positive value of piloting at the time of the resolution of piloting.*

### **3.11.7 Operand $ETA\_PILO\_MAX/ETA\_PILO\_MIN$**

**$ETA\_PILO\_MAX:$**   
 **$etamax$**

*Stop of calculation when the parameter of piloting reaches the value given  $etamax$ .*

## ***ETA\_PILO\_MIN:***

***etamin***

***Allows to stop calculation when parameter ETA\_PILOTAGE reaches this minimal value etamin (for lenitive models, makes it possible to stop calculation when the structure is sufficient softened).***

### ***Caution:***

***With law ENDO\_ISOT\_BETON, these two words key are obligatory.***

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## ***3.11.8 Operand PROJ\_BORNES***

***PROJ\_BORNES***

***=***

***/***

***“YES” [DEFECT]***



***/“NOT”***

*In the event of going beyond of the interval (etamin, etamax), the user can indicate if he wants to project the value of piloting on (etamin, etamax).*

*With PROJ\_BORNE=' OUI', projection will be carried out (if  $\eta > \eta_{\max}$  -  $\rightarrow \eta = \eta_{\max}$ ; if  $\eta < \eta_{\min}$  -  $\rightarrow \eta = \eta_{\min}$ ), which allows, in the event of convergence to stop calculation precisely on etamin or etamax.*

*With PROJ\_BORNE=' NON', one does nothing, therefore calculation will stop, in the event of convergence, with a value higher than etamax or lower than etamin.*

### ***3.11.9 Operand SELECTION***

***/SELECTION***

***=/“NORM\_INCR\_DEPL”, [DEFECT]***

***/***  
***“ANGL\_INCR\_DEPL”,***

***/***  
***“RESIDUE”,***

*This operand makes it possible to select the method allowing for choice of the value of piloting if several solutions are provided by the resolution of piloting.*

*“NORM\_INCR\_DEPL” makes it possible to select the value of piloting by the smallest standard of the increment of displacement on the step of time considered.*

*“ANGL\_INCR\_DEPL” makes it possible to select the value of piloting by the smallest angle enters the displacement obtained for the step of current time and the displacement obtained for the step of previous time.*

*“RESIDUE” makes it possible to select the value of piloting leading to the smallest residue.*

### ***3.12 Word***

***key***

***SOLVEUR***

*The syntax of this key word common to several orders is described in the document [U4.50.01].*

### ***3.13 Word***

***key***

***CONVERGENCE***

***CONVERGENCE:***

*If none of the two operands following is present, then all occurs like if:*

***RESI\_GLOB\_RELA = 1.E-6.***

### 3.13.1 Operand *RESI\_GLOB\_RELA/RESI\_GLOB\_MAXI*

*/RESI\_GLOB\_RELA*

=

*resrel*

*The algorithm continues the total iterations as long as:*

**Max**

*Fn > resrel max*

*I*

**L**

*I =,*

*1..., nb\_ddl*

*where Fn is the residue of iteration N and L the vector of the imposed loading and the reactions supports (cf [R5.03.01] for more details).*

*When the loading and the reactions of support become null, i.e. when L is no one (for example in the case of a total discharge), one passes from the criterion of convergence relating to the absolute criterion of convergence RESI\_GLOB\_MAXI. This operation is transparent for the user (message of alarm emitted in the file .mess). When the vector L becomes again different from zero, one passes by again automatically with the relative criterion of convergence RESI\_GLOB\_RELA.*

*If this operand misses, the test is carried out with the default value, except if RESI\_GLOB\_MAXI is present.*

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**/RESI\_GLOB\_MAXI**

=

**resmax**

*The algorithm continues the total iterations as long as:*

*Max*

*Fn >*

*I*

*resmax*

*I =,*

*1..., nb\_ddl*

*where Fn is the residue of iteration N (cf [R5.03.01] for more details).*

*If this operand misses, the test is not carried out.*

*If RESI\_GLOB\_RELA and RESI\_GLOB\_MAXI are present both, the two tests are carried out.*

### **3.13.2 Operand RESI\_REFE\_RELA**

/

**RESI\_REFE\_RELA**

=

**resref,**

**[R]*****SIGM\_REFE***

=

***sigref, [R]******EPSI\_REFE***

=

***epsref, [R]******FLUX\_THER\_REFE***

=

***fthref, [R]******FLUX\_HYD1\_REFE***

=

***fh1ref, [R]******FLUX\_HYD2\_REFE***

=

***fh2ref, [R]***

***This operand results in estimating the convergence of the algorithm of Newton in the manner following (cf [R5.03.01] for more details). From the constraint of reference sigref (and/or a deformation of reference epsref if one uses nonlocal laws with gradient of deformation, and/or a heat flux of reference fthref in a case THM, and/or two hydrous references of flow fh1ref and fh2ref in a case HHM), one calculate a reference of residue Fref (a of the same vector length than the vector residue). Convergence will be carried out if and only if:***

***I******[ ,...,******I******Nb \_ddl]******N******ref.***

*F < resref*

*F*

*I*

*I*

### ***3.13.3 Operand ITER\_GLOB\_MAXI***

***ITER\_GLOB\_MAXI =/10***

***[DEFECT]***

*/*

***maglob***

***Maximum iteration count carried out to solve the total problem at every moment (10 per defect). This test is always carried out.***

### ***3.13.4 Operand ITER\_GLOB\_ELAS***

***ITER\_GLOB\_ELAS =/25***

***[DEFECT]***

*/*

***maxelas***

***Maximum iteration count carried out with the elastic matrix when the word is used key PAS\_MINI\_ELAS of the key word factor NEWTON (see [§3.8.2]) .pour to solve the problem total at every moment (25 per defect).***

***It is pointed out that PAS\_MINI\_ELAS makes it possible to pass from the tangent matrix to the matrix***

***rubber band when the step of time is or becomes (by recutting) lower than one certain value specified under PAS\_MINI\_ELAS.***

### ***3.13.5 Operand STOP***

**STOP**

=

/

**“YES”**

**[DEFECT]**

*If one of the criteria of total convergence chosen is not checked after maglob iterations, then the program stops (the preceding results are safeguarded).*

/

**“NOT”**

*If maglob is insufficient to check the criteria of convergence given by the user, one passes nevertheless at the next moment. Use to be avoided.*

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**3.13.6 Operands RESI\_INTE\_RELA/ITER\_INTE\_MAXI**

**RESI\_INTE\_RELA =/**

**1.E-6**

**[DEFECT]**

/

**resint****ITER\_INTE\_MAXI =/****10****[DEFECT]**

/

**iteint**

*In the majority of the relations of behavior, a nonlinear equation or a system nonlinear must be solved locally (in each point of GAUSS). These operands (residue and a maximum number of iterations known as intern) are used to test the convergence of this iterative algorithm of resolution. For more details, to refer to reference material, for example with the document [R5.03.02]. These operands are **useless** with behaviors ELAS, VMIS\_CINE\_LINE, VMIS\_ECMI, LINE, VMIS\_ECMI\_TRAC, VMIS\_ISOT\_LINE, VMIS\_ISOT\_TRAC, VISC\_ISOT\_LINE, VISC\_ISOT\_TRAC, BARENBLATT, NORTON\_HOFF, DIS\_CONTACT, DIS\_CHOC, ARMS, ASSE\_CORN, DIS\_GOUJ2E\_PLAS, DIS\_GOUJ2E\_ELAS, VMIS\_ASYM\_LINE, GRILLE\_ISOT\_LINE, GRILLE\_CINE\_LINE, GRILLE\_PINTO\_MEN, PINTO\_MENEGOTTO, GRANGER\_FP and GRANGER\_FP\_V (except constraint planes), BAZANT\_FD and all them relations META\_XXX.*

### **3.13.7 Operand ITER\_INTE\_PAS**

**ITER\_INTE\_PAS**

=

**0****[DEFECT]****itepas**

*Redécouper localement le pas de temps permet de faciliter l'intégration de la relation de comportement aux points de GAUSS (pour les relations de CHABOCHE, VISC\_TAHERI, LMARC, LAIGLE, MONOCRYSTAL, ROUSS\_PR, ROUSS\_VISC, CJS et BETON\_DOUBLE\_DP). If itepas is worth*

*0, 1 or -1 it do not have there recutting. If itepas is positive, one redécoupe systematically it no time locally in itepas small steps of time before carrying out the integration of relation of behavior. If itepas is negative, recutting in |itepas| small steps of time is carried out only in the event of nonlocal convergence.*

### **3.13.8 Operand RESO\_INTE**

**RESO\_INTE**

**=/"IMPLICIT"**

**[DEFECT]**

**/**  
**"RUNGE\_KUTTA\_2"**

**/**  
**"RUNGE\_KUTTA\_4"**

*Allows to specify the type of diagram of integration to solve the system of equations not linear formed by the equations constitutive of the models of behavior to variables interns:*

- the models POLY\_CFC and POLYCRYSTAL are treated only by the explicit diagram RUNGE-KUTTA of order 2,*
- two models VMIS\_POU\_LINE and VMIS\_POU\_FLEJOU can be treated by two implicit schemes and RUNGE\_KUTTA\_4,*
- two models MONOCRYSTAL and VENDOCHAB can be treated by both implicit schemes and RUNGE\_KUTTA\_2,*
- the other models use the implicit scheme.*

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**3.14 Key word**

**CRIT\_FLAMB**

**CRIT\_FLAMB**

**=\_F (**

**NB\_FREQ**

**=**

**/**

**3,**

**[DEFECT]**

**/**

**nbfreq,**

**[I]**

**CHAR\_CRIT =/**

**(-10,10),**

**[DEFECT]**

**/**

**intcc,**

**),**

***This key word makes it possible to start calculation, at the end of each increment of time, of a criterion of stability.***

***This criterion is useful to detect, during the loading, the point from which one loses stability (by buckling for example).***

*This criterion is calculated in the following way: at the end of a step of time, in small disturbances, one solves  $\det (T$*

*K -*

*G*

*K) = 0.  $KT$  is the coherent tangent matrix at this moment.  $Kg$  is*

*stamp geometrical rigidity, calculated starting from the stress field at this moment.*

*In practice, the loading is unstable if  $< 1$  ( $-1 < < 0$  make some). The values are calculated clean by the method of Sorensen (Cd `MODE_ITER_SIMULT`). This can be rather expensive for the problems of big size.*

*Key word `CHAR_CRIT` makes it possible to save time by making only one test of Sturm in provided frequency band. If at least a frequency is found, then one calculates really them values of the critical loads in this interval.*

*For great displacements and great deformations `GREEN (_GR)` or `SIMO_MIEHE`, one solves  $\det (K T - Id) = 0$  bus  $KT$  contains  $kg$  then (and possibly  $Kp$ ).*

*The criterion is then a criterion of instability: when sign (thus passes by 0) it changes loading is unstable.*

*Key word `NB_FREQ` (3 per defect) indicates the number of critical loads to calculate. In fact only the first is enough but there can be multiple modes*

*One stores the clean mode the corresponding to smallest critical load (in absolute value) in the S.D. `RESULT`, under name `MODE_FLAMB`. This clean mode can be extracted and visualized (like a field of displacements or a traditional clean mode). It is standardized to 1 on more large component of displacement.*

### **3.15 Key word**

#### **`SENSITIVITY`**

*The syntax of this key word common to several orders is described in the document [U4.50.02].*

### **3.16 Word**

*key*

#### **`FILING`**

**`FILING =`**

*Allows to file or certain results with all or certain moments of calculation.*

*In the absence of this key word all the steps of time are filed, including the moments of calculations lately created by automatic recutting of the step of time. Filing allows to appreciably reduce the size of the bases by selecting the safeguarded moments.*

**Note:**

***In the presence of contact, one cannot file more than 99.999 moments of calculations.***

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### ***3.16.1 Operand LIST\_INST/INST/PAS\_ARCH***

***/“LIST\_INST”***

***= list\_r8***

***/***

***“INST”***

***=***

***l\_r8***

***/***

***“PAS\_ARCH”***

***=***

***npas***

***The designation of the moments to be stored is carried out either by a list of moments (list\_r8 or l\_r8) provided that the evolution is ordered (EVOLUTION: CHRONOLOGICAL or RETROGADE, cf [§3.6.1]) or then by a frequency of filing (all npas of time).***

***In the absence of these key words all the steps of time are filed.***

**Two note:**

- *the last step of calculation is always stored to be able to carry out a recovery,*
- *if one employs an access by list of moments, then moments of calculations lately created by automatic recutting of the step of time are not filed*

**3.16.2 Operand PRECISION**

**PRECISION = prec**

**Cf [U4.71.00]**

**3.16.3 Operand ARCH\_ETAT\_INIT/NUME\_INIT/DETR\_NUME\_SUIV**

**^ARCH\_ETAT\_INIT`  
= "NOT"**

**[DEFECT]**

**"YES"**

*Only for one concept not réentrant if not error message. Allows to impose the filing of the initial state in the sequence number 0 (interesting when the initial state comes of another STAT\_NON\_LINE. Allows to have the 1st point on a curve).*

**^NUME\_INIT`**

**= nuinit**

*Only for one réentrant concept if not error message. Allows to specify from which sequence number one files.*

**By defect:**

- *if the initial state is not fixed by the calculated concept, it acts of the last sequence number +1 (example A),*
- *if the calculated concept coincides with the concept which fixes L`initial state, it acts of the number of order +1 pennies ETAT\_INIT (example B and C).*

**DETR\_NUME\_SUIV**

**=**

**"NOT"**

**[DEFECT]**

**“YES”**

***This operation can result in crushing preexistent sequence numbers: the key word DETR\_NUME\_SUIV confirms this destruction, while its absence puts an end to calculation.***

***With - Simple example***

***LIST =  
DEFI\_LIST\_REEL (=0 BEGINNING,  
INTERVAL  
=\_F (UNTIL  
=5.,  
NUMBERS  
=5)),***

***U1 = STAT\_NON\_LINE (INCREMENT =\_F (  
LIST\_INST  
=LIST,  
INST\_FIN  
=3.))***

***U2 = STAT\_NON\_LINE (INCREMENT =\_F (LIST\_INST =LIST)),***

***U2 = STAT\_NON\_LINE (reuse=U2,  
ETAT\_INIT  
=\_F (EVOL\_NOLI  
=U1),  
INCREMENT  
=\_F (LIST\_INST  
=LIST),  
FILING  
=\_F (LIST\_INST  
=  
LIST))***

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The final result for the filing of U2 is as follows:

*number of filing*

: 1

2

3

4

5

6

7

*corresponding moments*

: 1. 2. 3. 4. 5. 4. 5.

**B - Simple example**

*LIST = DEFI\_LIST\_REEL (=0 BEGINNING.,*

*INTERVAL*

*=\_F (UNTIL*

*=10.,*

*NUMBERS*

*=5)),*

*U2 = STAT\_NON\_LINE (*

*INCREMENT =\_F (LIST\_INST =LIST)),*

```
&U2 = STAT_NON_LINE (  
reuse=U2,  
ETAT_INIT  
=_F (  
EVOL_NOLI  
=U2,  
INST  
=4.),  
INCREMENT  
=_F (  
LIST_INST  
=LIST),  
FILING  
=_F (  
LIST_INST  
=LIST,  
DETR_NUME_SUIV  
= ' OUI'))  
,
```

*The result of filing for 1st U2 is as follows:*

*number of filing*

*: 1*

*2*

*3*

*4*

*5*

*corresponding moments*

*: 2.*

*4.*

*6.*

*8.*

*10.*

*The final result of filing for U2 is as follows (by defect nuinit = 3):*

*number of filing*

*: 1*

*2*

*3*

*4*

*5*

*corresponding moments*

*: 2.*

- 4.
- 6.
- 8.
- 10.

### ***C - Example with NUME\_INIT***

*LIST = DEFI\_LIST\_REEL (=0 BEGINNING.,*

*INTERVAL*  
*=\_F (UNTIL*  
*=10.,*  
*NUMBERS*  
*=5)),*

*U2 = STAT\_NON\_LINE (*  
*INCREMENT =\_F (LIST\_INST =LIST)),*

*U2 = STAT\_NON\_LINE (*  
*reuse=U2,*  
*ETAT\_INIT*  
*=\_F (*  
*EVOL\_NOLI*  
*=U2,*  
*INST*  
*=4.),*  
*INCREMENT*  
*=\_F (*  
*LIST\_INST*  
*=LIST),*  
*FILING*  
*=\_F (*  
*LIST\_INST*  
*=LIST,*  
*NUME\_INIT*  
*=2*  
*,*  
*DETR\_NUME\_SUIV*  
*= ' OUI'))*  
*,*

*The result of filing for 1st U2 is as follows:*  
*number of filing*  
*: 1*



- 2
- 3
- 4
- 5

*corresponding moments*

- : 2.
- 4.
- 6.
- 8.
- 10.

*The final result of filing for U2 is as follows:*

*number of filing*

- : 1
- 2
- 3
- 4

*corresponding moments:*

- 2. 6. 8.
- 10.

### ***3.16.4 Operand CHAM\_EXCLU***

***CHAM\_EXCLU = /  
“DEPL”***

***/  
“SIEF\_ELGA”***

***/  
“VARI\_ELGA”***

***/  
“VARI\_NON\_LOCAL”***

***/  
“LANL\_ELGA”***

*Allows to specify the fields which will not be filed, except with the last step of time.*

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*3.17 Word*

*key*

*POSTING*

*This keyword factor makes it possible to personalize the posting of the table of convergence in STAT\_NON\_LINE.*

*POSTING:*

*If this keyword is not indicated, the table is posted in “STANDARD” mode and with INFO\_RESIDU='NON'.*

*Each occurrence of POSTING relates to the posting of a column and its format. The order of columns given by the succession of the NOM\_COLONNE is respected.*

*3.17.1 Operand UNIT*

*UNIT =*

*links*

*The table of convergence will be duplicated in the file of unit links.*

**Note:**

*The unit can be repeated with each occurrence of the keyword factor but only first is taking into account (with posting of an alarm).*

**3.17.2 Operand NOM\_COLONNE**

**NOM\_COLONNE**

=

/

**“STANDARD”,**

/

**“MINIMUM”,**

/

**“ITER\_NEWT”,**

/

**“INCR\_TPS”,**

/

**“RESI\_RELA”,**

/

**“RELA\_NOEU”,**

/

**“RESI\_MAXI”,**

/

**“MAXI\_NOEU”,**

/

**“RESI\_REFE”,**

/

**“REFE\_NOEU”,**

/

**“RELI\_ITER”,**

/

**“RELI\_COEF”,**

/

**“PILO\_PARA”,**

/

**“LAGR\_ECAR”,**

/

**“LAGR\_INCR”,**

/

**“LAGR\_ITER”,**

/

**“MATR\_ASSE”,**

/  
“ITER\_DEBO”,  
/  
“CTCD\_ITER”,  
/  
“CTCD\_INFO”,  
/  
“CTCD\_GEOM”,  
  
/  
“CTCD\_NOEU”,  
/  
“CTCC\_CONT”,  
/  
“CTCC\_FROT”,  
/  
“CTCC\_GEOM”,

*Type of the column to be posted (each value corresponds to a posted column):*

*ITER\_NEWT: number of the iteration of Newton in progress. The column is marked by “X” as long as it convergence there on all the criteria did not have.*

*INCR\_TPS: moment of current calculation.*

*RESI\_RELA and RELA\_NOEU: value of RESI\_GLOB\_RELA and posting of the node where it is maximum.*

*column is marked by X as long as the residue is larger than that specified by the user (operand RESI\_GLOB\_RELA).*

*RESI\_MAXI and MAXI\_NOEU: value of RESI\_GLOB\_MAXI and posting of the node where it is maximum.*

*column is marked by X as long as the residue is larger than that specified by the user (operand RESI\_GLOB\_MAXI).*

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*RESI\_REFE and REFE\_NOEU: value of RESI\_REFE\_RELA and posting of the node where it is maximum.*

*column is marked by X as long as the residue is larger than that specified by the user (operand RESI\_REFE\_RELA).*

*RELI\_ITER and RELI\_COEF: iteration count and linear coefficient of research.*

*PILO\_PARA: value of the parameter of piloting.*

*LAGR\_ECAR,*

*LAGR\_INCR and LAGR\_ITER: parameters of Lagrangian increased (see LAGR\_NON\_LOCAL)*

*MATR\_ASSE: option of assembly for the matrix (elastic, tangent, secant)/*

*ITER\_DEBO: indicate an iteration of Borst for the plane constraints or the behaviors unidimensional (see COMP\_INC)*

*CTCD\_ITER: iteration count intern contact/friction, methods discrete. The column is marked by X as long as the contact did not converge on the geometry.*

*CTCD\_INFO: information on the state of contact for the discrete methods:*

- ALGO: resolution of the problem of contact (iterations intern)*

- ALGO/REAC\_GEOM: resolution of the problem of contact (internal iterations) and updated of geometry for reactualization*

- INIT\_GEOM/ALGO: initialization of the geometry for the contact and resolution of the problem of contact.*

- ATT\_PT\_FIXE: do not make an attempt fixes for the contact discrete methods*

*CTCD\_GEOM: value of maximum displacement for the geometrical reactualization of the contact, discrete methods.*

*CTCD\_NOEU: node where the value of displacement is maximum during the geometrical reactualization*

*contact, discrete methods.*

*CTCC\_GEOM: number of the iteration of contact continuous method at the time of the loop on the geometry.*

*column is marked by X as long as one did not converge.*

*CTCC\_FROT: number of the iteration of contact continuous method at the time of the loop on the threshold of*

*friction. The column is marked by X as long as one did not converge.*

*CTCC\_CONT: number of the iteration of contact continuous method at the time of the loop on the state of contact*

(active constraints). The column is marked by X as long as one did not converge.

Composite types (posts several columns):

**STANDARD:** standard posting (by defect) of the table of convergence. Contains:

- The number of the iteration of Newton (ITE\_NEWT)
- All columns necessary according to functionalities' activated (linear research, contact, piloting,...)
- The value of residues (RESI\_MAXI and RESI\_RELA)

**MINIMUM:** minimum posting of the table of convergence. Contains:

- The number of the iteration of Newton (ITER\_NEWT)
- The value of residues (RESI\_MAXI and RESI\_RELA)

**Note:**

- One cannot require more than sixteen columns (16 columns of 16 characters, that is to say a width total of 256)
- The columns are cumulable: one can ask for MINIMUM posting and add one unspecified column
- One can have several times the same column
- As long as "X" is posted in column ITER\_NEWT, calculation did not converge. This depends of course on the value of the residues but also of the convergence of the contact or on De Borst.
- For the method of contact continues, the iterations of Newton constitutes an internal loop with three other loops (CTCC\_GEOM, CTCC\_FROT and CTCC\_CONT). ITER\_NEWT is not thus not in first position in "STANDARD" mode and it is the marking of columns CTCC\_\* who exploits the part of final Justice of the Peace convergence.

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### ***3.17.3 Operand INFO\_RESIDU***

***INFO\_RESIDU***

=

***“NOT”,  
[DEFECT]***

***“YES”***

***This operand makes it possible to add a column for each residue evaluated (RESI\_RELA, RESI\_MAXI and RESI\_REFE). This column will indicate the node where the residue is maximum, which can help the user when there are difficulties of convergence. For example, to see whether the material were badly definite with an incorrect value on an element.***

***This option is strictly equivalent to the addition of columns RELA\_NOEU, RELA\_MAXI or RELA\_REFE when one completely describes the posting of the table of convergence but allows to post information on the nodes when one is in STANDARD” or “MINIMUM” mode “, without needing to describe all the other columns.***

### ***3.17.4 Operands LONG\_R, PREC\_R and LONG\_I***

***LONG\_R***

= /

12

***[DEFECT]***

/

***long\_r***

***[I]***

***PREC\_R =***

/ 5

***[DEFECT]***

/

***prec\_r***  
**[I]**  
***LONG\_I =***

***/ 6***  
**[DEFECT]**

***/***  
***long\_i***  
**[I]**

*These operands make it possible to modify the posting of information in the table of convergence. All the columns have a fixed width of 16 characters. When information is a reality, one can require a personalized posting: the length long\_r of posted reality (maximum 16) and numbers it significant figures.*

*When it is an entirety, one can regulate the length by long\_i. For a it, character string format is always of 16 characters.*

### ***3.18 Operand OBSERVATION***

*The syntax of this key word common to order DYNA\_NON\_LINE is described in the document [U4.53.01].*

### ***3.19 Operand SOLV\_NON\_LOCAL***

*The syntax of this key word is identical to key word SOLVEUR describes in the document [U4.50.01].  
With  
to use for a nonlocal model.*

### ***3.20 Operand LAGR\_NON\_LOCAL***

*The integration of nonlocal laws of behavior imposes the resolution of a total problem (on all the structure): the minimization of a functional calculus energy (the expression of Lagrangian increased) by  
report/ratio with a scalar nodal variable.*

*The resolution of this problem is carried out by means of an algorithm primal newton and dual BFGS compound, which consists of two phases:*

- Résolution of the primal problem:*
  - Minimization compared to the variable interns nonlocal and its gradient (cham\_elem)*
  - Minimization compared to the variable interns with the nodes (cham\_no)*
  - Primal Test of convergence: the largest component of the assembled residue*
- Résolution of the dual problem: (Maximization compared to the multipliers of Lagrange)*



- *Calculation of a direction of descent BFGS*
- *Linear Research by method of Wolfe*
- *Dual Test of convergence: the largest component of the gradient*
- *Reactualization of the multipliers of Lagrange*

***ITER\_PRIM\_MAXI: iterprimmax (10 per defect)***

*Iteration count maximum for the resolution of the primal problem.*

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***RESI\_PRIM\_ABSO: resiprimab***

*Precision for the test of convergence for the primal problem.*

***ITER\_DUAL\_MAXI: iterdmax (50 per defect)***

*Iteration count maximum for the resolution of the dual problem.*

***RESI\_DUAL\_ABSO: residabso***

*Precision for the test of convergence for the dual problem.*

***R: rho (1000 per defect)***

*Coefficient of penalization of Lagrangian increased.*

**Note:**

*As the precision of the dual problem strongly depends on that of the primal problem, one advise to choose a better precision for the primal problem, for example 100 or 1000 times more than for the dual problem.*

**3.21 Operand  
INFORMATION**

**INFORMATION**

**:**  
**inf**

*Allows to carry out in the file message various intermediate impressions in the presence of unilateral contact treaty by the method of the active constraints.*

*inf =  
1 impression of the list of the nodes in contact after convergence with each iteration of Newton.*

*= 2  
idem 1 plus impression of associations/dissociations of nodes enters iterations of the method of the active constraints.*

*Other impressions are made systematically during nonlinear calculation, independently value assigned to the key word INFORMATION: they are the impressions of the residues and the increments relative of displacement during iterations of Newton.*

**3.22 Operand  
TITRATE**

**TITRATE: tx**

*tx is the title of calculation. It will be printed at the head results. See [U4.03.01].*

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***Nonlinear behaviors***

***1 Goal***

*One describes here the nonlinear behaviors of Code\_Aster, introduced into the operators STAT\_NON\_LINE, DYNA\_NON\_LINE, or DYNA\_TRAN\_EXPLI, via the key words COMP\_INCR or COMP\_ELAS.*

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*Count*

*matters*

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## ***2 Syntax***

***/COMP\_INCR = \_F (***

***RELATION***

***= /***

***“VMIS\_ISOT\_TRAC”,***

***[DEFECT]***

***/ ...***

***/other relations [§ 3.3.1],***

***/ ...***

***RELATION\_KIT=***

***/“ELAS”,***

/ ...

*/other relations [§ 3.3.2],*

/ ...

***DEFORMATION***

=

/  
***“SMALL”, [DEFECT]***

/

***“PETIT\_REAC”,***

/

***“SIMO\_MIEHE”,***

/

***“GREEN”,***

/

***“GREEN\_GR”,***

***/ALL***

=

***“YES”,  
[DEFECT]***

/



/  
**GROUP\_MA=**  
**lgrma,**  
**[l\_gr\_maille]**  
/  
**NET**  
=  
**lma,**  
**[l\_maille]**

**ALGO\_C\_PLAN**  
=  
/  
**“ANALYTICAL”**  
**[DEFECT]**

**/“DEBORST”**

**ALGO\_ID =**  
**/“ANALYTICAL”**

**[DEFECT]**

**/“DEBORST”**

**),**

***/COMP\_ELAS***

***=\_F***

***(***

***RELATION***

***= /***

***“ELAS”,***

***[DEFECT]***

***/ ...***

***/other relations [§ 3.4.1],***

***/ ...***

***DEFORMATION***

***=***

***/***

**'SMALL,  
[DEFECT]**

/

**“GREEN”,**

/

**“GREEN\_GR”,**

**/ALL**

=

**“YES”**

**[DEFECT]**

/

/

**GROUP\_MA=**

**lgrma**

**[l\_gr\_maille]**

/

**NET**

**= lma**

**[l\_maille]**

),

**RESI\_INTE\_RELA**

=

/

**1.E-6,**

**[DEFECT]**

/

**resint,**

**[R]**

***ITER\_INTE\_MAXI***

=  
/  
10,  
[DEFECT]  
/  
***iteint,***  
**[I]**

***ITER\_INTE\_PAS***

=  
/  
0,  
[DEFECT]  
/  
***itepas,***  
**[I]**

***RESO\_INTE***

=  
/  
“***IMPLICIT***”,  
[DEFECT]  
/  
“***RUNGE\_KUTTA\_2***”,  
/  
“***RUNGE\_KUTTA\_4***”,  
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**3 Operands**

**3.1 Word**

**key**

**COMP\_INCR**

**/ COMP\_INCR:**

*This key word factor makes it possible to define the relations of behavior for which history material influences its behavior: majority of the laws of behavior (in particular in plasticity) are written in an incremental way then. The history seen by material is stored in the internal variables. One can have in same calculation certain parts of structure obeying with various incrémentaux behaviors (COMP\_INCR) and other parts obeying various elastic behaviors (COMP\_ELAS).*

*Certain models of behaviors were not developed in plane constraint.*

*However, key word ALGO\_C\_PLAN [§3.3.5] makes it possible to add this condition to all them models: algorithm called "DEBORST" allows a taking into account of the assumption of plane constraints on the level of the algorithm of balance (contrary to the models of "ANALYTICAL" behavior developed explicitly in the language Aster - in plane constraints, which adopt this approach on the level of the integration of the laws of behavior). One can thus also assign a nonlinear law to the elements of structure DKT, COQUE\_3D and PIPE.*

*In the same way, for the uses using a monodimensional state of stresses (POU\_D\_EM, POU\_D\_TGM, GRILLE\_MEMBRANE, BAR), to be able to use the behaviors 3D, it is necessary to use key word ALGO\_1D (METHOD = "DEBORST").*

### **3.1.1 Operand RELATION**

**RELATION:**

**# Model traditional**

**/**  
**“ELAS”**  
**/**  
**“VMIS\_ISOT\_TRAC”**  
**[DEFECT]**  
**/**  
**“VMIS\_ISOT\_LINE”**  
**/**  
**“VISC\_ISOT\_TRAC”**  
**/**  
**“VISC\_ISOT\_LINE”**  
**/**  
**“VMIS\_CINE\_LINE”**  
**/**  
**“VMIS\_ECMI\_TRAC”**  
**/**  
**“VMIS\_ECMI\_LINE”**  
**/**  
**“LEMAITRE”**  
**/**  
**“CHABOCHE”**  
**/**  
**“VISC\_CIN1\_CHAB”**  
  
**/**  
**“VISC\_CIN2\_CHAB”**  
**/**  
**“NORTON\_HOFF”**  
**/**  
**“CZM\_EXP\_REG”**  
**/**  
**“CZM\_EXP”**  
**/**  
**“ZMAT”**

**# Model buildings with damage (see also behavior for concrete)**

/  
“**ENDO\_FRAGILE**”  
/  
“**ENDO\_ISOT\_BETON**”  
/  
“**ENDO\_ORTH\_BETON**”  
/  
“**ROUSSELIER**”  
/  
“**ROUSS\_PR**”  
/  
“**ROUSS\_VISC**”  
/  
“**VENDOCHAB**”

**# Model treaties in formulation not room**

/  
“**ENDO\_FRAGILE**”  
/  
“**ENDO\_ISOT\_BETON**”  
/  
“**ENDO\_ORTH\_BETON**”  
/  
“**RUPT\_FRAG**”  
/  
“**VMIS\_ISOT\_TRAC**”  
/  
“**VMIS\_ISOT\_LINE**”

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/

**“DRUCKER\_PRAGER”**

/

**“MAZARS”**

/

**“ROUSSELIER”**

**# Model describing the progressive deformation**

/

**“VISC\_TAHERI”**

/

**“POLY\_CFC”**

**# Model describing the behavior of microstructures**

/

**“MONOCRYSTAL”**

/

**“POLYCRYSTAL”**

**# Behaviors specific to the pencils AND FUEL ASSEMBLIES**

/

**“LMARC”**

/

**“ZIRC\_CYRA2”**

/

**“ZIRC\_EPRI”**

/

**“LEMAITRE\_IRRA”**

/

**“GRAN\_IRRA\_LOG”**

/

**“VISC\_IRRA\_LOG”**



/

**“GATT\_MONNERIE”**

*# Behaviors specific to the elements of beams and discrete*

/

**“DIS\_CONTACT”**

/

**“DIS\_GRICRA”**

/

**“DIS\_CHOC”**

/

**“VMIS\_POU\_LINE”**

/

**“VMIS\_POU\_FLEJOU”**

/

**“WEAPON”**

/

**“ASSE\_CORN”**

/

**“DIS\_GOUJ2E\_PLAS”**

/

**“DIS\_GOUJ2E\_ELAS”**

/

**“VMIS\_ASYM\_LINE”**

/

**“CORR\_ACIER”**

/

**“LMARC\_IRRA”**

*# Model mechanical with effects of the metallurgical transformations*

/

**“META\_P\_IL”**

/

**“META\_P\_INL”**

/

**“META\_P\_IL\_PT”**

/

**“META\_P\_INL\_PT”**

/

**“META\_P\_IL\_RE”**

/

**“META\_P\_INL\_RE”**

/

**“META\_P\_IL\_PT\_RE”**

/

**“META\_P\_INL\_PT\_RE”**

/

**“META\_P\_CL”**

/

**“META\_P\_CL\_PT”**

/

**“META\_P\_CL\_RE”**

/

**“META\_P\_CL\_PT\_RE”**

/

**“META\_V\_IL”**

/

**“META\_V\_INL”**

/

**“META\_V\_IL\_PT”**

/

**“META\_V\_INL\_PT”**

/

**“META\_V\_IL\_RE”**

/

**“META\_V\_INL\_RE”**

/

**“META\_V\_IL\_PT\_RE”**

/

**“META\_V\_INL\_PT\_RE”**

/

**“META\_V\_CL”**

/

**“META\_V\_CL\_PT”**

/

**“META\_V\_CL\_RE”**

/

**“META\_V\_CL\_PT\_RE”**

**# Behaviors for the concrete**

/

**“BETON\_DOUBLE\_DP”**

/

**“MAZARS”**

/

**“LABORD\_ID”**

/

**“JOINT\_BA”**

/

**“GRILLE\_ISOT\_LINE”**

/

**“GRILLE\_CINE\_LINE”**

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/

**“GRILLE\_PINTO\_MEN”**

**/“PINTO\_MENEGOTTO”**

/

**“GLRC”**

/

**“GRANGER\_FP”**

/

**“GRANGER\_FP\_INDT”**

/

**“GRANGER\_FP\_V”**

/

**“BAZANT\_FD”**

/

**“BETON\_UMLV\_FP”**

/

**“KIT\_DDI”**

/

**“CORR\_ACIER”**

**# Behaviors for the porous environments and the grounds**

/

**“KIT\_HM”**

/

**“KIT\_THM”**

/

**“KIT\_HHM”**

/

**“KIT\_THH”**

/

**“KIT\_THHM”**

/

**“KIT\_THV”**

/

**“CJS”**

/

**“DRUCKER\_PRAGER”**

/

**“LAIGLE”**

/

**, HOEK\_BROWN'**

/

**“ELAS\_THM”**

/

**“CAM\_CLAY”**

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**“BARCELONA”**

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***Small dictionary of the modelings supported by the laws of nonlinear behavior  
Not to overload this document, we will invite thereafter:***

.

***Modeling 3D***

***= modelings 3D and 3D\_SI***

.

***Modeling D\_PLAN***

***= modelings D\_PLAN and D\_PLAN\_SI***

.

***Modeling AXIS***

***= modelings AXIS and AXIS\_SI***

.

***Modeling C\_PLAN***

***= modelings C\_PLAN and C\_PLAN\_SI***

.

***Modeling HULL***

***= modelings COQUE\_3D and DKT***

.

***Modeling PIPE***

***= modelings TUYAU\_3M and TUYAU\_6M***

.

***Modeling COQUE1D***

***= modelings COQUE\_AXIS, COQUE\_C\_PLAN and  
COQUE\_D\_PLAN***

.

***Modeling 3D\_DIS***

***= modelings DIS\_T and DIS\_TR***

.

***Modeling 2D\_DIS***

***= modelings 2D\_DIS\_T and 2D\_DIS\_TR***

•  
**Modeling ROASTS**

= *modelings ROASTS and GRILLE\_MEMBRANE*

•  
**Modeling INCO**

= *modelings 3D\_INCO, AXIS\_INCO and D\_PLAN\_INCO*

•  
**Modeling LOUSE**

= *modelings POU\_D\_E, POU\_D\_T, POU\_D\_TG,*

•  
**Modeling PMF**

= *POU\_D\_EM and POU\_D\_TGM*

•  
**Modeling BARS**

= *modeling BARS and 2D\_BARRE*

•  
**Modeling THM**

= *modelings 3D\_HHM, 3D\_HM, 3D\_JOINT\_CT,  
3D\_THH, 3D\_THHM, 3D\_THM, 3D\_HHMD, 3D\_HMD,  
3D\_THHD, 3D\_THHMD, 3D\_THMD, 3D\_THVD, AXIS\_HHM,  
AXIS\_HM, AXIS\_THH, AXIS\_THHM, AXIS\_THM,  
AXIS\_HHMD, AXIS\_HH2MD, AXIS\_HMD, AXIS\_THHD,  
AXIS\_THH2D, AXIS\_THHMD, AXIS\_THH2MD, AXIS\_THMD,  
AXIS\_THVD, D\_PLAN\_HHM, D\_PLAN\_HM, D\_PLAN\_THH,  
D\_PLAN\_THHM, D\_PLAN\_THM, D\_PLAN\_HHMD,  
D\_PLAN\_HH2MD, D\_PLAN\_HMD, D\_PLAN\_THHD,  
D\_PLAN\_THH2D, D\_PLAN\_THHMD, D\_PLAN\_THH2MD,  
D\_PLAN\_THMD and D\_PLAN\_THVD*

•  
**Modeling GRAD\_EPSI** = *modelings 3D\_GRAD\_EPSI, D\_PAN\_GRAD\_EPSI and  
C\_PLAN\_GRAD\_EPSI*

•  
**Modeling GRAD\_VARI** = *modelings 3D\_GRAD\_VARI, D\_PAN\_GRAD\_VARI,  
C\_PLAN\_GRAD\_VARI and AXIS\_GRAD\_VARI*

•  
**Modeling FISSURES**

*PLAN\_FISSURE, AXIS\_FISSURE*

**Note:**

*If a law of behavior is used with one of modelings INCO (for  
incompressible), it is necessary to use only the tangent matrix (key word factor  
PREDICTION=' TANGENTE' and MATRICE=' TANGENTE' under NEWTON of*

## **STAT\_NON\_LINE**

**[U4.51.03] and DYNA\_NON\_LINE [U4.53.01]). In the contrary case, one stops in fatal error.**

### **Note:**

**Thereafter, one will give, for each law of behavior, the number of variables interns stored under VARI\_ELGA and their significance (if this number is not too large).**

**For the precise significance of these various relations one will refer to various documentations of Reference like to the documentation of DEFI\_MATERIAU.**

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### **3.1.1.1 Models**

**traditional**

**Unless otherwise specified, all the models can include a dependence compared to temperature.**

**/“ELAS”**

**Relation of elastic behavior incremental: it makes it possible to take into account initial displacements and constraints given under key word ETAT\_INIT. Data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key word ELAS (\_FO).**

**Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, HULL, PIPE, COQUE1D, 3D\_DIS, 2D\_DIS, INCO, LOUSE, BAR, PMF, GRID.**

**A number of internal variables: 1**

**Significance: V1: vacuum thus is worth always zero (with the deformations of the type SIMO\_MIEHE**

**only cf [§3.3.3], V1 is equal to the trace of the tensor of elastic strain divided by 3 used for formulation SIMO\_MIEHE).**

**/“VMIS\_ISOT\_TRAC”**

**Relation of behavior of elastoplasticity of Von Mises with nonlinear isotropic work hardening. The curve (,) in simple traction is provided in operator DEFI\_MATERIAU [U4.43.01], under the key word TRACTION (cf [R5.03.02] for more details). One can possibly define several traction diagrams according to the temperature. One must also inform the key word ELAS (\_FO) in operator DEFI\_MATERIAU. It is the relation of behavior per defect for incrémentaux behaviors.**

**If a traction diagram is provided, the YOUNG modulus used for the relation of behavior is that calculated starting from the first point of the traction diagram, that used for the calculation of the elastic matrix (see key word NEWTON [U4.51.03]) is that given in ELAS (\_FO).**

**Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, HULL, PIPE, COQUE1D, BAR, PMF and INCO.**

**A number of internal variables: 2**

**Significance: V1: cumulated plastic deformation, V2: indicator of plasticity (0 for rubber band, 1 for plastic). With the deformations of the type SIMO\_MIEHE only (cf [§3.3.3]), one internal variable additional V3: trace tensor of elastic strain divided by 3 used for formulation SIMO\_MIEHE.**

**Supported nonlocal modeling (see [§ 3.3.1.3]): GRAD\_VARI**

**/“VMIS\_ISOT\_LINE”**

**Relation of behavior of elastoplasticity of Von Mises with linear isotropic work hardening. data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01] under key words ECRO\_LINE (\_FO) and ELAS (\_FO) (cf [R5.03.02]).**

**Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, HULL, PIPE, COQUE1D, INCO, PMF and BAR.**

**A number of internal variables: 2**

**Significance (except modeling BARS): V1: cumulated plastic deformation, V2: indicator of**



*plasticity (0 for rubber band, 1 for plastic). With the deformations of the type SIMO\_MIEHE only (cf [§3.3.3]), an internal variable additional V3: trace tensor of elastic strain divided by 3 used for formulation SIMO\_MIEHE.*

*Supported nonlocal modeling (see [§ 3.3.1.3]): GRAD\_VARI*

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*/“VISC\_ISOT\_LINE”*

*Visco-elastoplastic relation of behavior in great deformations (formulation SIMO\_MIEHE only). The plastic model is VMIS\_ISOT\_LINE i.e. with work hardening isotropic linear. The data necessary of the field material are provided in the operator DEF1\_MATERIAU [U4.43.01] under key words ECRO\_LINE (\_FO), ELAS (\_FO). The law of viscosity is a hyperoblic law in sine (cf [R5.03.21]). The viscous parameters are to inform under key word VISC\_SINH in operator DEF1\_MATERIAU.*

*Supported modelings: 3D, D\_PLAN, AXIS and INCO.*

*A number of internal variables: 3*

*Significance: V1: cumulated plastic deformation, V2: indicator of plasticity (0 for rubber band, 1 for plastic), V3: trace tensor of elastic strain divided by 3 used for formulation SIMO\_MIEHE.*

*/“VISC\_ISOT\_TRAC”*

**Visco-elastoplastic relation of behavior in great deformations (formulation SIMO\_MIEHE only). The plastic model is VMIS\_ISOT\_TRAC i.e. with work hardening isotropic nonlinear. The curve (,) in simple traction is provided in the operator DEF1\_MATERIAU [U4.43.01], under the key word TRACTION (cf [R5.03.02] for more details). One can possibly define several traction diagrams according to the temperature. One must also to inform key word ELAS (\_FO) in operator DEF1\_MATERIAU. The law of viscosity is a law in hyperbolic sine (cf [R5.03.21]). The viscous parameters are to inform under key word VISC\_SINH in operator DEF1\_MATERIAU.**

**Supported modelings: 3D, D\_PLAN, AXIS and INCO.**

**A number of internal variables: 3**

**Significance: V1: cumulated plastic deformation, V2: indicator of plasticity (0 for rubber band, 1 for plastic), V3: trace tensor of elastic strain divided by 3 used for formulation SIMO\_MIEHE.**

**/“VMIS\_CINE\_LINE”**

**Relation of behavior of elastoplasticity of Von Mises with linear kinematic work hardening. The data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under key words ECRO\_LINE (\_FO) and ELAS (\_FO) (cf [R5.03.02] for more details).**

**Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), HULL, PIPE, COQUEID, INCO, BAR and PMF.**

**A number of internal variables (except modelings BARS and PMF): 7**

**Significance: V1 with V6: 6 components of the tensor of kinematic work hardening X, V7: indicator of plasticity (0 for rubber band, 1 for plastic).**

**A many internal variables for modeling BAR: 2**

**Significance: V1: kinematic work hardening X.**

**V2: indicator of plasticity**

**/“VMIS\_ECMI\_TRAC”**

**Relation of behavior of elastoplasticity of Von Mises with combined, kinematic work hardening linear and isotropic nonlinear (cf [R5.03.02] for more details). Isotropic work hardening is given by a traction diagram (,) or possibly by several curves if those  $C_i$  depend on the temperature. The characteristics of material are provided in the operator DEF1\_MATERIAU [U4.43.01], under key words PRAGER (\_FO) (for kinematic work hardening), TRACTION (for isotropic work hardening) and ELAS (\_FO).**

**Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, INCO, HULL, PIPE and COQUEID (by DEBORST key word ALGO\_ID: modelings BARS, PMF, GRID).**

***A number of internal variables: 8***  
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***Significance: V1: cumulated plastic deformation, V2: indicator of plasticity (0 for rubber band, 1 for plastic), V3 with V8: 6 components of the kinematic tensor of work hardening X.***

***/"VMIS\_ECMI\_LINE"***

***Relation of behavior of elastoplasticity of Von Mises with combined, kinematic work hardening linear and isotropic linear (cf [R5.03.02] for more details). Characteristics of material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words PRAGER (\_FO) (for kinematic work hardening), ECRO\_LINE (\_FO) (for isotropic work hardening) and ELAS (\_FO).***

***Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, INCO, HULL, PIPE and COQUE1D (by DEBORST key word ALGO\_ID: modelings BARS, PMF, GRID).***

***A number of internal variables: 8***

***Significance: V1: cumulated plastic deformation, V2: indicator of plasticity (0 for rubber band, 1 for plastic), V3 with V8: 6 components of the kinematic tensor of work hardening X.***

***/"LEMAITRE"***

***Relation of viscoplastic behavior nonlinear of Lemaitre (without threshold). A particular case***

*of this relation (by cancelling parameter UN\_SUR\_M) a relation of NORTON gives. data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words LEMAITRE (\_FO) and ELAS (\_FO) (cf [R5.03.08] for more details). The correspondence of the internal variables allows the chaining with a calculation using one elastoplastic behaviour with isotropic work hardening (“VMIS\_ISOT\_LINE” or “VMIS\_ISOT\_TRAC”). The integration of this model is carried out by an semi-implicit method (coded into hard thus nothing to specify of private individual by the user).*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), INCO, HULL, PIPE, COQUEID and DEBORST, key word ALGO\_ID: BAR, PMF, GRID.*

*A number of internal variables: 2*

*Significance: V1: cumulated plastic deformation, V2: vacuum thus is worth always 0.*

*/“CHABOCHE”*

*Relation of behavior of Chaboche in isothermal elastoplasticity with 2 tensors of nonlinear kinematic work hardening (without effect of work hardening on the term of recall) more one isotropic work hardening. The data necessary of the field material are provided in the operator DEFI\_MATERIAU [U4.43.01], under key words CHABOCHE and ELAS (cf [R5.03.04] for more details). To facilitate the integration of this model, one can use local automatic recutting step of time (see [§3.13.6], key word ITER\_INTE\_PAS).*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, INCO, HULL, PIPE, COQUEID (and by DEBORST, key word ALGO\_ID: PMF, BARS, GRID).*

*A number of internal variables: 14*

*Significance: V1 with V6: 6 components of the 1st tensor of kinematic work hardening X1, V7 with V12:*

*6 components of the 2nd kinematic tensor of work hardening X2, V13: plastic deformation cumulated, V14: 1 is worth.*

*/“VISC\_CINI\_CHAB”*

*Relation of behavior of Chaboche (account of the cyclic behavior of material returns) in élasto- (visco) - plasticity with a tensor of kinematic work hardening nonlinear, a work hardening isotropic nonlinear, an effect of work hardening on the tensorial variable of recall and possibly the taking into account of viscosity. All the constants of material possibly can to depend on the temperature (contrary to CHABOCHE). Data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under the key words CINI\_CHAB (\_FO), ELAS (\_FO) (cf [R5.03.04] for more details) and LEMAITRE if one holds count viscosity (if there is no viscosity especially not to inform*

***LEMAITRE). Integration is completely implicit.***

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*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), INCO, HULL, PIPE, COQUE1D (and by DEBORST, key word ALGO\_1D: PMF, BARS, ROAST).*

*A number of internal variables: 8*

*Significance: V1: cumulated plastic deformation, V2: indicator of plasticity (0 for rubber band, 1 for plastic), V3 with V8: 6 components of the kinematic tensor of work hardening **X**.*

**/"VISC\_CIN2\_CHAB"**

*Relation of behavior of Chaboche (account of the cyclic behavior of material returns) in élasto- (visco) - plasticity with 2 tensors of nonlinear kinematic work hardening, a work hardening isotropic nonlinear, an effect of work hardening on the tensorial variable of recall and possibly the taking into account of viscosity. All the constants of material possibly can depend on the temperature (contrary to CHABOCHE). Data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under the key words CIN2\_CHAB (\_FO), ELAS (\_FO) (cf [R5.03.04] for more details) and LEMAITRE if one holds count viscosity (if there is no viscosity especially not to inform LEMAITRE). Integration is completely implicit.*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), INCO, HULL, PIPE, COQUE1D (and by ALGO\_1D/DEBORST: PMF, BARS, GRID).*

*A number of internal variables: 14*

*Significance: V1: cumulated plastic deformation, V2: indicator of plasticity (0 for rubber band, 1 for plastic), V3 with V8: 6 components of the 1st tensor of the kinematic variable **1**, V9 with V14: 6 components of the 2nd tensor of the kinematic variable **2**.*

**/"NORTON\_HOFF"**

*Relation of behavior of viscosity independent of the temperature, to use in particular for the calculation of loads limit structures, with threshold of Von Mises. The only parameter material is elastic limit to be informed in operator `DEFI_MATERIAU` [U4.43.01] under the key word `ECRO_LINE` (cf [R7.07.01] and [R5.03.12] for more details). For the calculation of the limiting load, it exist a specific key word under `PILOTING` for this model (see key word `PILOTING`: "ANA\_LIM" [§3.11]). It is strongly advised to employ linear research (see key word `RECH_LINEAIRE` [§3.9]). Indeed, the calculation of the limiting load requires much iterations of linear research (about 50) and of iterations of Newton (about 50).*

*Supported modeling: INCO.*

*A number of internal variables: 1*

*Significance: V1: vacuum thus is worth 0.*

*A number of internal variables: 2*

*Significance: V1: threshold corresponding to the greatest jump of displacement (in standard) never reached, V2: indicator of cracking (0 for elastic mode, 1 for softening mode).*

**/"CZM\_EXP\_REG"**

*Cohesive relation of behavior (Cohesive Exponential Model Zone Regularized) of type Barenblatt (cf [R7.02.11] for more detail) modelling the opening of a crack. This law is usable with the finite element of type joint (cf [R3.06.09] for more detail) and allows to introduce a force of cohesion enters the lips of the crack. Data necessary of the field material are provided in operator `DEFI_MATERIAU` [U4.43.01], under key word `RUPT_FRAG`. The use of this model requires the presence of piloting by `PRED_ELAS` (cf [§3.11]).*

*Supported modeling: PLAN\_JOINT, AXIS\_JOINT.*

*A number of internal variables: 4*

*Significance: V1: threshold corresponding to the greatest jump of displacement (in standard) never reached, V2: indicator of cracking (0 for linear mode, 1 for softening mode), V3: indicator of the percentage of dissipated energy, V4: indicator being worth 2 if the lips are in contact or 1 if there is separation.*

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**/“CZM\_EXP”**

*Cohesive relation of behavior (Cohesive Exponential Model Zone) of Barenblatt type (Cf [R7.02.12] for more detail) modelling the opening of a crack. This law is usable with the finite element with internal discontinuity (cf [R7.02.12] for more detail) and allows to introduce a force of cohesion enters the lips of the crack. Data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key word RUPT\_FRAG. The use of this model requires the presence of piloting by PRED\_ELAS (cf [§3.11]).*

*Supported modeling: PLAN\_ELDI, AXIS\_ELDI.*

*A number of internal variables: 7*

*Significance: V1: normal jump, V2: tangential jump, V3: variable threshold, V4: indicator of cracking (0 for linear mode, 1 for softening mode), V5: indicator of the percentage of dissipated energy, V6: normal constraint, V7: tangential constraint.*

**/“ZMAT”**

**NB\_VARI =**

**nbvar**

**UNIT**

**= links**

***ZMAT, is the module of definition of the behaviors of the code Zebulon (Center of Materials, École Nationale Supérieure of the Mines of Paris) the coupling Zmat Code\_Aster is translated for***



*the user of Code\_Aster in the following way:*

- on the level of COMP\_INCR, key word RELATION=' ZMAT', to go to read the file containing the data ZMAT (which allows at the same time the choice of the behavior and definition of the coefficients material). This file can call upon a behavior already available in Zmat, or well defined by the user in a relatively simple language (Zebfront).*
- always under COMP\_INCR, a key word UNIT makes it possible to define the logical unit on which comes to read to card-index it zmat and one have mot\_clé NB\_VARI making it possible to specify the number of variables intern behavior, and of course the usual key words: GROUP\_MA, DEFORMATION (SMALL or PETIT\_REAC for the moment), In ASTK, compared to one traditional study, it is enough to add file ZMAT corresponding to the unit defined above.*

*The use of Zmat for Code\_Aster is envisaged, within the framework of the partnership School of the Mines -*

*EDF, for calculations of R & D only, which excludes in particular in the version 8.2 them studies IPS. Out of this framework, the licence of Zmat can be acquired near the Center of Materials of the ENSMP.*

*For more details, to see the document [U2.10.01] Note of use of the coupling Zmat-Aster  
The documentation of use of ZMat is available on the machine of development  
Alphaservor in the /aster/public/Z8.3/HANDBOOK repertory*

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### **3.1.1.2 local Models with damage**

#### **Caution:**

**The response of a model of local behavior with damage is dependent on grid.**

**/“ENDO\_FRAGILE”**

**Relation of elastic behavior fragile. It is about a local modeling with damage scalar and with negative linear isotropic work hardening (cf [R5.03.18] for more details). characteristics of material are defined in operator *DEFI\_MATERIAU* [U4.43.01] under key words *ECRO\_LINE* (*\_FO*) (negative *DSDE*) and *ELAS* (*\_FO*).**

**Supported modelings: 3D, *D\_PLAN*, *AXIS*, *C\_PLAN*, *INCO*, *HULL*, *PIPE* and *COQUE1D*.**

**A number of internal variables: 2**

**Significance: *V1*: value of the damage, *V2*: indicator of damage (0 if the damage is worth 0, 1 if the damage is higher than 0).**

**Supported nonlocal modeling (see [§ 3.3.1.3]): *GRAD\_VARI* and *GRAD\_EPSI*.**

**/“ENDO\_ISOT\_BETON”**

**Relation of elastic behavior fragile. It is about a local modeling with damage scalar and with negative linear isotropic work hardening which distinguishes behaviour in traction and in compression of the concrete (cf [R7.01.04] for more details). The characteristics of material are defined in operator *DEFI\_MATERIAU* [U4.43.01] under key words *BETON\_ECRO\_LINE* and *ELAS*.**

**Supported modelings: 3D, *D\_PLAN*, *AXIS*, *C\_PLAN* (by *DEBORST*, key word *ALGO\_C\_PLAN* [§3.3.5]), *INCO*, *HULL*, *PIPE*, *COQUE1D*.**

**A number of internal variables: 2**

**Significance: *V1*: value of the damage, *V2*: indicator of damage (0 for mode rubber band (null damage), 1 if damaged, 2 if broken (damage equal to 1)).**

**Supported nonlocal modeling (see [§ 3.3.1.3]): *GRAD\_EPSI***

**/“ENDO\_ORTH\_BETON”**

**Relation of anisotropic behavior of the concrete with damage [R7.01.09]. It is about one local modeling of fascinating damage of account refermeture of the cracks.**

*characteristics of materials are defined in operator DEFI\_MATERIAU under the key words ELAS and ENDO\_ORTH\_BETON.*

*Supported modelings: 3D, D\_PLAN, AXIS (by DEBORST: C\_PLAN...)*

*A number of internal variables: 7*

*Significance: V1 with V6: tensor of damage of traction  
V7: damage of compression*

**Note:**

*Three following models “ROUSSELIER” (elastoplastic model), “ROUSS\_PR” (model elastoplastic) and “ROUSS\_VISC” (model elastoviscoplastic) are three versions different from the model of Rousselier. This model is a relation of behavior élasto (visco) plastic which makes it possible to account for the growth of the cavities and to describe ductile rupture in steels. Apart from the with dimensions viscous plastic/, the difference essential resides in the way in which the great deformations are treated. For model*

*“ROUSSELIER” it acts of a standard formulation Simo\_Miehe (DEFORMATION: “SIMO\_MIEHE” to see [§3.3.3]) and for the two others of a formulation type “PETIT\_REAC” (DEFORMATION: “PETIT\_REAC” to see [§3.3.3]). On different examples treated in plasticity, it was noted that model “ROUSS\_PR” needs much more iterations of Newton to converge compared to model “ROUSSELIER”.*

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*It should be also noted that these three models treat in a different way broken material. In models “ROUSS\_PR” and “ROUSS\_VISC”, when porosity reaches a porosity limit, one considers broken material. The behavior is then replaced by a fall imposed constraints. To activate this modeling of broken material, it is necessary then to inform in operator DEF1\_MATERIAU [U4.43.01], under the key word ROUSSELIER (\_FO), two coefficients “PORO\_LIMI” and “D\_SIGM\_EPSI\_NORM”. For “ROUSSELIER”, one does not do anything in particular because the constraint tends naturally towards zero when porosity tends towards one. The two preceding parameters can be indicated but do not have impact on the model.*

### ***/“ROUSSELIER”***

*Elastoplastic relation of behavior. It makes it possible to account for the growth of cavities and to describe the ductile rupture. This model gets busy exclusively with the key word DEFORMATION: “SIMO\_MIEHE” (see [§3.3.3]). Data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under the key words ROUSSELIER (\_FO) and ELAS (\_FO) (cf [R5.03.06] for more details). To facilitate integration this model, it is advised systematically to use the total recutting of the step of time (see [§3.7.4], key word SUBD\_PAS). This model is not developed in plane constraint. Moreover, with key word SIMO\_MIEHE, one cannot use the plane constraints by the method DEBORST.*

*Supported modelings: 3D, D\_PLAN, AXIS.*

*A number of internal variables: 9*

*Significance: V1: cumulated plastic deformation, V2: value of porosity, V3 with V8: 6 components of a tensor eulérien in great deformations of elastic strain, V9: indicator of plasticity (0 so elastic, 1 so plastic with regular solution, 2 so plastic with singular solution).*

### ***/“ROUSS\_PR”***

*Elastoplastic relation of behavior. It makes it possible to account for the growth of cavities and to describe the ductile rupture. This model gets busy exclusively with the key words DEFORMATION: “PETIT\_REAC” or “SMALL”, to see [§3.3.3], (to use modeling preferably “PETIT\_REAC” because it is a model great deformations). Data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under the key words ROUSSELIER (\_FO) and ELAS (\_FO) (cf [R5.03.06] for more details). One also can to take into account the nucleation of the cavities. It is then necessary to inform the parameter YEAR (key word not activated for model ROUSSELIER and ROUSS\_VISC) under ROUSSELIER (\_FO) to facilitate the integration of this model, it is advised to use the local automatic recutting of the step of time (see [§3.13.6], key word ITER\_INTE\_PAS).*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), INCO, HULL, PIPE and COQUE1D.*

*A number of internal variables: 3*

*Significance: V1: cumulated plastic deformation, V2: value of porosity, V3: indicator of plasticity (0 so elastic, 1 so plastic).*

***/"ROUSS\_VISC"***

*Relation of behavior élasto-visco-plastic. It makes it possible to account for the growth cavities and to describe the ductile rupture. This model gets busy exclusively with the key words DEFORMATION: "PETIT\_REAC" or "SMALL", to see [§3.3.3], (to take modeling "PETIT\_REAC" because it is a model great deformations). Data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under the key words VISC\_SINH, ROUSSELIER (\_FO) and ELAS (\_FO) (cf [R5.03.06] for more details). To facilitate the integration of this model, it is advised to use the local automatic recutting of the step of time (see [§3.12.5], key word ITER\_INTE\_PAS). For the integration of this law, one - method is available and one advises to use an semi-implicit integration i.e.:*

*PARAM\_THETA:*

*0.5*

*CONVERGENCE*

*:*  
*(RESO\_INTE*

*:*  
*"IMPLICIT"*

*)*  
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*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), INCO, HULL, PIPE and COQUEID.*

*A number of internal variables: 3*

*Significance: V1: cumulated plastic deformation, V2: value of porosity, V3: indicator of plasticity (0 so elastic, 1 so plastic).*

**/“VENDOCHAB”**

*Viscoplastic model coupled with the isotropic damage of Lemaitre-Chaboche [R5.03.15]. It model gets busy with key words DEFORMATION = SMALL or PETIT\_REAC. Data necessary are defined in DEFI\_MATERIAU under key words VENDOCHAB (\_FO) and ELAS (\_FO).*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, INCO, HULL, PIPE and COQUEID.*

*A number of internal variables: 9*

*Significance: V1 with V6: viscoplastic deformation, V7: cumulated plastic deformation, V8: isotropic work hardening, V9: damage.*

### **3.1.1.3 nonlocal Models**

***There are two types of laws in nonroom.***

***First is activated in AFFE\_MODELE by the key word MODELING: “3D\_GRAD\_EPSI”, “D\_PLAN\_GRAD\_EPSI” or “C\_PLAN\_GRAD\_EPSI”. They are nonlocal laws regularized on deformation. One defines a field of regularized deformation, dependent on the traditional local deformation by***

***a regularizing operator who aims to limit the concentrations of deformations (Cf [R5.04.02] for more detail).***

***The second type is activated in AFFE\_MODELE by the key word MODELING: “3D\_GRAD\_VARI”, “D\_PLAN\_GRAD\_VARI”, “C\_PLAN\_GRAD\_VARI” or “AXIS\_GRAD\_VARI”.***

***They are nonlocal laws here where the gradient of the internal variables of the local model intervenes.***

***The key word MODELING makes it possible to activate in operator STAT\_NON\_LINE the key word LAGR\_NON\_LOCAL (and SOLV\_NON\_LOCAL), algorithm of resolution specific to the models not buildings.***

*Any model written in nonroom involves the introduction of a characteristic of material additional, the characteristic length which is defined under the key word factor NON\_LOCAL of operator DEFI\_MATERIAU.*

***The response of a nonlocal modeling is independent of the grid.***

*The nonlocal models being sophisticated than their equivalent locally, calculation is more expensive in computing times. The first modeling GRAD\_EPSI is nevertheless faster than modeling GRAD\_VARI.*

*The various laws available in nonlocal are as follows:*

***/"ENDO\_FRAGILE"***

*Cf [R5.04.02] for more detail for the nonlocal version.*

*Supported nonlocal modeling: GRAD\_VARI and GRAD\_EPSI*

*A number of variables intern for modeling GRAD\_EPSI: 2*

*Significance: V1: value of the damage, V2: indicator of damage (0 if the damage is worth 0, 1 if the damage is higher than 0).*

*A number of variables intern for modeling GRAD\_VARI: 6*

*Significance: V1: value of the damage, V2 with V4: 3 components of the gradient of the damage, V5*

*: variable useful for the formulation for gradient, V6*

*: indicator*

*of damage (0 so elastic, 1 if the damage is higher than 0, 2 if broken (damage of 0.999)).*

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### **/“RUPT\_FRAG”**

*Nonlocal relation of behavior based on the formulation of J.J. Marigo and G. Frankfurt of breaking process (not of equivalent in local version). This model describes the appearance and propagation of cracks in an elastic material. The characteristics of material are defined in operator DEF1\_MATERIAU [U4.43.01] under key words ELAS, RUPT\_FRAG and NON\_LOCAL.*

*Supported nonlocal modeling: GRAD\_VARI.*

*A number of internal variables: 4*

*Significance: V1: value of the damage, V2 with V4: 3 components of the gradient of the damage.*

### **/“VMIS\_ISOT\_LINE”**

*Cf [R5.04.02] for more detail on the nonlocal version.*

*Supported nonlocal modeling: GRAD\_VARI.*

*A number of internal variables: 6*

*Significance: V1: cumulated plastic deformation, V2 with V4: 3 components of the gradient of plastic deformation cumulée, V5: null variable (useless), V6: indicator of damage (0 so elastic, 1 so plastic and regular solution, 2 so plastic and singular solution).*

### **/“VMIS\_ISOT\_TRAC”**

*Cf [R5.04.02] for more detail on the nonlocal version.*

*Supported nonlocal modeling: GRAD\_VARI*

*A number of internal variables: 6*

*Significance: V1: cumulated plastic deformation, V2 with V4: 3 components of the gradient of plastic deformation cumulée, V5: null variable (useless), V6: indicator of damage (0 so elastic, 1 so plastic and regular solution, 2 so plastic and singular solution).*

### **/“ENDO\_ISOT\_BETON”**



*Cf [R5.04.02] for more detail on the nonlocal version.*

*Supported nonlocal modeling: GRAD\_EPSI*

*A number of internal variables: 2*

*Significance: V1: value of the damage, V2: indicator of damage (0 for mode rubber band (null damage), 1 if damaged, 2 if broken (damage equal to 1)).*

***/"ENDO\_ORTH\_BETON"***

*Relation of anisotropic behavior of the concrete with damage [R7.01.09]. It is about one local modeling of fascinating damage of account refermeture of the cracks. characteristics of materials are defined in operator DEFI\_MATERIAU under the key words ELAS and ENDO\_ORTH\_BETON.*

*Supported modeling: GRAD\_EPSI*

*A number of internal variables: 7*

*Significance: V1 with V6: tensor of damage of traction  
V7: damage of compression*

***/"MAZARS"***

*Cf [R7.01.08] for more detail on the nonlocal version.*

*Supported nonlocal modeling: GRAD\_EPSI*

*A number of internal variables: 3*

*Significance: V1: value of the damage, V2: indicator of damage (0 for mode rubber band (null damage), 1 if damaged), V3: maximum temperature attack at the point of Gauss considered.*

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**/“ROUSSELIER”**

*Cf [R5.04.02] for more detail for the nonlocal version.*

*Supported nonlocal modeling: GRAD\_VARI*

*A number of internal variables: 12*

*Significance:*

*V1: cumulated plastic deformation,*

*V2 with V4: gradient of the plastic deformation cumulated along axes X, y, Z, respectively,*

*V5: porosity,*

*V6 with V11: elastic strain used for SIMO\_MIEHE,*

*V12: indicator of plasticity*

*(0 so elastic,*

*1 so plastic and regular solution,*

*2 so plastic and singular solution).*

### **3.1.1.4 Models describing the phenomenon of progressive deformation**

**/“VISC\_TAHERI”**

*Relation of behavior (visco) - plastic modelling the response of materials under loading cyclic plastic. The data necessary of the field material are provided in the operator DEF1\_MATERIAU [U4.43.01], under key words TAHERI (\_FO) for the description of work hardening, LEMAITRE (\_FO) for viscosity and ELAS (\_FO) (cf [R5.03.05] for more details). In the absence of LEMAITRE, the law is purely plastic.*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), INCO, HULL, PIPE and COQUE1D.*

*A number of internal variables: 9*

*Significance: V1: cumulated plastic deformation, V2: constraint of peak, V3 with V8: 6 components tensor of plastic deformations due to the last discharge, V9: loadmeter/discharge (0 for elastic discharge, 1 if traditional plastic load, 2 if plastic load on two surfaces, 3 if pseudo-discharge).*

**/“POLY\_CFC”**

***Relation of behavior élasto-visco-plastic based on the polycrystalline approach, developed in the Center of Materials of the School of the Mines of Paris. It makes it possible to treat materials with cubic structure with Centered Face having an isotropic texture, under monotonous loadings or cyclic. The data necessary of the field material are provided in the operator `DEFI_MATERIAU [U4.43.01]`, under key words `POLY_CFC (_FO)` and `ELAS (_FO)` (cf [R5.03.13] for more details). The integration of this model can be done only with method `RUNGE KUTTA 2` (see [§3.13.7], key word `RESO_INTE`).***

***Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, INCO, HULL, PIPE, BAR and COQUE1D.***

***A number of internal variables: 1688  
Significance: Cf [R5.03.13]***

### ***3.1.1.5 Behaviors of microstructures***

***Models describing the behavior of microstructures.***

***/“POLYCRYSTAL”***

***/“MONOCRYSTAL”***

***COMPOR = comp [compor]***

***These models make it possible to describe the behavior of a monocrystal or a polycrystal of which their relations of behavior are provided via the concept compor, resulting from `DEFI_COMPOR`. a many internal variables are a function of the choices carried out in `DEFI_COMPOR`; for more specified to consult [R5.03.11].***

***Modeling: 3D***

***Instruction manual***

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### **3.1.1.6 Behaviors specific with the fuel pins**

**/“ZIRC\_CYRA2”**

*Relation of viscoplastic behavior nonlinear for the sheath in Zircaloy of the pencil fuel (law of CYRANO2). This relation describes creep with a formulation in work hardening for time (time-hardening). The data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under key words ZIRC\_CYRA2 and ELAS (Cf [R5.03.08] for more details). For the integration of this law, one advises to use one semi-implicit integration i.e.:*

**PARAM\_THETA:**  
**0.5**  
**CONVERGENCE**

:  
**(RESO\_INTE**  
:  
**“IMPLICIT”**  
)

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), INCO, HULL, PIPE, BARS and COQUE1D.*

*A number of internal variables: 2*

*Significance: V1: cumulated plastic deformation, V2: vacuum thus is worth always 0.*

**/“LMARC”**

*Phenomenologic model developed with the LMA-RC of Besancon to obtain a fine description behavior of the tubes of sheath in Zircaloy of the fuel pin of the power stations REFERENCE MARK which present an anisotropic and strongly viscous mechanical behavior [R5.03.10].*

*The model is available in 3D, plane deformations (D\_PLAN), and axisymetry (AXIS) under name of LMARC.*

*Internal variables: 20*

- *three variables of kinematic work hardening. X, X1, X2 (18 variables intern)*
- *cumulated viscoplastic deformation p*
- *indicating of plasticity*

*The properties material are defined in DEF1\_MATERIAU under key words ELAS (\_FO) and LMARC (\_FO).*

### ***/“ZIRC\_EPRI”***

*Relation of viscoplastic behavior nonlinear for the sheath in Zircaloy of the pencil fuel (used in program ESCORE of the EPRI). This relation describes creep with a formulation in work hardening for time (time-hardening). Data necessary of field material are provided in operator DEF1\_MATERIAU [U4.43.01], under the key words ZIRC\_EPRI and ELAS (cf [R5.03.08] for more details). For the integration of this law, one advise to use an semi-implicit integration i.e.:*

*PARAM\_THETA:  
0.5  
CONVERGENCE*

*:  
(RESO\_INTE  
:  
“IMPLICIT”  
)*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN (by DEBORST, key word ALGO\_C\_PLAN [§3.3.6]), INCO, HULL, PIPE, BARS and COQUE1D.*

*A number of internal variables: 2*

*Significance: V1: cumulated plastic deformation, V2: vacuum thus is worth always 0.*

### ***/“VISC\_IRRA\_LOG”***

*Law of axial creep under irradiation of the tubes guides. It makes it possible to model primary education creep and*

*secondary (law of the type time hardening) the parameters are provided in the operator DEF1\_MATERIAU [U4.43.01], under key words VISC\_IRRA\_LOG.*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN (by DEBORST, key word ALGO\_C\_PLAN [§3.3.6]), (HULL, COQUE\_1D, PIPE) and by DEBORST, key word ALGO\_1D: BAR, PMF, GRID.*

*A number of internal variables: 2*

*Significance: V1: cumulated viscoplastic deformation, V2: vacuum thus is worth always 0.*

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## ***/GATT\_MONNERIE***

*The thermomechanical law of behavior of fuel “GATT-Monerie” makes it possible to simulate tests of indentation. This law of behavior is an isotropic élasto-viscoplastic law without work hardening whose specificities are:*

- the potential of dissipation is the sum of two potentials of the Norton type (without threshold),*
- the fuel having a residual porosity likely to evolve/move encompression (thickening), this potential depends, in addition to the equivalent constraint, of the constraint hydrostatic.*

*The two internal variables of this model are the cumulated plastic deformation and the fraction voluminal of porosity.*

## ***/“GRAN\_IRRA\_LOG”***

*Relation of behavior of creep and growth under irradiation for the assemblies fuels.*

*The field of fluence is defined by key word AFFE\_VARC of order AFFE\_MATERIAU. characteristics of the behavior are provided in operator DEFI\_MATERIAU [U4.43.01], under key word GRAN\_IRRA\_LOG. The growth being done only according to one direction, it is necessary in the cases 3D and 2D to give the direction of the growth by the operand ANGL\_REP of the MASSIVE key word of operator AFFE\_CARA\_ELEM. Characteristics of creep (relation of behavior of the type LEMAITRE modified for the integration of the model is carried out by an semi-implicit method (coded into hard thus nothing in particular to be specified by the user).*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), INCO, PIPE. PMF*

*A number of internal variables: 1  
V1: cumulated equivalent viscoplastic deformation,*

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**/"LEMAITRE\_IRRA"**

*Relation of behavior of creep and growth under irradiation for the assemblies  
fuels.*

*The field of fluence is defined by key word AFFE\_VARC of order AFFE\_MATERIAU.  
characteristics of the behavior are provided in operator DEFI\_MATERIAU [U4.43.01],  
under key word LEMAITRE\_IRRA. The growth being done only according to one direction, it is  
necessary in the cases 3D and 2D to give the direction of the growth by the operand  
ANGL\_REP of the MASSIVE key word of operator AFFE\_CARA\_ELEM. For the beams, creep and it  
growth take place only in the axial direction of the beam: in the other directions, it  
behavior is elastic. For modelings 1D (LOUSE), there are the choice of the diagram  
of integration (implicit or semi-implicit), but one advises to use an semi-implicit integration  
i.e.:*

*PARAM\_THETA:  
0.5*

## CONVERGENCE

:  
 (RESO\_INTE  
 :  
 “IMPLICIT”  
 )

*For all other modelings, the integration of the model is carried out by a method semi-implicit (coded into hard thus nothing in particular to be specified by the user).*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), INCO, PIPE and LOUSE (only POU\_D\_T and POU\_D\_E).*

*A number of internal variables: 2*

*V1: cumulated plastic deformation,*

*V2: null*

*For modeling LOUSE:*

*V1: cumulated plastic deformation,*

*V2: value of the irradiation at the point of Gauss considered.*

### **/“LMARC\_IRRA”**

*Relation of behavior of viscoplasticity of the LMARC with taking into account of the irradiation for fuel assemblies. The field of fluence is defined by key word AFFE\_VARC of order AFFE\_MATERIAU. The characteristics of the behavior are provided in operator DEFI\_MATERIAU [U4.43.01], under key word LMARC\_IRRA.*

*For the beams, creep takes place only in the axial direction of the beam: in the other directions, the behavior is elastic.*

*Supported modelings: LOUSE (only POU\_D\_T and POU\_D\_E).*

*A number of internal variables: 5*

- *three variables of kinematic work hardening. X, X1, X2*
- *cumulated viscoplastic deformation p*
- *value of the irradiation at the point of Gauss considered.*

### **/“LEMA\_SEUIL”**

*Viscoplastic relation between behavior and threshold under irradiation for the assemblies fuels.*

*The field of fluence is defined by key word AFFE\_VARC of order AFFE\_MATERIAU. characteristics of the growth are provided in operator DEFI\_MATERIAU [U4.43.01], under key word LEMA\_SEUIL. The integration of the model is carried out by an semi-implicit method (coded into hard thus nothing in particular to be specified by the user).*



*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), INCO, PIPE.*

*A number of internal variables: 2*

*V1: cumulated plastic deformation,*

*V2: represent the current threshold*

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**3.1.1.7 Behaviors****specific*****with the discrete elements and beams******/"DIS\_GRICRA"***

*Behavior DIS\_GRICRA is pressed on discrete elements with 2 nodes, with 6 ddl by node (translation+rotation. From the total degrees of freedom, one solves 3 subsystems: 2 bosses + 1 spring for which one takes stock of the forces. One is reduced then to the system total by expressing the force total and the moment. The law of behavior on each under system is of the plasticity type with positive work hardening in the tangential directions with the discrete one to model the slip, and of the unilateral elastic type in the direction of discrete for to model the contact.*

*The parameters characterizing the contact and friction are provided in the operator DEFI\_MATERIAU [U4.43.01], under key word DIS\_GRICRA. Contrary to the other discrete ones, one*

*does not take into account the characteristics of rigidity of AFFE\_CARA\_ELEM. The matrix of rigidity of discrete must thus be taken null in AFFE\_CARA\_ELEM. Rigidity is only exit of the parameters in DEFI\_MATERIAU.*

*The unilateral contact takes place in the direction X data by mesh SEG2 of the discrete element, and the slip takes place in the direction Y given by the key word ORIENTATION of*

*AFFE\_CARA\_ELEM* (cf [R5.03.17] for more details). The tangent matrix is nonsymmetrical.  
Supported modelings: *DIS\_TR*

A number of internal variables: 12  
Significance:

### ***/"DIS\_CONTACT"***

*Model of contact with friction of COULOMB, relation of isothermal behavior of type elastoplastic, being pressed on a discrete element with 2 nodes. Parameters characterizing it contact and friction is provided in operator DEFI\_MATERIAU [U4.43.01], under the word key DIS\_CONTACT. The values of rigidities are given by AFFE\_CARA\_ELEM [U4.42.01] (word key DISCRETE). The unilateral contact takes place in the direction X data by mesh SEG2 of the discrete element, and the slip takes place in the direction Y given by the key word ORIENTATION*

*AFFE\_CARA\_ELEM* (cf [R5.03.17] for more details). However, this modeling described not well behaviour in rotation of the connection, particularly on the level of discharge. It is preferable to use *DIS\_GRICRA*.

Supported modelings: *3D\_DIS*

A number of internal variables: 6  
Significance: V1: indicator of contact/friction (1 if slip, 0 so not slip, -1 if separation), V2: plastic displacement cumulated around local direction Z, V3: plastic displacement cumulated around local direction X, V4 with V6: vacuums thus equal to 0.

### ***/"DIS\_CHOC"***

*Isothermal model of shock with friction of Coulomb being pressed on a discrete element with 1 or 2 nodes. The parameters characterizing the shock and friction are provided in the operator DEFI\_MATERIAU [U4.43.01], under key word DIS\_CONTACT. In comparison with DIS\_CONTACT, this model is to be used preferentially in dynamics (writing of the behavior of speed) [R5.03.17].*

Supported modelings: *3D\_DIS*

A number of internal variables: 7

### ***Note:***

*The internal variables describe the behavior in the tangential plan defined by*

*local directions y and Z, which are defined compared to the normal direction of shock X. Significance: V1 and V2: displacements (differential between nodes 1 and 2 if there is one net SEG2) in local directions y and Z, respectively, V3 and V4: speed (differentials between nodes 1 and 2 if there is a mesh SEG2) in the directions local y and Z, respectively, V5 and V6: forces intern in the local directions y and Z, respectively, V7: indicator of adherence (0 if slip, 1 if adherence).*

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***/"VMIS\_POU\_LINE"***

*Relation of elastoplastic behavior isothermal of the elements of beam with total criterion of plasticity. The data necessary of the field material are provided in the operator DEF1\_MATERIAU [U4.43.01], under key word VMIS\_POUTRE, and ECRO\_LINE for work hardening*

*who is linear (cf [R5.03.30] for more details). The integration of this model can be done is with an implicit method is with method RUNGE KUTTA 4 (see [§3.13.7], key word RESO\_INTE).*

*Supported modelings: LOUSE*

*A number of internal variables: 9*

*Significance: V1: plastic deformation along axis X, V2 with V4: plastic curve according to*

*axes Y, Z and X respectively, V6 and V7: internal variables used in post treatment for calculation of the pylons, V8 and V9: plastic curve cumulated along the axis Y and Z respectively.*

### ***/"VMIS\_POU\_FLEJOU"***

*Relation of elastoplastic behavior isothermal of the elements of beam with total criterion of plasticity. The data necessary of the field material are provided in the operator DEF1\_MATERIAU [U4.43.01], under key word VMIS\_POUTRE, and ECRO\_FLEJOU for work hardening*

*who is nonlinear (cf [R5.03.30] for more details). The integration of this model can be done either with an implicit method or with method RUNGE KUTTA 4 (see [§3.13.7], key word RESO\_INTE).*

*Supported modelings: LOUSE*

*A number of internal variables: 9*

*Significance: V1: plastic deformation along axis X, V2 with V4: plastic curve according to axes Y, Z and X respectively, V6 and V7: internal variables used in post treatment for calculation of the pylons, V8 and V9: plastic curve cumulated along the axis Y and Z respectively.*

### ***/"WEAPON"***

*Relation of elastoplastic behavior isothermal for the conductor arrangements. Data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under the key word ARMS.*

*Supported modelings: 3D\_DIS*

*A number of internal variables: 1*

*Significance: V1: maximum value attack of the quantity in absolute value ( $u_y$  ule) where  $u_y$  is it displacement in the local direction there of mesh SEG2 and displacement limits field rubber band.*

### ***/"ASSE\_CORN"***

*Relation of elastoplastic behaviour isothermal for the assemblies bolted of angles of pylons. The data necessary of the field material are provided in the operator DEF1\_MATERIAU [U4.43.01], under key word ASSE\_CORN.*

*Supported modelings: 3D\_DIS*

*A number of internal variables: 4*

*Significance: V1: displacement reduces maximum equivalent reached for the first mechanism of deformation, V2: displacement reduces maximum equivalent reached for the second mechanism of deformation, V3: indicator of plasticity, V4: vacuum thus is worth 0.*

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**/“DIS\_GOUJ2E\_PLAS”**

*Model to represent the local behavior of a net of pin of assembly threaded (element discrete). The behavior is elastic safe everywhere along local axis Y. In this direction, it acts of an isothermal law of elastoplasticity of Von Mises with nonlinear isotropic work hardening*

*(Cf [R5.03.17] for more details). The data necessary of the field material are provided in operator `DEFI_MATERIAU` [U4.43.01], under the key words `TRACTION` (for the direction local Y) and `ELAS`. The curve indicated in `TRACTION` represents actually the curve effort of shearing-jump of displacement Y of a local calculation of a net and `ELAS` defines the rigidity affected to discrete for the other directions (in fact X room)).*

*Supported modelings: 2D\_DIS\_T.*

*A number of internal variables: 2*

*Significance: V1: plastic displacement cumulated, V2: indicator of plasticity (0 so elastic, 1 if plastic).*

***/"DIS\_GOUJ2E\_ELAS"***

*Model to represent the local elastic behavior of a net of pin of threaded assembly (discrete element). The behavior is elastic everywhere (cf [R5.03.17] for more details). data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key word ELAS.*

*Supported modelings: 2D\_DIS\_T.*

*A number of internal variables: 1*

*Significance: V1: vacuum (thus 0 are worth).*

***/"VMIS\_ASYM\_LINE"***

*Relation of isothermal behavior uniaxial of elastoplasticity of Von Mises with work hardening isotropic with different elastic limits in traction and compression. This model asymmetrical of elements of bar allows to model the interaction between a control or a cable buried and ground. The data necessary of the field material are provided in the operator DEFI\_MATERIAU [U4.43.01], under key word ECRO\_ASYM\_LINE (cf [R5.03.09] for more details).*

*Supported modeling: BAR*

*A number of internal variables: 4*

*Significance: V1: plastic deformation cumulated in traction, V2: indicator of plasticity in traction, V3: plastic deformation cumulated in compression, V4: indicator of plasticity in compression.*

### ***Mechanical 3.1.1.8 Models with effects of the metallurgical transformations***

*The following relations of behavior apply to a material which undergoes changes of metallurgical phases (cf [R4.04.02] for more detail).*

*Significance of the letters for the metallurgical behaviors:*

***P***

***= plastic behavior***

**V**

= *viscoplastic behavior*

*IT = linear isotropic work hardening*

*Nonlinear INL = isotropic work hardening*

*Linear CL = kinematic work hardening*

*Pt = plasticity of transformation*

*RE = restoration of metallurgical work hardening of origin*

*One can activate by key word RELATION\_KIT [§3.3.2] of operator STAT\_NON\_LINE two types of*

*material, is STEEL which comprises with more the 5 different metallurgical phases, that is to say ZIRC which*

*comprise with more the 3 different metallurgical phases.*

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*Example:*

*COMP\_INCR = (RELATION*

*= "META\_P\_INL"*

*RELATION\_KIT*

*= "ZIRC"*



)

*In this case, for each metallurgical phase in presence in the material (3 or 2 or 1), one inform a traction diagram.*

### ***A number of internal variables and significances***

*One gathers here the information on the internal variables because their number varies according to the type of work hardening (isotropic or kinematic), type of material (STEEL or ZIRC) and type of deformations (SMALL, PETIT\_REAC, GREEN or SIMO\_MIEHE).*

*The phases are arranged in the following order:*

*For steel:*

*1 to 4 = cold phases,*

*5 = hot phase*

*For Zircaloy:*

*1 and 2 = cold phases,*

*3 = hot phase*

*Deformation Work hardening*

*isotropic*

*Work hardening*

*kinematics*

***STEEL ZIRC***

***STEEL***

***ZIRC***

*V1 with V5: variables*

*V1 with V3: V1 variables in V30:*

*V1 with V18:*

*dependent on work hardening*

*bound to*

*variables related to*

*variables related to*

*isotropic for the 5*

*work hardening*

*work hardening*

*work hardening*

*phases*  
*isotropic for the 3 kinematics*  
*kinematics*

*phases*  
*for the 5 phases for the 3 phases*  
*SMALL,*  
*PETIT\_REAC*  
*and GREEN*

*V6: indicator of*  
*V4: indicator of*  
*V31 with V36:*  
*V19 with V24:*  
*plasticity (0 if*  
*plasticity (0 if*  
*work hardening*  
*work hardening*  
*rubber band, 1 if*  
*rubber band, 1 if*  
*kinematics*  
*kinematics*  
*plastic)*  
*plastic)*  
*means X*  
*means X*

*V7: work hardening*  
*V5: work hardening*  
*V37: indicator*  
*V25: indicator*  
*isotropic means*  
*isotropic means*  
*of plasticity (0 if*  
*of plasticity (0 if*  
*rubber band, 1 if*  
*rubber band, 1 if*  
*plastic)*  
*plastic)*

V8: trace

V6: trace

*deformations*

*deformations*

*Elastic SIMO\_MIEHE divided by rubber bands divided*

*Do not exist*

*Do not exist*

*3 used into large by 3 used in*

*deformations*

*large*

*deformations*

**Note:**

*For all the metallurgical laws, the plane constraints are impossible even with method DEBORST (cf [§3.3.5]).*

**/“META\_P\_IL”**

*Relation of behavior of elastoplasticity of Von Mises with linear isotropic work hardening. In effects due to structure transformations, phenomena of plasticity of transformation and of metallurgical restoration of work hardening are neglected. Data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under the key words ELAS\_META (\_FO) and META\_ECRO\_LINE.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

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**/“META\_P\_INL”**

*Relation of behavior of elastoplasticity of Von Mises with nonlinear isotropic work hardening. In the effects due to structure transformations, the phenomena of plasticity of transformation and of metallurgical restoration of work hardening are neglected. Data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words ELAS\_META (\_FO) and META\_TRACTION. Attention, under META\_TRACTION, it is necessary to not inform the forced curve deformation but the isotropic curve work hardening according to the cumulated plastic deformation.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

**/“META\_P\_IL\_PT”**

*Relation of behavior of elastoplasticity of Von Mises with linear isotropic work hardening. In the effects due to structure transformations, one takes account of the phenomenon of plasticity of transformation but one neglects that of the metallurgical restoration of work hardening. Data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words ELAS\_META (\_FO), META\_ECRO\_LINE and META\_PT.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

**/“META\_P\_INL\_PT”**

*Relation of behavior of elastoplasticity of Von Mises with nonlinear isotropic work hardening. In the effects due to structure transformations, one takes account of the phenomenon of plasticity of transformation but one that of the metallurgical restoration of work hardening neglects. data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words ELAS\_META (\_FO), META\_TRACTION and META\_PT. Attention, under META\_TRACTION, it is necessary to inform the forced curve not deformation but*

***isotropic curve work hardening according to the cumulated plastic deformation.***

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/“META\_P\_IL\_RE”***

*Relation of behavior of elastoplasticity of Von Mises with linear isotropic work hardening. In the effects due to structure transformations, one takes account of the phenomenon of restoration of metallurgical work hardening but one that of the plasticity of transformation neglects. Data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words ELAS\_META (\_FO), META\_ECRO\_LINE and META\_RE.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/“META\_P\_INL\_RE”***

*Relation of behavior of elastoplasticity of Von Mises with nonlinear isotropic work hardening. In the effects due to structure transformations, one takes account of the phenomenon of restoration of work hardening metallurgical but one neglects that of the plasticity of transformation.*

*The data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words ELAS\_META (\_FO), META\_TRACTION and META\_RE.*

***Attention,***

***under META\_TRACTION, it is necessary to inform the forced curve not deformation but isotropic curve work hardening according to the cumulated plastic deformation.***

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/“META\_P\_IL\_PT\_RE”***

*Relation of behavior of elastoplasticity of Von Mises with linear isotropic work hardening. One account of the phenomenon of plasticity of transformation and restoration of work hardening takes*

*metallurgical. The data necessary of the field material are provided in the operator DEFI\_MATERIAU [U4.43.01], under the key words ELAS\_META (\_FO), META\_ECRO\_LINE, META\_PT and META\_RE.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

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**/"META\_P\_INL\_PT\_RE"**

*Relation of behavior of elastoplasticity of Von Mises with nonlinear isotropic work hardening. One takes account of the phenomenon of plasticity of transformation and the restoration of work hardening*

*metallurgical. The data necessary of the field material are provided in the operator DEF1\_MATERIAU [U4.43.01], under key words ELAS\_META (\_FO), META\_TRACTION, META\_PT*

*and META\_RE. Attention, under META\_TRACTION, it is necessary to inform the curve not constraint deformation but the isotropic curve work hardening according to the deformation figure cumulated.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

**/"META\_P\_CL"**

*Relation of behavior of elastoplasticity of Von Mises with linear kinematic work hardening.*

*In the effects due to structure transformations, the phenomena of plasticity of transformation and of metallurgical restoration of work hardening are neglected. Data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under key words ELAS\_META (\_FO) and META\_ECRO\_LINE.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/"META\_P\_CL\_PT"***

*Relation of behavior of elastoplasticity of Von Mises with linear kinematic work hardening. In the effects due to structure transformations, one takes account of the phenomenon of plasticity of transformation but one that of the metallurgical restoration of work hardening neglects. data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words ELAS\_META (\_FO), META\_ECRO\_LINE and META\_PT.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/"META\_P\_CL\_RE"***

*Relation of behavior of elastoplasticity of Von Mises with linear kinematic work hardening. In the effects due to structure transformations, one takes account of the phenomenon of restoration of work hardening metallurgical but one neglects that of the plasticity of transformation.*

*The data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words ELAS\_META (\_FO), META\_ECRO\_LINE and META\_RE.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/"META\_P\_CL\_PT\_RE"***

*Relation of behavior of elastoplasticity of Von Mises with linear kinematic work hardening. One takes account of the phenomenon of plasticity of transformation and the restoration of work hardening*

*metallurgical. The data necessary of the field material are provided in the operator DEFI\_MATERIAU [U4.43.01], under the key words ELAS\_META (\_FO), META\_ECRO\_LINE, META\_PT and META\_RE.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/"META\_V\_IL"***

*Relation of behavior élasto-visco-plastic. The model is isotropic with a function threshold of type Von Mises and a linear isotropic work hardening with viscous restoration of work hardening. One does not take account of the phenomena of plasticity of transformation and of*

*metallurgical restoration of work hardening. The data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words ELAS\_META (\_FO),*

*META\_ECRO\_LINE and META\_VISC\_FO.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

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**/“META\_V\_INL”**

*Relation of behavior élasto-visco-plastic. The model is isotropic with a function threshold of type Von Mises and a nonlinear isotropic work hardening with viscous restoration of work hardening. One does not take account of the phenomena of plasticity of transformation and of metallurgical restoration of work hardening. The data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words ELAS\_META (\_FO), META\_TRACTION and META\_VISC\_FO. **Attention, under META\_TRACTION, it is necessary to inform not not the forced curve deformation but the isotropic curve work hardening according to cumulated plastic deformation.***

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

**/“META\_V\_IL\_PT”**



*Relation of behavior élasto-visco-plastic. The model is isotropic with a function threshold of type Von Mises and a linear isotropic work hardening with viscous restoration of work hardening. In the effects due to structure transformations, one takes account of phenomenon of plasticity of transformation but one neglects that of the restoration of work hardening*

*metallurgical. The data necessary of the field material are provided in the operator DEF1\_MATERIAU [U4.43.01], under the key words ELAS\_META (\_FO), META\_ECRO\_LINE, META\_VISC\_FO and META\_PT.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/“META\_V\_INL\_PT”***

*Relation of behavior élasto-visco-plastic. The model is isotropic with a function threshold of type Von Mises and a nonlinear isotropic work hardening with viscous restoration of work hardening. In the effects due to structure transformations, one takes account of phenomenon of plasticity of transformation but one neglects that of the restoration of work hardening*

*metallurgical. The data necessary of the field material are provided in the operator DEF1\_MATERIAU [U4.43.01], under the key words ELAS\_META (\_FO), META\_TRACTION,*

*META\_VISC\_FO and META\_PT. **Attention, under META\_TRACTION, it is necessary to inform not***

***forced curve deformation but the isotropic curve work hardening according to cumulated plastic deformation.***

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/“META\_V\_IL\_RE”***

*Relation of behavior élasto-visco-plastic. The model is isotropic with a function threshold of type Von Mises and a linear isotropic work hardening with viscous restoration of work hardening. In the effects due to structure transformations, one takes account of phenomenon of restoration of work hardening metallurgical but one neglects that of the plasticity of*

*transformation. The data necessary of the field material are provided in the operator DEF1\_MATERIAU [U4.43.01], under the key words ELAS\_META (\_FO), META\_ECRO\_LINE, META\_VISC\_FO and META\_RE.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/"META\_V\_INL\_RE"***

*Relation of behavior élasto-visco-plastic with a function threshold of the Von Mises type, one nonlinear isotropic work hardening and viscous restoration of work hardening. In the effects due with structure transformations, one takes account of the phenomenon of restoration of work hardening*

*metallurgical but one neglects that of the plasticity of transformation. Data necessary of field material are provided in operator DEFIL\_MATERIAU [U4.43.01], under the words keys ELAS\_META (\_FO), META\_TRACTION, META\_VISC\_FO and META\_RE. **Attention, under***

***META\_TRACTION, it is necessary to inform the forced curve not deformation but isotropic curve work hardening according to the cumulated plastic deformation.***

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

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***/"META\_V\_IL\_PT\_RE"***

*Relation of behavior élasto-visco-plastic. The model is isotropic with a function threshold of type Von Mises and a linear isotropic work hardening with viscous restoration of*

*work hardening. One takes account of the phenomenon of plasticity of transformation and the restoration*

*of metallurgical work hardening. The data necessary of the field material are provided in the operator*

*DEFI\_MATERIAU [U4.43.01], under the key words*

*ELAS\_META (\_FO),*

*META\_ECRO\_LINE, META\_VISC\_FO, META\_PT and META\_RE.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/“META\_V\_INL\_PT\_RE”***

*Relation of behavior élasto-visco-plastic. The model is isotropic with a function threshold of type Von Mises and a nonlinear isotropic work hardening with viscous restoration of work hardening. One takes account of the phenomenon of plasticity of transformation and the restoration*

*of metallurgical work hardening. The data necessary of the field material are provided in the operator*

*DEFI\_MATERIAU [U4.43.01], under the key words*

*ELAS\_META (\_FO),*

*META\_TRACTION, META\_VISC\_FO, META\_PT and META\_RE. Attention, under*

***META\_TRACTION, it***

***the forced curve deformation is necessary to not inform but the curve work hardening isotropic according to the cumulated plastic deformation.***

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/“META\_V\_CL”***

*Relation of behavior élasto-visco-plastic. The model is isotropic with a function threshold of type Von Mises and a linear kinematic work hardening with viscous restoration of work hardening. One does not take account of the phenomena of plasticity of transformation and of*

*metallurgical restoration of work hardening. The data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words ELAS\_META (\_FO), META\_ECRO\_LINE and META\_VISC\_FO.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/“META\_V\_CL\_PT”***

*Relation of behavior élasto-visco-plastic. The model is isotropic with a function threshold*

*of type Von Mises and a linear kinematic work hardening with viscous restoration of work hardening. In the effects due to structure transformations, one takes account of phenomenon of plasticity of transformation but one neglects that of the restoration of work hardening*

*metallurgical. The data necessary of the field material are provided in the operator **DEFI\_MATERIAU** [U4.43.01], under the key words **ELAS\_META** (**\_FO**), **META\_ECRO\_LINE**, **META\_VISC\_FO** and **META\_PT**.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

***/“META\_V\_CL\_RE”***

*Relation of behavior élasto-visco-plastic. The model is isotropic with a function threshold of type Von Mises and a linear kinematic work hardening with viscous restoration of work hardening. In the effects due to structure transformations, one takes account of phenomenon of restoration of work hardening metallurgical but one neglects that of the plasticity of*

*transformation. The data necessary of the field material are provided in the operator **DEFI\_MATERIAU** [U4.43.01], under the key words **ELAS\_META** (**\_FO**), **META\_ECRO\_LINE**, **META\_VISC\_FO** and **META\_RE**.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

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### ***/"META\_V\_CL\_PT\_RE"***

*Relation of behavior élasto-visco-plastic. The model is isotropic with a function threshold of type Von Mises and a linear kinematic work hardening with viscous restoration of work hardening. One takes account of the phenomenon of plasticity of transformation and the restoration*

*of metallurgical work hardening. The data necessary of the field material are provided in the operator*

*DEFI\_MATERIAU [U4.43.01], under the key words ELAS\_META (\_FO), META\_ECRO\_LINE, META\_VISC\_FO, META\_PT and META\_RE.*

*Supported modelings: 3D, D\_PLAN, AXIS, INCO.*

### ***3.1.1.9 Behavior for the concrete***

#### ***/"BETON\_DOUBLE\_DP"***

*Three-dimensional relation of behavior used for the description of the behavior not linear of the concrete. It comprises a criterion of Drucker Prager in traction and a criterion of Drucker*

*Prager in compression, uncoupled. The two criteria can have a lenitive work hardening. The data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words BETON\_DOUBLE\_DP and ELAS (\_FO) (cf [R7.01.03] for more details). To facilitate the integration of this model, one can use local automatic recutting step of time (see [§3.13.6], key word ITER\_INTE\_PAS).*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), INCO, HULL, PIPE and COQUE1D.*

*A number of internal variables: 4*

*Significance: V1: plastic deformation cumulated in compression, V2: plastic deformation cumulated in traction, V3: maximum temperature attack at the point of Gauss considered, V4: indicator of plasticity.*

#### ***/"MAZARS"***

*Relation of elastic behavior fragile. It makes it possible to account for the softening of concrete and distinguishes the damage in traction and compression. Only one variable of scalar damage is used (cf [R7.01.08] for more details). Characteristics material are defined in operator DEF1\_MATERIAU [U4.43.01] under the key words MAZARS and ELAS (\_FO). In the event of thermal loading, the coefficients materials depend on the maximum temperature reached at the point of Gauss considered. Moreover thermal dilation presumedly linear does not contribute to the evolution of the damage.*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, INCO, HULL, PIPE and COQUE1D.*

*A number of internal variables: 3*

*Significance: V1: value of the damage, V2: indicator of damage (0 so not damaged, 1 if damaged), V3: maximum temperature attack at the point of Gauss considered.*

*Supported nonlocal modeling (see [§ 3.3.1.3]): GRAD\_EPSI.*

*/“LABORD\_ID”*

*Unidimensional relation of behavior of unilateral damage dedicated to the concrete, adapted to the cases of monotonous loadings (static) and cyclic (statics and dynamics without effect speed). It makes it possible to describe the behavior generated by the creation of microscopic cracks*

*(lowering of the stiffnesses) and bound operation, during cycles, with their refermeture (unilaterality). Two variables of damage are used (one in traction, the other in compression), the anelastic deformations related to the damage are taken into account and the opening and the refermeture of the cracks are managed by a function of progressive restoration*

*stiffness with the refermeture (cf [R7.01.07] for more details). Characteristics of material are defined in operator DEF1\_MATERIAU [U4.43.01] under the key words LABORD\_ID and ELAS.*

*Supported modeling: PMF*

*A number of internal variables: 5*

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*Significance: V1: value of the damage of traction, V2: value of the damage of compression, V3: value of the threshold of traction, V4: value of the damage of compression, V5: unrecoverable deformation.*

***/"GRILLE\_ISOT\_LINE"***

*Isothermal relation of behavior of uniaxial elastoplasticity of Von Mises with work hardening isotropic linear used for the modeling of the reinforcements of the reinforced concrete. Data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under key words ELAS and ECRO\_LINE (cf for more detail the document [R5.03.09]).*

*Supported modelings: ROAST*

*A number of internal variables: 4*

*Significance: V1: plastic deformation cumulated in the longitudinal direction, V2: indicator of plasticity.*

***/"GRILLE\_CINE\_LINE"***

*Isothermal relation of behavior of uniaxial elastoplasticity of Von Mises with work hardening linear kinematics used for the modeling of the reinforcements of the reinforced concrete. Data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under key words ELAS and ECRO\_LINE (cf for more detail the document [R5.03.09]).*

*Supported modelings: ROAST*

*A number of internal variables: 4*

*Significance: V1: kinematic work hardening in the longitudinal direction, V2: indicator of plasticity,*

*V3: unutilised.*

---



## **/"GRILLE\_PINTO\_MEN"**

Elastoplastic relation of isothermal behavior uniaxial of Pinto\_Menegotto for modeling of the reinforcements of the concrete reinforced under cyclic loading. Data necessary field material are provided in operator DEFI\_MATERIAU [U4.43.01], under the word key PINTO\_MENEGOTTO (cf for more detail the document [R5.03.09]).

Supported modelings: ROAST

A number of internal variables: 16

Significance: cf the document [R5.03.09]

## **/"PINTO\_MENEGOTTO"**

Relation of isothermal behavior uniaxial elastoplastic modelling the answer of steel reinforcements in the concrete reinforced under cyclic loading. Data necessary of field material are provided in operator DEFI\_MATERIAU [U4.43.01], under the word key PINTO\_MENEGOTTO (cf for more detail the document [R5.03.09]).

Supported modelings: BAR

A number of internal variables: 8

Significance: cf the document [R5.03.09]

## **/GLRC**

Elastoplastic model of reinforced concrete plate expressed in aggregate variables (efforts generalized deformations), with possible influence of the membrane effort on the limits of elasticity in inflection.

Supported modelings: DKTG

A number of internal variables: 7

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**/“CORR\_ACIER”**

*Elastoplastic model endommageable for which the plastic deformation with rupture depends rate of corrosion.*

*Modelings: 3D, D\_PLAN, AXIS, BAR, PMF*

*3 internal variables*

*V1: cumulated plastic deformation*

*V2: coefficient of damage*

*V3: indicator of plasticity*

**/“JOINT\_BA”**

*Local relation of behavior in 2D describing the phenomenon of the steel-concrete connection for reinforced concrete structures. It makes it possible to account for the influence of the connection in redistribution of the constraints in the body of the concrete as well as the prediction of the cracks and them*

*spacing. Available for loadings into monotonous and cyclic, it takes into account effects of the friction of the cracks, and containment. Only one variable of damage scalar is used (cf [R7.01.21] for more details). The characteristics of material are defined in operator `DEFI_MATERIAU` [U4.43.01] under key words `JOINT_BA` and `ELAS`.*

*Supported modelings: `PLAN_FISSURE` and `AXIS_FISSURE`.*

*A number of internal variables: 6*

*Significance: V1: value of the damage in the normal direction, V2: value of the damage in the tangential direction, V3: scalar variable of isotropic work hardening for the damage in mode 1, V4: scalar variable of isotropic work hardening for the damage in mode 2, V5: deformation of slip cumulated by friction of cracks, V6: value of kinematic work hardening by friction of the cracks.*

### ***/"GRANGER\_FP"***

*Relation of behavior for the modeling of the clean creep of the concrete. Data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under key word GRANGER\_FP (cf [R7.01.01] for more details).*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, INCO, HULL, PIPE and COQUE1D.*

*A number of internal variables: 55*

*Significance: Cf [R7.01.01]*

### ***/"GRANGER\_FP\_V"***

*Relation of behavior for the modeling of the clean creep of the concrete with taking into account phenomenon of ageing. The data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under key word V\_GRANGER\_FP (cf [R7.01.01] for more details).*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, INCO, HULL, PIPE and COQUE1D.*

*A number of internal variables: 55*

*Significance: Cf [R7.01.01]*

### ***/"GRANGER\_FP\_INDT"***

*Identical to GRANGER\_FP\_V but treating only one isothermal behavior.*

### ***/"UMLV\_FP"***

*Relation of behavior for the modeling of the clean creep of the concrete with taking into account distinction between voluminal creep and creep deviatoric in order to account for phenomena in the cases of multiaxial creeps. Data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under key word BETON\_UMLV\_FP (Cf [R7.01.06] for more details).*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, INCO, HULL, PIPE, BAR and COQUE1D.*

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**/“BAZANT\_FD”**

*Relation of behavior for the modeling of the creep of dessiccation of the concrete. This phenomenon occurs in the long-term concrete under the simultaneous effect of drying and a loading mechanics. The data necessary of the field material are provided in the operator **DEFI\_MATERIAU** [U4.43.01], under key words **BAZANT\_FD** and **ELAS\_FO** (cf [R7.01.05] for more details). Under **ELAS\_FO**, it is imperative to inform key word **FONC\_DESORP**.*

*Supported modelings: 3D, **D\_PLAN**, **AXIS**, **C\_PLAN** (by **DEBORST**, key word **ALGO\_C\_PLAN** [§3.3.6]), **INCO**, **HULL**, **PIPE**, **BARS** and **COQUE1D**.*

*A number of internal variables: 1*

*Significance: **V1**: value of the hygroscoopy*

**/“KIT\_DDI”**

*Allows to add two terms with anelastic deformations defined by certain laws of already existing behavior in **COMP\_INCR** (cf [R5.03.60] for more details). One can to assemble a model of creep of concrete **GRANGER\_FP** or **GRANGER\_FP\_V** with either **ELAS**, or **BETON\_DOUBLE\_DP**, either **VMIS\_ISOT\_TRAC**, or **VMIS\_ISOT\_LINE**, or **ROUSS\_PR** or **CHABOCHE**. The two models to be associated are to be specified in **RELATION\_KIT** [§3.3.2]. data necessary of the field material are provided in operator **DEFI\_MATERIAU** [U4.43.01], under key words **ELAS** (**\_FO**) (the **two laws must have the same module of YOUNG**) and those corresponding to the two selected models.*

*The internal variables of each law are cumulated in the table of the internal variables, and restored law by law. Under the assumption that creep is a phenomenon which evolves/moves more slowly*

*that plasticity, one compares the tangent matrix of the complete model to that of plasticity. It choice will thus require to adapt the increments of calculation to times characteristic of phenomena modelled in order not to handicap calculation in term of iteration count.*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, INCO, HULL, PIPE, BAR and COQUE1D.*

*Example:*

```
STAT_NON_LINE = (
COMP_INCR = _F (
RELATION
= "KIT_DDI"
RELATION_KIT = ("GRANGER_FP", "BETON_DOUBLE_DP"))
```

*In this case, local parameters of convergence (RESI\_INTE\_RELA and ITER\_INTE\_MAXI under the key word CONVERGENCE) are the same ones for the integration of the two models.*

### ***3.1.1.10 Behavior for the porous environments (modeling thermo-hydro-mechanics)***

*For more details on modelings thermo-hydro-mechanics and the models of behavior, one will be able to consult the documents [R7.01.10] and [R7.01.11].*

*Relations make it possible to solve simultaneously from two to four equations of balance. The equations considered depend on suffix with the following rule:*

- M indicates the mechanical equilibrium equation,*
- T indicates the thermal equilibrium equation,*
- H indicates a hydraulic equilibrium equation.*
- V indicates the presence of a phase in form vapor (in addition to the liquid)*

*The associated problems thermo-hydro-mechanics are dealt with in a completely coupled way. Only one letter H means that the porous environment is saturated (only one variable of pressure p), by example either of gas, or of liquid, or of a liquid mixture/gas (of which the pressure of gas is constant).*

*Two letters H mean that the porous environment is not saturated (two variables of pressure p), by example a liquid mixture/vapor/gas.*

*The presence of two letters HV means that the porous environment is saturated by a component (with practical of water), but that this component can be in liquid form or vapor. There is not whereas one*

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*conservation equation of this component, therefore only one degree of freedom pressure, but there is a flow liquid and a flow vapor.*

*For each modelled phenomenon (thermal and/or mechanical and/or hydraulic), one must specify in RELATION\_KIT [§ 3.3.2.3]:*

- the mechanical model of behavior of the skeleton,*
- the behavior of the liquids/gas,*
- the thermal behavior.*

*Moreover, in all the cases, one must imperatively inform:*

- HYDR\_UTIL (if the mechanical behavior is not endommageable, i.e if one does not use “MAZARS” or “ENDO\_ISOT\_BETON”) or HYDR\_ENDO (if one uses “MAZARS” or “ENDO\_ISOT\_BETON”) under RELATION\_KIT (this key word makes it possible to inform the curve of saturation and its derivative according to the capillary pressure as well as the relative permeability and its derivative according to saturation)*
- THM\_INIT in DEFI\_MATERIAU.*

**Example:**

**COMP\_INCR**

**=\_F (**  
**RELATION**

**=**  
**“KIT\_THM”,**  
**RELATION\_KIT**

**= (“LIQU\_SATU”, “CJS”, “HYDR\_UTIL”))**

*In this example, one deals with in a coupled way a problem thermo-hydro-mechanics for a medium porous saturated, LIQU\_SATU like behavior of the liquid, CJS like mechanical behavior.*

**Caution:**

*According to chosen, all the behaviors are not licit (for example if one chosen porous environments unsaturated, one cannot affect a behavior of the gas type perfect). [§ 3.3.2.3] summarizes all the possible combinations.*

**/“KIT\_HM”**

*Modeling of the coupling of the mechanical and hydrous phenomena for porous environments saturated. It is necessary to specify in RELATION\_KIT the mechanical behavior of the skeleton, it behavior of the liquid or gas or liquid mixture/gas (constant pressure of gas) and HYDR\_UTIL.*

**Supported modeling: THM**

**/“KIT\_THM”**

*Modeling of the coupling of the mechanical, thermal and hydrous phenomena for saturated mediums. It is necessary to specify in RELATION\_KIT the mechanical behavior of the skeleton, it thermal behavior, the behavior of the liquid or gas or liquid mixture/gas (pressure of gas constant) and HYDR\_UTIL.*

**Supported modeling: D\_PLAN\_THM, D\_PLAN\_THMD, AXIS\_THM, AXIS\_THMD, 3D\_THM, 3D\_THMD**

**/“KIT\_HHM”**

*Modeling of the coupling of the mechanical and hydrous phenomena for porous environments not saturated. It is necessary to specify in RELATION\_KIT the mechanical behavior of the skeleton, it behavior of the liquid mixture and/or gas and/or vapor and HYDR\_UTIL.*

**Supported modelings: D\_PLAN\_HHM, D\_PLAN\_HHMD, AXIS\_HHM, AXIS\_HHMD, 3D\_HHM,**

**3D\_HHMD, D\_PLAN\_HH2MD, AXIS\_HH2MD**

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**/“KIT\_THH”**

***Modeling of the coupling of the thermal and hydrous phenomena for porous environments not saturated. It is necessary to specify in RELATION\_KIT the thermal behavior, the behavior of liquid mixture and/or gas and/or vapor and HYDR\_UTIL.***

***Supported modelings: D\_PLAN\_THH, D\_PLAN\_THHD, AXIS\_THH, AXIS\_THHD, 3D\_THH, 3D\_THHD, D\_PLAN\_THH2D, AXIS\_THH2D***

**/“KIT\_THV”**

***Modeling of the coupling of the thermal and hydrous phenomena for porous environments saturated by a component present in liquid form or vapor. It is necessary to specify in RELATION\_KIT the thermal behavior, the behavior of the liquid mixture vapor and HYDR\_UTIL.***

***Supported modelings: D\_PLAN\_THVD, AXIS\_THVD, 3D\_THVD***

**/“KIT\_THHM”**

***Modeling of the coupling of the mechanical, thermal and hydrous phenomena for unsaturated mediums. It is necessary to specify in RELATION\_KIT the mechanical behavior of***



*skeleton, the thermal behavior, the behavior of the liquid mixture and/or gas and/or vapor and HYDR\_UTIL.*

*Supported modelings: D\_PLAN\_THHM, D\_PLAN\_THHMD, AXIS\_THHM, AXIS\_THHMD, 3D\_THHM, 3D\_THHMD, D\_PLAN\_THH2MD, AXIS\_THH2MD*

*/“CJS”*

*Elastoplastic relation of behavior for calculations in soil mechanics. This model is a multicriterion model which comprises a nonlinear elastic mechanism, a mechanism isotropic plastic and a plastic mechanism déviatoire (cf [R7.01.13] for more details). It model can be used independently of relations. Data necessary of field material are provided in operator DEFI\_MATERIAU [U4.43.01], under the key words CJS and ELAS. To facilitate the integration of this model, one can use recutting local automatic of the step of time (see [§3.13.6], key word ITER\_INTE\_PAS).*

*In CONVERGENCE [§3.13], if ITER\_INTE\_MAXI is strictly positive, calculation does not stop so not local convergence. In addition, if ITER\_INTE\_PAS is strictly negative, calculation stop if local convergence is not reached.*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), INCO, HULL, PIPE, BARS, COQUEID and THM.*

*A number of internal variables: 16 in 3D and 14 in 2D*

*Significance: V1: isotropic threshold, V2: angle of the threshold déviatoire, V3 with V8 (V3 with V6 in 2D): 6 (4 in*

*2D) component of the tensor of work hardening kinematic, V9 (V7 in 2D): outdistance standardized with*

*threshold déviatoire, V10 (V8 in 2D): relationship between the threshold déviatoire and the critical threshold deviatoric,*

*V11 (V9 in 2D): outdistance standardized in the isotropic threshold, V12 (V10 in 2D): iteration count interns, V13 (V11 in 2D): value of the local test of stop of the iterative process, V14 (V12 in 2D):*

*a number of local recuttings of the step of time, V15 (V13 in 2D): sign contracted product deviatoric constraint by the deviatoric plastic deformation, V16 (V14 in 2D):*

*indicator (0 so elastic, 1 so elastoplastic with isotropic plastic mechanism, 2 if elastoplastic with plastic mechanism déviatoire, 3 so elastoplastic with mechanisms plastics isotropic and déviatoire).*

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***/"LAIGLE"***

***Relation of behavior for the modeling of the rocks according to the model of Laigle. It model can be used independently of relations. Data necessary of field material are provided in operator DEFI\_MATERIAU [U4.43.01], under the key word LAIGLE (cf the document [R7.01.15] for more details). To facilitate the integration of this model, one can use the local automatic recutting of the step of time (see [§3.13.6], key word ITER\_INTE\_PAS).***

***Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN and THM***

***A number of internal variables: 4***

***Significance: V1: plastic deformation déviatoire cumulated, V2: plastic voluminal deformation cumulated, V3 fields of behavior of the rock, V4: indicator of state.***

***/"HOEK\_BROWN"***

***Relation of behavior of Hoek and Brown modified for the modeling of the behavior of rocks [R7.01.18]. This model can be used independently of relations. data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key word HOEK\_BROWN to facilitate the integration of this model, one can use the local automatic recutting of the step of time (see key word ITER\_INTE\_PAS).***

***Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN and THM***

***A number of internal variables: 3***

***Significance:***

***V1: V2: ,***

***V3: indicator of state.***

***/"ELAS\_THM"***

***Relation between elastic behavior linear and nonlinear dependence of the modules and coefficients of coupling compared to the temperature (cf [R7.01.11] for more details). Valid only in saturated medium. The data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key word ELAS\_THM.***

***Supported modeling: THM***

***/"ELAS\_THER"***

***Relation between elastic behavior linear and dependence of the Young moduli compared to the temperature, usable for an elastic model. Data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key word ELAS\_FO.***

***Supported modeling: THM***

***/"CAM\_CLAY"***

***Elastoplastic relation of behavior for calculations in soil mechanics normally consolidated (cf [R7.01.14] for more detail). The elastic part is non-linear. The part plastic can be hardening or lenitive. This model perhaps used independently of relations KIT\_XXX. The data necessary to the field material are provided in the operator DEFI\_MATERIAU [U4.43.01], under key words CAM\_CLAY and ELAS. If model CAM\_CLAY is used with modeling THM, key word PORO indicated under CAM\_CLAY and THM\_INIT must be the same one.***

***Modeling supported: 3D, D\_PLAN, AXIS and THM***

***A number of internal variables: 2***

***Significance: V1: voluminal plastic deformation, V2: indicator of plasticity.***

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**/“BARCELONA”**

***Relation describing the elastoplastic mechanical behavior of the unsaturated grounds coupled with hydraulic behavior (cf [R7.01.14] for more detail). This model is reduced to the model of Cam\_Clay in the saturated case. Two criteria intervene: a mechanical criterion of plasticity (that of Cam\_Clay) and a hydrous criterion controlled by suction (or capillary pressure). It model must be used in relations KIT\_HHM or KIT\_THHM. Data necessary to field material are provided in operator DEFI\_MATERIAU [U4.43.01], under the key words BARCELONA, CAM\_CLAY and ELAS.***

***A number of internal variables: 5***

***Significance: V1: p critical (1/2 pressure of consolidation), V2: indicator of plasticity mechanics, V3: hydrous threshold, V4: hydrous indicator of irreversibility, V5: PS (cohesion).***

**/“MAZARS”**

***Relation of elastic behavior fragile. It makes it possible to account for the softening of concrete and distinguishes the damage in traction and compression. Only one variable of scalar damage is used (cf [R7.01.08] for more details). Characteristics material are defined in operator DEFI\_MATERIAU [U4.43.01] under the key words MAZARS and ELAS (\_FO). In the event of thermal loading, the coefficients materials depend on the maximum temperature reached at the point of Gauss considered. Moreover thermal dilation presumedly linear does not contribute to the evolution of the damage.***

***Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, INCO, HULL, PIPE, BAR, COQUEID and THM.***

***A number of internal variables: 3***

***Significance: V1: value of the damage, V2: indicator of damage (0 so not damaged, 1 if damaged), V3: maximum temperature attack at the point of Gauss considered.***

**/“DRUCKER\_PRAGER”**

***Relation of behavior of the Drucker-Prager type for the soil mechanics (cf [R7.01.16] for more details). The characteristics of material are defined in the operator DEFI\_MATERIAU [U4.43.01] under key words DRUCKER\_PRAGER and ELAS (\_FO). One***

***supposes***

***however that the thermal dilation coefficient is constant. Work hardening can be linear or parabolic.***

***Modeling supported: THM, 3D, D\_PLAN, AXIS***

***A number of internal variables: 3***

***V1: plastic deformation déviatoire cumulated, V2: cumulated plastic voluminal deformation, Indicating V3 of state.***

***/“ENDO\_ISOT\_BETON”***

***Relation of elastic behavior fragile. It is about a local modeling with damage scalar and with negative linear isotropic work hardening which distinguishes behaviour in traction and in***

***compression of the concrete (cf [R7.01.04] for more details). The characteristics of material are defined in operator DEFI\_MATERIAU [U4.43.01] under key words BETON\_ECRO\_LINE) and ELAS. In the event of thermal loading, only the thermal deformation is taken into account, them coefficients constant materials being supposed.***

***Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN (by DEBORST, key word ALGO\_C\_PLAN [§3.3.5]), INCO, HULL, PIPE, BARS, COQUEID etTHM.***

***A number of internal variables: 2***

***Significance: V1: value of the damage, V2: indicator of damage (0 for mode rubber band (null damage), 1 if damaged, 2 if broken (damage equal to 1)).***

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### **3.1.2 Operand**

#### **RELATION\_KIT under COMP\_INCR**

#### **RELATION\_KIT:**

*For the behaviors specific to the concrete and the porous environments, RELATION\_KIT allows to couple several behaviors.*

*For the mechanical behaviors with effects of the metallurgical transformations, RELATION\_KIT makes it possible to choose the type of treated material (STEEL or ZIRCALOY).*

##### **3.1.2.1 KIT associated with the metallurgical behavior**

*/“STEEL”*

*/“ZIRC”*

*Allows to choose for all the laws of behavior of the type META\_XXX\_XXX (cf [§ 3.3.1.7]) if one wants to treat a material of the steel type or Zircaloy type. The standard material STEEL comprises with*

*more 5 different metallurgical phases, material ZIRC comprises with more the 3 phases metallurgical different (cf [§ 3.3.1.7] for example).*

##### **3.1.2.2 KIT associated with the behavior with the concrete**

*/“GRANGER\_FP”*

*/“GRANGER\_FP\_V”*

*/“BETON\_DOUBLE\_DP”*

*/“VMIS\_ISOT\_TRAC”*

*/“VMIS\_ISOT\_LINE”*

*/“ROUSS\_PR”*

*/“CHABOCHE”*

*Allows to associate one of the two models of creep GRANGER\_FP or GRANGER\_FP\_V with one other models among those quoted above. Under the key word RELATION, one uses the behavior KIT\_DIDI (cf [§ 3.3.1.8] for explanation and example).*

##### **3.1.2.3 KIT associated with the behavior with the porous environments (relation)**

*Concern, under the key word RELATION, behaviors KIT\_HM, KIT\_THM, KIT\_HHM, KIT\_THH, KIT\_THV and KIT\_THHM (cf [§ 3.3.1.9] for explanation and example).*

***With - Mechanical behaviors available under***

***/"ELAS"  
/"CJS"  
/"LAIGLE"  
/"ELAS\_THM"  
/"CAM\_CLAY"  
/"BARCELONA"  
/"DRUCKER\_PRAGER"  
/"MAZARS"  
/"ENDO\_ISOT\_BETON"***

***B - Reaction of gases and liquids available under***

***/"GAS"***

***Law of reaction of a perfect gas i.e. checking the relation  $P = \rho RT/Mv$  where  $P$  is pressure,  $\rho$  density,  $Mv$  molar mass,  $R$  the constant of Boltzman and  $T$  temperature (cf [R7.01.11] for more details). For only saturated medium. Data necessary of the field material are provided in operator `DEFI_MATERIAU [U4.43.01]`, under key word `THM_GAZ`.***

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***/"LIQU\_SATU"***

*Law of behavior for porous environments saturated by only one liquid (cf [R7.01.11] for more details). The data necessary of the field material are provided in the operator **DEFI\_MATERIAU [U4.43.01]**, under key word **THM\_LIQ**.*

*/“**LIQU\_GAZ\_ATM**”*

*Law of behavior for a porous environment unsaturated with a liquid and gas with pressure atmospheric (cf [R7.01.11] for more details). Data necessary of the field material are provided in operator **DEFI\_MATERIAU [U4.43.01]**, under key words **THM\_LIQ**.*

*/“**LIQU\_VAPE\_GAZ**”*

*Law of behavior for a porous environment unsaturated water/vapor/dry air with change with phase (cf [R7.01.11] for more details). The data necessary of the field material are provided in operator **DEFI\_MATERIAU [U4.43.01]**, under key words **THM\_LIQ**, **THM\_VAPE** and **THM\_GAZ**.*

*/“**LIQU\_AD\_GAZ\_VAPE**”*

*Law of behavior for a porous environment unsaturated water/vapor/dry air/air dissolved with phase shift (cf [R7.01.11] for more details).*

*The data necessary of the field material are provided in operator **DEFI\_MATERIAU [U4.43.01]**, under key words **THM\_LIQ**, **THM\_VAPE**, **THM\_GAZ** and **THM\_AIR\_DISS**.*

*/“**LIQU\_VAPE**”*

*Law of behavior for porous environments saturated by a component present in liquid form or vapor. with phase shift (cf [R7.01.11] for more details). Data necessary of the field material are provided in operator **DEFI\_MATERIAU [U4.43.01]**, under key words **THM\_LIQ** and **THM\_VAPE***

*/“**LIQU\_GAZ**”*

*Law of behavior for a porous environment unsaturated liquid/gas without phase shift (Cf [R7.01.11] for more details). The data necessary of the field material are provided in operator **DEFI\_MATERIAU [U4.43.01]**, under key words **THM\_LIQ** and **THM\_GAZ**.*

*C - Thermal behaviors available under*

*D - Hydraulic behaviors available under*

*/“**HYDR\_UTIL**”*

*Allows to return point by point the 4 curves (by **DEFI\_FONCTION**) following:*



- *saturation according to the capillary pressure,*
- *the derivative of this curve,*
- *the relative permeability according to saturation,*
- *its derivative.*

*The data necessary of the field material are provided in operator **DEFI\_MATERIAU** [U4.43.01], under key word **THM\_DIFFU**.*

*/“HYDR”*

*This behavior only exists to make it possible the developer to come to overload a profile in order to program into hard its own law of hydration according to the capillary pressure (and its derived) and from the permeability according to saturation (and its derivative).*

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*E - Possible combinations*

*For relation **KIT\_HM**:*

*(“ELAS” “GAS”*

*“HYDR\_UTIL”)*

*(“CJS”*

*“GAS”*

*“HYDR\_UTIL”)*

**(“LAIGLE”  
“GAS”  
“HYDR\_UTIL”)  
“CAM\_CLAY”  
“GAS”  
“HYDR\_UTIL”)  
“MAZARS”  
“GAS”  
“HYDR\_ENDO”)  
“ENDO\_ISOT\_BETON”  
“GAS”  
“HYDR\_ENDO”)**

**(“ELAS” “LIQU\_SATU”  
“HYDR\_UTIL”)  
“CJS”  
“LIQU\_SATU”  
“HYDR\_UTIL”)  
“LAIGLE”  
“LIQU\_SATU”  
“HYDR\_UTIL”)  
“CAM\_CLAY”  
“LIQU\_SATU”  
“HYDR\_UTIL”)  
“MAZARS”  
“LIQU\_SATU”  
“HYDR\_ENDO”)  
“ENDO\_ISOT\_BETON”  
“LIQU\_SATU”  
“HYDR\_ENDO”)**

**(“ELAS” “LIQU\_GAZ\_ATM”  
“HYDR\_UTIL”)  
“CJS”  
“LIQU\_GAZ\_ATM”  
“HYDR\_UTIL”)  
“LAIGLE”  
“LIQU\_GAZ\_ATM”  
“HYDR\_UTIL”)  
“CAM\_CLAY”  
“LIQU\_GAZ\_ATM”  
“HYDR\_UTIL”)  
“MAZARS”**

**“LIQU\_GAZ\_ATM”**  
**“HYDR\_ENDO”**  
**(“ENDO\_ISOT\_BETON” “LIQU\_GAZ\_ATM”**  
**“HYDR\_ENDO”)**

***For relation KIT\_THM:***

**(“ELAS”**

**“GAS”**  
**“HYDR\_UTIL”)**  
**(“CJS”**

**“GAS”**

**“HYDR\_UTIL”)**  
**(“LAIGLE”**

**“GAS”**

**“HYDR\_UTIL”)**  
**(“CAM\_CLAY”**

**“GAS”**

**“HYDR\_UTIL”)**  
**(“MAZARS”**

**“GAS”**

**“HYDR\_ENDO”)**  
**(“ENDO\_ISOT\_BETON” “GAS”**

**“HYDR\_ENDO”)**

**(“ELAS”**

**“LIQU\_SATU”**

**“HYDR\_UTIL”)**  
**(“CJS”**

**“LIQU\_SATU”**

**“HYDR\_UTIL”)**  
**(“LAIGLE”**

**“LIQU\_SATU”**

**“HYDR\_UTIL”)**  
**(“CAM\_CLAY”**

**“LIQU\_SATU”**

**“HYDR\_UTIL”)**  
**(“MAZARS”**

**“LIQU\_SATU”**

**“HYDR\_ENDO”)**  
**(“ENDO\_ISOT\_BETON” “LIQU\_SATU”**

**“HYDR\_ENDO”)**

**(“ELAS”**

**“LIQU\_GAZ\_ATM”**

**“HYDR\_UTIL”)**  
**(“CJS”**

**“LIQU\_GAZ\_ATM” “HYDR\_UTIL”)**  
**(“LAIGLE”**

**“LIQU\_GAZ\_ATM”**  
**“HYDR\_UTIL”)**  
**(“CAM\_CLAY”**

**“LIQU\_GAZ\_ATM”**

**“HYDR\_UTIL”)**

**(“MAZARS”**

**“LIQU\_GAZ\_ATM”**

**“HYDR\_ENDO”)**

**(“ENDO\_ISOT\_BETON” “LIQU\_GAZ\_ATM”**

**“HYDR\_ENDO”)**

**(“ELAS”**

**“GAS”**

**“HYDR\_UTIL”)**

**(“CJS”**

**“GAS”**

**“HYDR\_UTIL”)**

**(“LAIGLE”**

**“GAS”**

**“HYDR\_UTIL”)**

**(“CAM\_CLAY”**

**“GAS”**

**“HYDR\_UTIL”)**

**(“MAZARS”**

**“GAS”**

**“HYDR\_ENDO”)**

**(“ENDO\_ISOT\_BETON” “GAS”**

**“HYDR\_ENDO”)**

**(“ELAS”**

**“LIQU\_SATU”**  
**“HYDR\_UTIL”**)  
**“CJS”**

**“LIQU\_SATU”**

**“HYDR\_UTIL”**)  
**“LAIGLE”**

**“LIQU\_SATU”**

**“HYDR\_UTIL”**)  
**“CAM\_CLAY”**

**“LIQU\_SATU”**

**“HYDR\_UTIL”**)  
**“MAZARS”**

**“LIQU\_SATU”**  
**\_ “HYDR\_ENDO”**)  
**“ENDO\_ISOT\_BETON” “LIQU\_SATU”**  
**\_ “HYDR\_ENDO”**)

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***For relation KIT\_HHM:***

***(“ELAS” “LIQU\_GAZ”***

***“HYDR\_UTIL”)***

***(“CJS”***

***“LIQU\_GAZ”***

***“HYDR\_UTIL”)***

***(“LAIGLE”***

***“LIQU\_GAZ”***

***“HYDR\_UTIL”)***

***(“CAM\_CLAY”***

***“LIQU\_GAZ”***

***“HYDR\_UTIL”)***

***(“BARCELONA”***

***“LIQU\_GAZ”***

***“HYDR\_UTIL”)***

***(“MAZARS”***

***“LIQU\_GAZ”***

***“HYDR\_ENDO”)***

***(“ENDO\_ISOT\_BETON” “LIQU\_GAZ”***

***“HYDR\_ENDO”)***

***(“ELAS” “LIQU\_VAPE\_GAZ”***

***“HYDR\_UTIL”)***

***(“CJS”***

***“LIQU\_VAPE\_GAZ”***

***“HYDR\_UTIL”)***

***(“LAIGLE”***

***“LIQU\_VAPE\_GAZ”***

***“HYDR\_UTIL”)***

***(“CAM\_CLAY”***

***“LIQU\_VAPE\_GAZ”***

**“HYDR\_UTIL”)**  
**(“BARCELONA”**  
**“LIQU\_VAPE\_GAZ”**  
**“HYDR\_UTIL”)**  
**(“MAZARS”**

**“LIQU\_VAPE\_GAZ”**  
**“HYDR\_ENDO”)**  
**(“ENDO\_ISOT\_BETON”**  
**“LIQU\_VAPE\_GAZ”**  
**“HYDR\_ENDO”)**

**(“ELAS” “LIQU\_AD\_GAZ\_VAPE”**  
**“HYDR\_UTIL”)**  
**(“CJS”**  
**“LIQU\_AD\_GAZ\_VAPE”**  
**“HYDR\_UTIL”)**  
**(“LAIGLE”**  
**“LIQU\_AD\_GAZ\_VAPE”**  
**“HYDR\_UTIL”)**  
**(“CAM\_CLAY”**  
**“LIQU\_AD\_GAZ\_VAPE”**  
**“HYDR\_UTIL”)**  
**(“BARCELONA”**  
**“LIQU\_AD\_GAZ\_VAPE”**  
**“HYDR\_UTIL”)**  
  
**(“MAZARS”**

**“LIQU\_VAPE\_GAZ”**  
**“HYDR\_ENDO”)**  
**(“ENDO\_ISOT\_BETON”**  
**“LIQU\_VAPE\_GAZ”**  
**“HYDR\_ENDO”)**

***For relation KIT\_THH:***

***For relation KIT\_THHM:***

**(“ELAS”**



**“LIQU\_GAZ”**

—  
**“HYDR\_UTIL”)**  
**“CJS”**

**“LIQU\_GAZ”**

—  
**“HYDR\_UTIL”)**  
**“LAIGLE”**

**“LIQU\_GAZ”**

—  
**“HYDR\_UTIL”)**  
**“CAM\_CLAY”**

**“LIQU\_GAZ”**

—  
**“HYDR\_UTIL”)**  
**“BARCELONA”**  
**“LIQU\_GAZ”**

**“THER\_HOMO” “HYDR\_UTIL”)**  
**“MAZARS”**

**“LIQU\_GAZ”**

—  
**“HYDR\_ENDO”)**  
**“ENDO\_ISOT\_BETON” “LIQU\_GAZ”**

—  
**“HYDR\_ENDO”)**

**“ELAS”**

**“LIQU\_VAPE\_GAZ”**

—  
**“HYDR\_UTIL”)**  
**“CJS”**

**“LIQU\_VAPE\_GAZ”**

—

**“HYDR\_UTIL”)**  
**(“LAIGLE”**

**“LIQU\_VAPE\_GAZ”**

—  
**“HYDR\_UTIL”)**  
**(“CAM\_CLAY”**

**“LIQU\_VAPE\_GAZ” \_**

**“HYDR\_UTIL”)**  
**(“BARCELONA”**  
**“LIQU\_VAPE\_GAZ” \_**

**“HYDR\_UTIL”)**  
**(“MAZARS”**

**“LIQU\_VAPE\_GAZ”**

—  
**“HYDR\_ENDO”)**  
**(“ENDO\_ISOT\_BETON”**  
**“LIQU\_VAPE\_GAZ”**

—  
**“HYDR\_ENDO”)**

**(“ELAS”**

**“LIQU\_GAZ”**

—  
**“HYDR\_UTIL”)**  
**(“CJS”**

**“LIQU\_GAZ”**

—  
**“HYDR\_UTIL”)**  
**(“LAIGLE”**

**“LIQU\_GAZ”**

—  
“HYDR\_UTIL”)  
 (“CAM\_CLAY”

“LIQU\_GAZ”

—  
“HYDR\_UTIL”)  
 (“BARCELONA”  
 “LIQU\_GAZ”

—  
“HYDR\_UTIL”)  
 (“MAZARS”

“LIQU\_GAZ”

—  
“HYDR\_ENDO”)  
 (“ENDO\_ISOT\_BETON” “LIQU\_GAZ”

—  
“HYDR\_ENDO”)

(“ELAS”

“LIQU\_VAPE\_GAZ”

—  
“HYDR\_UTIL”)  
 (“CJS”

“LIQU\_VAPE\_GAZ”

—  
“HYDR\_UTIL”)  
 (“LAIGLE”

“LIQU\_VAPE\_GAZ”

—  
“HYDR\_UTIL”)  
 (“CAM\_CLAY”

“LIQU\_VAPE\_GAZ” \_

**“HYDR\_UTIL”)**  
**(“BARCELONA”**  
**“LIQU\_VAPE\_GAZ” \_**

**“HYDR\_UTIL”)**  
**(“MAZARS”**

**“LIQU\_VAPE\_GAZ”**

—  
**“HYDR\_ENDO”)**  
**(“ENDO\_ISOT\_BETON”**  
**“LIQU\_VAPE\_GAZ”**

—  
**“HYDR\_ENDO”)**  
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“LIQU\_AD\_GAZ\_VAPE”

“HYDR\_UTIL”)

(“CJS”

“LIQU\_AD\_GAZ\_VAPE”

“HYDR\_UTIL”)

(“LAIGLE”

“LIQU\_AD\_GAZ\_VAPE”

“HYDR\_UTIL”)

(“CAM\_CLAY”

“LIQU\_AD\_GAZ\_VAPE”

“HYDR\_UTIL”)

(“BARCELONA”

“LIQU\_AD\_GAZ\_VAPE”

“HYDR\_UTIL”)

(“MAZARS”

“LIQU\_VAPE\_GAZ” “THER\_POLY” “HYDR\_ENDO”)

(“ENDO\_ISOT\_BETON” “LIQU\_VAPE\_GAZ” “THER\_POLY” “HYDR\_ENDO”)

### 3.1.3 Operand

**DEFORMATION under COMP\_INCR**

**DEFORMATION:**

/  
“SMALL”

*The deformations used in the relation of behavior are the deformations linearized:*

(U)  
ij  
=  
1/2 (iu  
J  
+ U J

,  
I,  
/

“PETIT\_REAC”

*The increments of deformations used for the relation of incremental behavior are linearized deformations of the increment of displacement in the reactualized geometry.*

*I.e. if X, U*

*, U  
the position, displacement indicate respectively and*

*the increment of displacement calculated with a given iteration of a material point:*

I  
U  
U

I  
J

$$ij =$$

$$+$$

$$2 ($$

$$X + U)$$

$$(X + U)$$

$$J$$

$$I$$

*Balance is thus solved on the current geometry but the behavior remains writes under the assumption of the small deformations.*

**Caution:**

*It is disadvised using this option with the elements of structure HULL, COQUE\_1D and LOUSE (a message of alarm appears in the file .mess).*

**Note:**

*One can use this option with modelings THM since rotations are small.*

**/“SIMO\_MIEHE”**

*All information on the gradient of the transformation  $F$  is taken into account, as well rotation that deformations:*

$$U$$

$$F$$

$$I$$

$$ij = I$$

$$J +$$

$$X J$$

*That makes it possible to carry out calculations in great plastic deformations, with the relations of behavior “ELAS”, “VMIS\_ISOT\_LINE”, “VMIS\_ISOT\_TRAC”, “ROUSSELIER” and all them behaviors, with isotropic work hardening only, associated a material undergoing of metallurgical phase shifts (relations META\_X\_IL\_XXX\_XXX and META\_X\_INL\_XXX\_XXX,), (cf [§ 3.3.1.7]).*

**Caution:**

*This option is valid only for modelings 3D, D\_PLAN, AXIS, 3D\_INCO,*

*AXIS\_INCO and PLAN\_INCO (not of constraint planes with method DEBORST).*

*For further information on the formulation of the great plastic deformations according to SIMO and MIEHE, one will be able to refer to [R5.03.21].*

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*In great deformations of the type “SIMO\_MIEHE”, the tangent matrices are not symmetrical except for case (hyper) - elastic. To version 7.4, one proceeded to a systematic symmetrization of the matrix. Henceforth, it is the matrix not symmetrical which is provided. If it wishes it, the user can nevertheless ask to symmetrize under the key word SOLVEUR = \_F (SYME = “YES”). Caution: SYME = “YES” is not the defect. The resolutions will thus take a priori more time with this new version if have it does not do anything with regard to the command file. By against the nonsymmetrical tangent matrix a better convergence will allow.*

**/“GREEN”**

*Allows to treat great rotations and the small deformations for all the laws of behavior under COMP\_INCR provided with modelings 3D, D\_PLAN, AXIS and C\_PLAN. The deformations used in the relation of behavior are the deformations of GREEN-LAGRANGE:*

$E(U$

$) =$

$1/2 (U$



+  $U$

+  $U$

. $u$

$ij$

$I, J$

$JI,$

$K I,$

$K, J)$

**/“GREEN\_GR”**

*Allows to treat great rotations and the small deformations for all the laws of behavior under COMP\_INCR provided with modelings COQUE\_3D.*

*The deformations used in the relation of behavior are the deformations of*

**GREEN-LAGRANGE:**

$E (U$

) =

$1/2 (U$

+  $U$

+  $U$

. $u$

$ij$

$I, J$

$JI,$

$K I,$

$K, J)$

**Caution:**

*It is strongly disadvised using linear research (cf [§3.9]) with the option*

*GREEN\_GR (sometimes convergence is impossible and if one converges, calculation needs more iterations of Newton).*

**3.1.4 Operands ALL/GROUP\_MA/MESH/GROUP\_NO/NODE under COMP\_INCR**

/

**ALL**

:

**“YES”**

// **GROUP\_MA: lgrma**

/ **NET**

: **lma**

*The meshes specify on which the incremental relation of behavior is used.*

### **3.1.5 Operand**

**ALGO\_C\_PLAN**

**ALGO\_C\_PLAN**

:

**“ANALYTICAL”**

**[DEFECT]**

**“DEBORST”**

*The method of DEBORST makes it possible to add the condition of plane constraint to all the models of COMP\_INCR (for more detail to see Doc. [R5.03.03]). The assumption of the plane constraints is checked with convergence. One recommends to use and reactivate the tangent matrix enough often (all the one with three iterations) in the method of Newton (MATRIX = “TANGENT”*

**REAC\_ITER**

*= 1 to 3). Attention, in AFFE\_MODELE, always to put PHENOMENON =*

**“C\_PLAN”**.

### **Caution:**

*Method DEBORST is not usable with the option of deformation SIMO\_MIEHE.*

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### **3.1.6 Operand**

**ALGO\_ID**

**ALGO\_ID:**

**“ANALYTICAL”**

**[DEFECT]**

**“DEBORST”**

*The method of DEBORST described above was generalized with the case of the behaviors 1D (used by modelings BARS, GRID, GRILLE\_MEMBRANE, POU\_D\_EM, POU\_D\_T\_GM). This makes it possible to add the condition of uniaxial constraint to all the models of COMP\_INCR (for detail to see Doc. [R5.03.09] more). The assumption of the uniaxial constraints is checked with convergence. One recommends to rather often use and reactualize the tangent matrix (all the one with three iterations) in the method of Newton (MATRIX = “TANGENT” REAC\_ITER = 1 to 3).*

#### **Caution:**

*Method DEBORST is not usable with the option of deformation SIMO\_MIEHE.*

### **3.2 Word**

**key**

**COMP\_ELAS**

/

**COMP\_ELAS:**

*This key word factor gathers the relations of behavior connecting the deformations (compared to configuration of reference) and the constraints (elastic behavior). One can have in even obeying calculation certain parts of the structure with various incrémentaux behaviors (COMP\_INCR) and other parts obeying with various elastic behaviors (COMP\_ELAS).*

#### **Small dictionary of the modelings supported by the laws of behavior**

*Not to overload this document, we will invite thereafter:*

.

**Modeling 3D**

= *modelings 3D and 3D\_SI*

.

*Modeling D\_PLAN = modelings D\_PLAN and D\_PLAN\_SI*

.

*Modeling AXIS*

= *modelings AXIS and AXIS\_SI*

.

*Modeling C\_PLAN = modelings C\_PLAN and C\_PLAN\_SI*

### **3.2.1 Operand**

#### **RELATION under COMP\_ELAS**

##### **RELATION**

= /

**“ELAS”**

**[DEFECT]**

/

**“ELAS\_VMIS\_LINE”**

/

**“ELAS\_VMIS\_TRAC”**

/

**“ELAS\_POUTRE\_GR”**

/

**“CABLE”**

**/“ELAS”**

*“Linear” relation of elastic behavior, i.e. the relation between the deformations and the constraints considered is linear. The data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under key words ELAS or ELAS\_FO, ELAS\_ORTH or ELAS\_ORTH\_FO and ELAS\_ISTR or ELAS\_ISTR\_FO. It is the relation of behavior by defect for the elastic behaviors.*

*Supported modelings: 3D, D\_PLAN, AXIS, C\_PLAN, CABLE\_POULIE and COQUE\_3D (with DEFORMATION: “GREEN\_GR”).*

**/“ELAS\_VMIS\_LINE”**

*“Nonlinear” relation of elastic behavior (law of HENCKY) of Von Mises with linear isotropic work hardening. The data necessary of the field material are provided in operator DEFI\_MATERIAU [U4.43.01], under the key words VMIS\_ISOT\_LINE and ELAS (Cf [R7.02.03] for more details).*

*Supported modelings: 3D, D\_PLAN, AXIS and C\_PLAN.*

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**/“ELAS\_VMIS\_TRAC”**

*“Nonlinear” relation of elastic behavior (law of HENCKY), of Von Mises with nonlinear isotropic work hardening. The data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under key words VMIS\_ISOT\_TRAC and ELAS (Cf [R7.02.03] for more details).*

*Supported modelings: 3D, D\_PLAN, AXIS and C\_PLAN.*

**/“ELAS\_POUTRE\_GR”**

*Elastic relation of behavior for the beams in great displacements and large rotations (DEFORMATION: “GREEN\_GR” is obligatory). Data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under key word ELAS or ELAS\_FO (cf [R5.03.40] for more detail).*

*Supported modelings: POU\_D\_T\_GD*

**/“CABLE”**

*Elastic relation of behavior adapted to the cables (DEFORMATION: Obligatory “GREEN”):*

*the YOUNG modulus of the cable can be different in compression and traction (in particular it can be null in compression). The data necessary of the field material are provided in operator DEF1\_MATERIAU [U4.43.01], under the key word CABLE (cf [R3.08.02] for more details).*

*Supported modelings: CABLE*

### **3.2.2 Operand**

#### **DEFORMATION under COMP\_ELAS**

#### **DEFORMATION**

:

/

**“SMALL”**

**[DEFECT]**

*The deformations used in the relation of behavior are the linearized deformations:*

(U

ij

=

1/2 (iu

J

+ U J

,

I,)

**“GREEN”**

*The deformations used in the relation of behavior are the deformations of GREEN-LAGRANGE:*

E (U

) =

1/2 (U

+ U

+ U

.u

ij

I, J

*J I,  
K I,  
K, J)*

***/“GREEN\_GR”***

*Allows to treat the hulls and the beams in great displacements and great rotations (Cf. [R5.03.40] pour les poutres et [R3.07.05] pour les coques pour plus de détail). Pour les poutres, GREEN\_GR n'est disponible que pour le comportement `ELAS\_POUTRE\_GR`, pour les coques uniquement avec `ELAS`.*

***Attention :***

*Pour les coques (modélisation COQUE\_3D), il est fortement déconseillé d'utiliser la recherche linéaire (cf. [§3.9]) avec l'option GREEN\_GR (parfois la convergence est impossible et si on converge, le calcul a besoin de plus d'itérations de Newton).*

*Manuel d'Utilisation*

*Fascicule U4.5- : Méthode de résolution*

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*Comportements non linéaires*

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*Auteur(s) :*

***J.M. PROIX Clé***

*:*

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***3.2.3 Opérandes TOUT / GROUP\_MA / MAILLE / GROUP\_NO / NOEUD sous  
COMP\_ELAS***

***/ TOUT : 'OUI'***

***// GROUP\_MA : lgrma***

***/***

***MAILLE***

:

**lma**

*Spécifient les mailles sur lesquelles la relation de comportement élastique est utilisée.*

### **3.2.4 Opérandes**

**RESI\_INTE\_RELA / ITER\_INTE\_MAXI**

**RESI\_INTE\_RELA = /  
1.E-6**

**[DEFAULT]  
/  
resint**

**ITER\_INTE\_MAXI = /  
10**

**[DEFAULT]  
/  
iteint**

*Dans la plupart des relations de comportement, une équation non linéaire ou un système non linéaire doivent être résolus localement (en chaque point de GAUSS). Ces opérandes (résidu et nombre maximum d'itérations dites internes) sont utilisés pour tester la convergence de cet algorithme itératif de résolution. Pour plus de détails, se reporter à la documentation de référence, par exemple au document [R5.03.02]. Ces opérandes sont **inutiles** avec les comportements ELAS, VMIS\_CINE\_LINE, VMIS\_ECMI,LINE, VMIS\_ECMI\_TRAC, VMIS\_ISOT\_LINE, VMIS\_ISOT\_TRAC, VISC\_ISOT\_LINE, VISC\_ISOT\_TRAC, BARENBLATT, NORTON\_HOFF, DIS\_CONTACT, DIS\_CHOC, ARME, ASSE\_CORN, DIS\_GOUJ2E\_PLAS, DIS\_GOUJ2E\_ELAS, VMIS\_ASYM\_LINE, GRILLE\_ISOT\_LINE, GRILLE\_CINE\_LINE, GRILLE\_PINTO\_MEN, PINTO\_MENEGOTTO,*



*GRANGER\_FP et GRANGER\_FP\_V (hors contrainte plane), BAZANT\_FD et toutes les relations META\_XXX.*

### **3.2.5 Opérande**

#### **ITER\_INTE\_PAS**

#### **ITER\_INTE\_PAS**

=  
0

#### **[DEFAULT]**

*itepas*

*Permet de redécouper localement le pas de temps pour faciliter l'intégration de la relation de comportement aux points de GAUSS (pour les relations de CHABOCHE, VISC\_TAHERI, LMARC, LAIGLE, MONOCRISTAL, ROUSS\_PR, ROUSS\_VISC, CJS et BETON\_DOUBLE\_DP). Si itepas vaut 0, 1 ou -1 il n'y a pas de redécoupage. Si itepas est positif, on redécoupe systématiquement le pas de temps localement en itepas petits pas de temps avant d'effectuer l'intégration de la relation de comportement. Si itepas est négatif, le redécoupage en |itepas| petits pas de temps n'est effectué qu'en cas de non convergence locale.*

### **3.2.6 Opérande**

#### **RESO\_INTE**

#### **RESO\_INTE**

= / 'IMPLICITE'

#### **[DEFAULT]**

/  
'RUNGE\_KUTTA\_2'

/  
'RUNGE\_KUTTA\_4'

*Permet de préciser le type de schéma d'intégration pour résoudre le système d'équations non linéaires formé par les équations constitutives des modèles de comportement à variables internes :*

- les modèles POLY\_CFC et POLYCRISTAL sont traités uniquement par le schéma explicite de RUNGE-KUTTA d'ordre 2,*
- les deux modèles VMIS\_POU\_LINE et VMIS\_POU\_FLEJOU peuvent être traités par les*

*deux schémas IMPLICITE et RUNGE\_KUTTA\_4,*

*· les deux modèles MONOCRISTAL et VENDOCHAB peuvent être traités par les deux schémas IMPLICITE et RUNGE\_KUTTA\_2,*

*· les autres modèles utilisent le schéma IMPLICITE.*

*Manuel d'Utilisation*

*Fascicule U4.5- : Méthode de résolution*

*HT-62/06/004/A*

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**Code\_Aster** ®

*Version*

8.2

*Titrate:*

*Nonlinear behaviors*

*Date*

:

31/01/06

*Author (S):*

**Key J.M. PROIX**

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*Instruction manual*

*U4.5- booklet: Method of resolution*

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***Code\_Aster*** ®

*Version*

*7.4*

*Titrate:*

*Procedure IMPR\_STURM*

*Date:*

*21/01/05*

*Author (S):*

***E. BOYERE, O. BOITEAU*** *Key*

*:*

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*Organization (S): EDF-R & D /AMA, SINETICS*

***Instruction manual***

***U4.5- booklet: Methods of resolution***

***Document: U4.52.01***

## ***Procedure IMPR\_STURM***

### ***1 Goal***

***To calculate the number of eigenvalues included/understood in an interval and to print out it. This procedure is***

***advised like checking a priori of the model and to define intervals of research containing a reasonable number of eigenvalues in order to optimize the computing time of the operators MODE\_ITER\_SIMULT or MODE\_ITER\_INV.***

***The execution of this procedure requires two factorizations LDLT.***

### ***Instruction manual***

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***Code\_Aster ®***

***Version***

***7.4***

***Titrate:***

***Procedure IMPR\_STURM***

***Date:***

***21/01/05***

***Author (S):***

***E. BOYERE, O. BOITEAU Key***

***:***

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### ***2 Syntax***

***IMPR\_STURM***

(  
**MATR\_A**  
=  
**With**  
/  
**[matr\_asse\_DEPL\_R]**  
/  
**[matr\_asse\_TEMP\_R]**  
/  
**[matr\_asse\_PRES\_R]**

**MATR\_B**  
=  
**B**  
/  
**[matr\_asse\_DEPL\_R]**  
/  
**[matr\_asse\_TEMP\_R]**  
/  
**[matr\_asse\_PRES\_R]**

**TYPE\_RESU=/  
“DYNAMIC”  
[DEFECT]**

**/“MODE\_FLAMB”**

**# If TYPE\_RESU = “DYNAMIC”**

**FREQ\_MIN=**  
**/**  
**f\_min**  
**[R]**

**/**  
**0.**  
**[DEFECT]**

**FREQ\_MAX=**  
**f\_max**  
**[R]**

**# If TYPE\_RESU = “MODE\_FLAMB”**

**CHAR\_CRIT\_MIN= \_min**  
**[R]**

**CHAR\_CRIT\_MAX= \_max**  
**[R]**

***SEUIL\_FREQ=***

***/***

***f\_seuil [R]***

***/***

***0.01***

***[DEFECT]***

***PREC\_SHIFT=***

***/***

***p\_shift [R]***

***/***

***0.01***

***[DEFECT]***

***NMAX\_ITER\_SHIFT=***

***n\_shift [I]***

***/***

***5***

**[DEFECT]**

***NPREC\_SOLVEUR =/***

***ndeci***

**[I]**

**/**

**8**

**[DEFECT]**

***UNIT***

**= /**

***nunite***

**[I]**

**/**

**8**

**[DEFECT]**

**);**

***Instruction manual***

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***Code\_Aster* ®**

***Version***

***7.4***



***Titrate:***  
***Procedure IMPR\_STURM***

***Date:***  
***21/01/05***  
***Author (S):***  
***E. BOYERE, O. BOITEAU Key***  
***:***  
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### ***3 Operands***

***3.1 Operands***  
***MATR\_A and MATR\_B***

***MATR\_A: With***  
***MATR\_B: B***

***With and B being names of the assembled matrices, the problem generalized with the eigenvalues studied is:***  
***(A B) v = 0***

***In the traditional case of dynamics, A is the matrix of rigidity and B the matrix of mass.***  
***2***  
***eigenvalue is then connected to the Eigen frequency F by the formula: = (***  
***2 F).***

***In the case of the theory of linear buckling, A is the matrix of rigidity and B the matrix of geometrical rigidity. The eigenvalue is called critical load.***

***This procedure allows, before carrying out the search for eigenvalues, to know it numbers in a band stipulated by the user.***

***Method of calculation:***

***One applies the property of the continuations of STURM and the theorem of SYLVESTER (cf [R5.01.01 §2.5 and §2.6]). If  $\mu$  is a given spectral shift, the appearing number of negative pivots during symmetrical factorization (by LDLT) of  $(A - \mu B)$  is equal to the number of values clean real lower than  $\mu$ .***

### ***3.2 Operand***

***TYPE\_RESU***

*TYPE\_RESU* = /  
 “DYNAMIC”  
 [DEFECT]

/“MODE\_FLAMB”

*This key word makes it possible to define the nature of the modal problem to treat: search for frequencies of vibration (traditional case of dynamics) or search for critical loads (case of the theory of linear buckling).*

***3.3 Operands******FREQ\_MIN and FREQ\_MAX***

*FREQ\_MIN = F min*

*FREQ\_MAX = F max*

*These key words must be used if TYPE\_RESU = “DYNAMIC”. They define the terminals lower and higher in Hertz of the frequency band in which one seeks it a number of Eigen frequencies. These two terminals are positive realities. One seeks then*

*2  
 the number of eigenvalues in the band [*

*,  
 min  
 max] with: = (*

*\*  
 2 f\*)*

*Action by defect:*

*If FREQ\_MIN misses then one the number of Eigen frequencies included/understood calculates enters 0. and F max.*

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**Code\_Aster** ®

Version

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Titrate:

Procedure *IMPR\_STURM*

Date:

21/01/05

Author (S):

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### **3.4 Operands**

#### ***CHAR\_CRIT\_MIN and CHAR\_CRIT\_MAX***

*CHAR\_CRIT\_MIN = min*

*CHAR\_CRIT\_MAX = max*

*These key words must be used if TYPE\_RESU = "MODE\_FLAMB". They define the terminals lower and higher of the band of critical loads in which one seeks the number clean critical loads. These two terminals are realities positive or negative. One seeks then the number of eigenvalues in the band [*

*,  
min  
max].*

### **3.5 Operands**

#### ***PREC\_SHIFT and NMAX\_ITER\_SHIFT***

*PREC\_SHIFT*

*=  
pshift*

*NMAX\_ITER\_SHIFT*

*=*

*nshift*

If  $F_{min}$  ( $min$ ) or  $F_{max}$  ( $max$ ) is detected as being eigenvalues or being located near eigenvalues (loss of more than eight decimals ( $ndeci$ ) at the time of factorization of the shifted matrix ( $A - B$ )), they are then modified:

$$\begin{aligned} & \cdot \\ F_{-} &= F_{min} \\ & - \\ & min \\ & min \times (1 - pshift) ( \\ & = \\ & min \\ & min \times (1 - pshift)) \\ & \cdot \\ F_{+} &= F_{max} \\ & + \\ & max \\ & max \times (1 + pshift) ( \\ & = \\ & max \\ & max \times (1 + pshift)) \end{aligned}$$

One then seeks the number of eigenvalues in the new interval  $[F_{-}, F_{+}]$

$min$   
 $max]$   
 $([-, +$   
 $min$   
 $max])$

One is not authorized more  $nshift$  modifications of the terminals of the interval.

**3.6 Operand*****SEUIL\_FREQ***

$SEUIL\_FREQ = F_{threshold}$

If  $F_{min}$   
 $F_{min}$   
 $min$  threshold and if  $F_{min}$  is detected like eigenvalue, then one seeks it a number of Eigen frequencies in the interval  $[- F_{min}, F_{min}]$   
 $F_{min}$

*threshold, max].*

*It is considered whereas  $F_{min}$  is associated a mode of rigid body. Modification of limit lower interval allows a priori to enter all the modes of body rigid.*

*In the case of the theory of linear buckling, one replaces  $F$  by and one defines:*

*= (  
2  
threshold  
2  $F_{threshold}$ )*

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### **3.7 Operand**

***NPREC\_SOLVEUR***

*NPREC\_SOLVEUR* = *ndeci*

*ndeci* represents the number of decimals which one is authorized to lose during factorization shifted matrix (*A - B*).

### **3.8 Operand**

***UNIT***

*UNIT*

Number of the logical unit corresponding to the file of writing. By defect, it is worth 8, i.e. file *RESU*.

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*Date:*

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***E. BOYERE, O. BOITEAU** Key*

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***Code\_Aster** ®*

*Version*

*7.4*

*Titrate:*

*Macro-order **MACRO\_MODE\_MECA***

*Date:*

*31/01/05*

*Author (S):*

*E. BOYERE, O. BOITEAU Key*

*:*

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*Organization (S): EDF-R & D /AMA, SINETICS*

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*Document: U4.52.02*

*Macro-order MACRO\_MODE\_MECA*

*1 Goal*

*To launch a succession of calculations of real clean modes. The following actions are carried out: obtaining the modes by simultaneous iterations, in specified frequency bands, application of a standard, filtering according to a criterion of value of modal parameter higher than some threshold and finally concatenation of the structures of data calculated in only one.*

*The modes are calculated by order MODE\_ITER\_SIMULT [U4.52.03] with the option "BANDAGES" and*



*normalized by order NORM\_MODE [U4.52.11]. The calculated modes are filtered and concaténés with means of order EXTR\_MODE [U4.52.12].*

*Product a structure of data of the mode\_meca type.*

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*Code\_Aster* ®

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*Titrate:*

*Macro-order MACRO\_MODE\_MECA*

*Date:*

*31/01/05*

*Author (S):*

*E. BOYERE, O. BOITEAU Key*

*:*

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*2 Syntax*

*mod\_meca =*

*MACRO\_MODE\_MECA (*

*# PARAMETERS OF MODE\_ITER\_SIMULT*

*MATR\_A*

*=*

*Matra*

*[matr\_asse\_DEPL\_R]*

**MATR\_B**

=

**Matra**

**[matr\_asse\_DEPL\_R]**

**INFORMATION**

=

/

1

**[DEFECT]**

/2

**OPTION**

**="/MODE\_RIGIDE"**

**[DEFECT]**

/

**"WITHOUT"**

**METHOD**

=

**/"TRI\_DIAG"**

/

**"JACOBI"**

/

**"SORENSEN" [DEFECT]**

**CALC\_FREQ = \_F (**

***/FREQ\_MIN = fmin***

***[R]***  
***FREQ\_MAX***

***=***  
***fmax***  
***[R]***  
***NB\_BLOC\_FREQ***  
***=***  
***npart [R]***  
***/***  
***FREQ***

***=***  
***lfr***  
***[l\_R]***

***PREC\_LANCZOS***  
***=***  
***/***  
***plancz***  
***[R]***

***/1.E-10  
[DEFECT]***

***NMAX\_ITER\_QR***

=

/

***nmiter***

***[I]***

***/ 30***

***[DEFECT]***

/

***DIM\_SOUS\_ESPACE=/0 [DEFECT]***

/  
**dse**  
**[I]**  
/  
**COEF\_DIM\_ESPACE=**  
**cde**  
**[I]**  
**EXCLUDED**  
(  
"DIM\_SOUS\_ESPACE",  
"COEF\_DIM\_ESPACE")

**NMAX\_ITER\_ORTHO**  
**=/5 [IDEFAUT]**

/  
**nio**  
**[I]**

**PREC\_ORTHO**  
**=**  
/  
**1.E-12**  
**[DEFECT]**

***/Po***

***[R]***

***NMAX\_ITER\_BATHE***

***= /***

***12***

***[DEFECT]***

***/***

***nbat***

***[I]***

***PREC\_BATHE***

***=***

***/***

***1.E-10***

***[DEFECT]***

***/***

***pbat***

***[R]***

***NMAX\_ITER\_JACOBI=/12***

***[DEFECT]***

***/***

***njaco***

***[I]***

*PREC\_JACOBI*

=

/

*1.E-2*

*[DEFECT]*

/

*pjaco*

*[R]*

*SEUIL\_FREQ*

=

/

*1.E-2*

*[DEFECT]*

/

*sfr*

*[R]*

*PREC\_SHIFT*

=

/

*pshif*

*[R]*

/0.05 [DEFECT]

STOP\_FREQ\_VIDE

=

/

“NOT”

[DEFECT]

/

“YES”

NMAX\_ITER\_SOREN

= /

20

[DEFECT]

/

nsoren

[I]

PARA\_ORTHO\_SOREN

= / 0.717

[DEFECT]

/



*passoren*  
[R]

*PREC\_SOREN*

=

/

0.

[DEFECT]

/

*prsoren* [R]

)

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**Code\_Aster** ®

*Version*

7.4

*Titrate:*

*Macro-order MACRO\_MODE\_MECA*

*Date:*

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*Author (S):*

**E. BOYERE, O. BOITEAU** Key

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*VERI\_MODE = \_F (*

*STOP\_ERREUR*

*=*

*/*

*“YES”*

*[DEFECT]*

*/*

*“NOT”*

*THRESHOLD*

*= /*

*rseuil*

*[R]*

*/*

*1.E-6*

*[DEFECT]*

*STURM*

*= /*

*“YES”*

*[DEFECT]*

*/*

*“NOT”*

*[l\_Kn]*

*PREC\_SHIFT*

=

/

*pshif*

[R]

/ 0.005

[DEFECT]

)

*# PARAMETERS OF NORM\_MODE*

*NORM\_MODE = \_F (*

*/STANDARD*

*=/"EUCL\_TRAN"*

/

*“MASS\_GENE”*

/

*“RIGI\_GENE”*

/

*“TRAN”*

/

*“TRAN\_ROTA”*

*[DEFECT]*

/

*“EUCL”*

*MASS\_INER*

=

*masstru [tabl\_MASS\_INER]*

*INFORMATION*

=

/

*1*

*[DEFECT]*

*/ 2*

)

*# PARAMETERS OF FILTERING OF THE MODES*

*FILTRE\_MODE*

*=\_F*

(

*CRIT\_EXTR*

*=/"MASS\_EFFE\_UN" [DEFECT]*

/

*"MASS\_GENE"*

*THRESHOLD*

*= /*

*0.001*

*[DEFECT]*

/

*rseuil*

*[R]*

)

#

*PARAMETERS*

*Of IMPRESSION*

*IMPRESSION = \_F (*

*OFFICE PLURALITY*

*= /*

*“YES”*

*[DEFECT]*

*/*

*“NOT”*

*CRIT\_EXTR*

*=/“MASS\_EFFE\_UN” [DEFECT]*

*/*

*“MASS\_GENE”*

*TOUT\_PARA*

*=*

*/*

*“YES”*

*[DEFECT]*

*/*

*“NOT”*

)

);

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**Code\_Aster** ®

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*Date:*

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*Author (S):*

*E. BOYERE, O. BOITEAU Key*

*:*

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### **3 Operands**

#### **3.1 Operands**

**MATR\_A/MATR\_B/INFORMATION/METHOD/OPTION**

*They have the same significance as in order MODE\_ITER\_SIMULT [U4.52.03].*

#### **3.2 Word**

*key*

**CALC\_FREQ**

*Play the same part as in order MODE\_ITER\_SIMULT [U4.52.03], has the same key words interns with the same default values, except for the following key words.*

### **3.2.1 Operands**

#### **FREQ\_MIN/FREQ\_MAX/NB\_BLOC\_FREQ**

*Give the terminals  $f_{min}$  and  $f_{max}$  of the total interval of frequencies of calculation and the number of subintervals  $npart$ .*

*In this case, the  $i$ ème terminal ( $i=1, npart+1$ ) is  $F(I) = f_{min} + (i-1) * (f_{max}-f_{min}) / npart$ .*

*Each subinterval has as respective terminals  $F(I)$  and  $F(i+1)$ .*

### **3.2.2 Operand**

#### **FREQ**

*One awaits a list of at least 2 values of frequencies  $F(I)$ .*

*$npart$  is obtained by the number of terms of the list -1.*

*The terminals of the subintervals are  $F(I)$  and  $F(i+1)$  for  $I = 1$  with  $npart$ .*

### **3.3 Word**

*key*

#### **VERI\_MODE**

*The operands intern have the same significance as in the key word of the same name, in order **MODE\_ITER\_SIMULT** [U4.52.03].*

### **3.4 Word**

*key*

#### **NORM\_MODE**

*Is used to define the arguments for the standardization of the modes. All the modes are normalized even way. The arguments are the same ones as for order **NORM\_MODE** [U4.52.11]*

### **3.5 Word**

*key*

#### **FILTRE\_MODE**

*If it is present, is used to introduce the arguments of filtering of the modes inside the  $npart$  key words **FILTRE\_MODE** (1 event by subinterval) of order **EXTR\_MODE** [U4.52.12] producing the final result. All the modes are filtered with the same criterion.*

*If it misses, the call to order **EXTR\_MODE** produces the final result by concatenation without filtering of the clean modes calculated in each subinterval. There is then  $npart$  words key*



*FILTRE\_MODE* having for argument *TOUT\_ORDRE* = “YES”.

*Instruction manual*

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**Code\_Aster** ®

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*Macro-order MACRO\_MODE\_MECA*

*Date:*

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*Author (S):*

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### **3.6 Word**

**key**

**IMPRESSION**

*Allows to possibly post the office plurality of values of a modal parameter chosen, for the modes clean calculated final result. The key words intern have the same significance as in order EXTR\_MODE [U4.52.12].*

*The selected modal parameter can not be the same one as that which was possibly used to filter them calculated modes.*

*Key word TOUT\_PARA makes it possible to post after each modal calculation and standardization, the value of all modal parameters (frequency, masses effective,...).*

### **4 Example**

***That is to say the following sequence:***

***mode = MACRO\_MODE\_MECA***

***(***

***MATR\_A***

=

***rigi***

,

***MATR\_B = mass,***

***CALC\_FREQ = \_F (FREQ\_MIN = 1. ,  
FREQ\_MAX***

=

***5.,***

***NB\_BLOC\_FREQ***

=

***2***

***),***

***NORM\_MODE***

=

***\_F (  
NORMALIZES***

=

***“TRAN\_ROTA”,  
MASS\_INER***

=

***masstru***

***),***

***FILTRE\_MODE = \_F (CRIT\_EXTR = “MASS\_EFFE\_UN”),***

***IMPRESSION = \_F (OFFICE\_PLURALITY = “YES”,  
CRIT\_EXTR***

=

**“MASS\_EFFE\_UN”**)

);

*Once interpreted, it consists with the following sequence of the usual orders:*

.

*The terminals of the intervals first of all are calculated:*

$npart = 2$

$F(i) = fmin + (i-1) * (fmax-fmin) / npart, i=1, npart + 1$

*of or  $F(1) = 1. F(2) = 3. F(3) = 5.$*

.

*One realizes*

$mode\_1 = MODE\_ITER\_SIMULT$

$(MATR\_A = rigi$

,  
 $MATR\_B = mass,$

$CALC\_FREQ$

=

$\_F ($

$OPTION$

=

**“BAND”,**

**FREQ**

=

**(F (1),**

**F (2))**

);

*mode\_1 = NORM\_MODE (MODE = mode\_1, reuse = mode1,  
NORMALIZES*

=

*“TRAN\_ROTA”,  
MASS\_INER*

=

*masstru*

)

;

*mode\_2 = MODE\_ITER\_SIMULT*

*(MATR\_A = rigi*

,

*MATR\_B = mass,*

*CALC\_FREQ*

=

*\_F (  
OPTION*

=

*“BAND”,*

*FREQ*

=

*(F (2),*

*F (3))*

);

*mode\_2 = NORM\_MODE (MODE = mode\_2, reuse = mode2,  
NORMALIZES*

=

*“TRAN\_ROTA”,  
MASS\_INER*

=

*masstru*

)

;

*mode*

=

*EXTR\_MODE*

*(FILTRE\_MODE=\_F (MODE = mode\_1,  
CRIT\_EXTR*

=

*“MASS\_EFFE\_UN”*

),

*FILTRE\_MODE=\_F (  
MODE*

=

*mode\_2,*

*CRIT\_EXTR*

=

*“MASS\_EFFE\_UN”*

),

*IMPRESSION=\_F*

*(OFFICE PLURALITY = “YES”,  
CRIT\_EXTR*

=

*“MASS\_EFFE\_UN”*

)

);  
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***Version***  
***7.4***

***Titrate:***  
***Macro-order MACRO\_MODE\_MECA***

***Date:***  
***31/01/05***  
***Author (S):***  
***E. BOYERE, O. BOITEAU Key***  
***:***  
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***Organization (S): EDF-R & D /AMA, SINETICS***

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***Operator MODE\_ITER\_SIMULT***

## ***1 Goal***

***To calculate clean values and vectors by methods of the subspace type. For the problem traditional of dynamics (without damping) or the problem of buckling of Euler, three algorithms are available: Sorensen, Lanczos, Bathe and Wilson. For the problem of dynamics with damping, only the methods of Sorensen and Lanczos are usable. Product one concept mode\_meca\_\* (dynamic case) or mode\_flamb (case buckling of Euler).***

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## ***2 Syntax***

***mode\_\*[\*] = MODE\_ITER\_SIMULT***

***# MODAL FACT OF THE CASE***

***(***

***MATR\_A***

***=***



**With**

/

**[matr\_asse\_DEPL\_R]**

/

**[matr\_asse\_DEPL\_C]**

/

**[matr\_asse\_PRES\_R]**

/

**[matr\_asse\_GENE\_R]**

**MATR\_B**

=

**B**

/

**[matr\_asse\_DEPL\_R]**

/

**[matr\_asse\_PRES\_R]**

/

**[matr\_asse\_GENE\_R]**

**MATR\_C**

=

**C**

/

**[matr\_asse\_DEPL\_R]**

**# STANDARD OF PROBLEM**

**TYPE\_RESU**

=

/

**“DYNAMIC”**

**[DEFECT]**

/

**“MODE\_FLAMB”**

**# CHOICE OF THE METHOD**

**METHOD**

=

/

**“SORENSEN” [DEFECT]**

/

**“TRI\_DIAG”**

**/“JACOBI”**

**# If METHOD = “TRI\_DIAG”**

**OPTION**

**=**

**/**

**“WITHOUT”**

**[DEFECT]**

**/**

**“MODE\_RIGIDE”**

**# STANDARD OF MODAL CALCULATION**

**CALC\_FREQ = \_F (OPTION**

**=/“CENTER”**

**/**

**“BAND”**

**/**

**“PLUS\_PETITE”**

**[DEFECT]**

**# CHARACTERISTIC OF CALCULATION**

**#**

**If TYPE\_RESU = “DYNAMIC”**

**APPROACH**

**= /**

**“REAL”**

**[DEFECT]**

**/**

**“IMAG”**

**/**

**“COMPLEX”**

**#**

**If**

**OPTION**

=

**“PLUS\_PETITE”**

**NMAX\_FREQ**

=

/

**10**

**[DEFECT]**

/

**nf**

**[I]**

**#**

**If**

**OPTION**

=

**“CENTER”**

**FREQ**

=

**l\_f**

**[l\_R]**

**AMOR\_REDUIT**

=

**l\_a**

**[l\_R]**

***NMAX\_FREQ***

=

/

10

***[DEFECT]***

/

***nf***

***[I]***

#

***If***

***OPTION***

=

***“BAND”***

***FREQ***

=

***l\_f***

***[l\_R]***

#

***If TYPE\_RESU = “MODE\_FLAMB”***

***APPROACH***

= /

***“REAL”***

***[DEFECT]***

/

***“IMAG”***

#

***If***

***OPTION***

=

***“PLUS\_PETITE”***

***NMAX\_FREQ***

=

/

10

***[DEFECT]***

/

***nf***

***[I]***

#

***If***

***OPTION***

=

***“CENTER”***

***CHAR\_CRIT***

=

***l\_c***

***[l\_R]***

***NMAX\_FREQ***

=

/

10

***[DEFECT]***

/

***nf***

***[I]***

#

***If  
OPTION  
=  
“BAND”***

***CHAR\_CRIT***

***=  
l\_c  
[l\_R]  
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*# CHARACTERISTIC OF THE SPACE OF PROJECTION*

*DIM\_SOUS\_ESPACE*

= *dse*

[I]

*COEF\_DIM\_ESPACE*

= *mse*

[I]

*EXCLUDE ("DIM\_SOUS\_ESPACE",  
"COEF\_DIM\_ESPACE")*

*# FOR PRE AND POSTPROCESSINGS*

*PREC\_SHIFT*

=

/

*0.05*

*[DEFECT]*

/

*PS*

*[R]*

*NMAX\_ITER\_SHIFT =/5 [DEFECT]*

/

*NS*

*[I]*

*NPREC\_SOLVEUR =/8 [DEFECT]*

/

*ndeci [R]*

*SEUIL\_FREQ*

=

/

*1.E-2 [DEFECT]*

/

*sf*

*[R]*

*# PARAMETER SETTING INTERNS METHODS*

*#*

*If METHOD = "SORENSEN"*



*PREC\_SOREN =*  
*/ 0*  
*[DEFECT]*  
*/*  
*pso*  
*[R]*

*NMAX\_ITER\_SOREN = /20*

*[DEFECT]*  
*/*  
*nso*  
*[I]*

*PARA\_ORTHO\_SOREN = 0.717*

*[DEFECT]*  
*/*  
*porso*  
*[I]*

*#*  
*If METHOD = "TRI\_DIAG"*

*PREC\_ORTHO*

=

/

*1.E-12*

*[DEFECT]*

*/Po*

*[R]*

*NMAX\_ITER\_ORTHO =/5 [DEFECT]*

/

*nio*

*[I]*

*PREC\_LANCZOS =*

*/1.E-8*

*[DEFECT]*

*/pl*

*[R]*

*NMAX\_ITER\_QR*

*=*

*/*

*30*

*[DEFECT]*

*/*

*nim*

*[I]*

*#*

*If METHOD = "JACOBI"*

*PREC\_BATHE*

=

/

*1.E-10*

*[DEFECT]*

/

*pbat*

*[R]*

*NMAX\_ITER\_BATHE*

=/

*40*

*[DEFECT]*

/

*nbat*

*[I]*

*PREC\_JACOBI*

=

/

*1.E-2 [DEFECT]*

/

*pjaco [R]*

*NMAX\_ITER\_JACOBI =/12*

*[DEFECT]*

/

*njaco [I]*

)

*# FOR FINAL CHECKS*

*VERI\_MODE*

*= \_F (*

*STOP\_ERREUR*

*=*

*/*

*“YES”*

*[DEFECT]*

*/*

*“NOT”*

*THRESHOLD*

*= /*

*1.E-6*

*[DEFECT]*

/R

[R]

*PREC\_SHIFT*

=

/

0.05

[DEFECT]

/

*prs*

[R]

*STURM*

= /

“YES”

[DEFECT]

/

“NOT”

)  
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***# SENSITIVITY***

***SENSITIVITY = (***

*... to see [U4.50.02]....*

)

# OTHERS

STOP\_FREQ\_VIDE

=  
/

“YES”  
[DEFECT]

/  
“NOT”

INFORMATION

=  
/  
1  
[DEFECT]  
/  
2  
[I]

TITRATE = Ti  
);

# GIVEN RESULT

If MATR\_C = [matr\_asse\_DEPL\_R]

then [\*]  
- > meca\_c

If  
TYPE\_RESU  
=

“MODE\_FLAMB”  
then [\*]

- > mode\_flamb  
If MATR\_A = [matr\_asse\_DEPL\_C]



*then [\*]*  
*- > meca\_c*  
*If MATR\_A = [matr\_asse\_DEPL\_R]*

*then [\*]*  
*- > meca*  
*If MATR\_A = [matr\_asse\_PRES\_R]*

*then [\*]*  
*- > acou*  
*If MATR\_A = [matr\_asse\_GENE\_R]*

*then [\*]*  
*- > embarrassment*  
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**3 Operands**

### 3.1 Principles

*This operator solves the problem generalized with the eigenvalues according to [R5.01.01]: To find  $(\lambda, X)$  such as  $Ax = \lambda Bx$ ,  $X \neq 0$ , where  $A$  and  $B$  are symmetrical matrices with coefficients realities. To model a damping hysteretic in the study of the free vibrations of a structure, matrix  $A$  can be complex [U2.06.03] [R5.05.04]. This type of problem corresponds, in mechanics, in particular with:*

*The study of the free vibrations of a not deadened and nonrevolving structure. For this structure, one seeks the smallest eigenvalues or those which are in one interval given to know if an exciting force can create a resonance. In this case, matrix  $A$  is the matrix of material rigidity, noted  $K$  (real or complex), \_éventuellement increased geometrical matrix of rigidity noted  $k_g$ , if the structure is précontrainte\_, and  $B$  is the matrix of mass or noted inertia  $M$ . the eigenvalues obtained are the squares of the pulsations associated with the sought frequencies. The system to be solved can be written:  $(K + \lambda B)$*

*where  $\lambda = \omega^2$*

*$F$  is the square of*

*$G) X = \{$*

*$MX$*

*$4$*

*$1 4$*

*$2 3$*

*$B$*

*With*

*pulsation,  $F$  the Eigen frequency and  $X$  the vector of associated clean displacement.*

*If  $K$  is complex, and  $F$  it are too.*

*The search for linear mode of buckling. Within the framework of the linearized theory, in supposing a priori that the phenomena of stability are suitably described by system of equations obtained by supposing the linear dependence of displacement by report/ratio at the level of critical load, the research of the mode of buckling  $X$  associated it level of critical load  $\mu = \lambda$ , brings back itself to a problem generalized to the eigenvalues form:  $(K + \mu B)$*

*=*

*=*

*with  $K$  stamps material rigidity and*

*$G) X$*

*$0$*

{  
**Kx**  
**K X**  
{G  
**With**  
**B**  
**Kg** stamps geometrical rigidity.

**Caution:**

*In the code, one treats only the eigenvalues of the generalized problem, them. For to obtain the true critical loads, the  $\mu$ , it is necessary to multiply them by 1.*

*This operator allows also the study of the **dynamic stability of an involved structure depreciation viscous (and/or quadratic) and gyroscopic effects**. That led to resolution of a modal problem of a nature higher, known as quadratic [R5.01.02]. One seeks then complex values and clean vectors by the method of Lanczos after having carried out a reduction linear of the problem.*

*The problem consists in finding ( $\lambda$ ,  $\mathbf{X}$ ) ( $\mathbf{C}$ ,  $\mathbf{C}$  NR) such as  $(2\mathbf{B} + \mathbf{C} + \mathbf{A}) \mathbf{X} = 0$  where typically, in linear mechanics,  $\mathbf{A} = \mathbf{K}$  will be the matrix of rigidity,  $\mathbf{B} = \mathbf{M}$  the matrix of mass and  $\mathbf{C}$  the matrix of damping. The matrices  $\mathbf{K}$ ,  $\mathbf{M}$  and  $\mathbf{C}$  are matrices with real coefficients. The eigenvalue complexes is connected to the Eigen frequency  $F$  and to the damping reduced by:  $\lambda = (2) \pm (2) 1 - 2$*

$F$   
 $I$   
 $F$

*$\mathbf{K}$  can be also complex to moreover simulate, one damping hysteretic [U2.06.03] [R5.05.04].*

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*To solve these generalized or quadratic modal problems, Code\_Aster proposes various approaches. Beyond their numerical specificities and functional calculuses which are taken again*

*in the document [R5.01.01], one can synthesize them in the shape of table below (the **values by defect are materialized in fat**).*

**Operator**

**Algorithm Key word Advantages**

**Disadvantages**

**Perimeter**

**of application**

**MODE\_ITER\_INV**

*1st phase*

*(heuristics)*

*Calculation of some*

*Bisection*

*“SEPARATE”*

*modes*

*Calculation of some*

*Bisection +*

*“ADJUSTS”*

*Better precision*

*Cost calculation*

*modes*

*Secant (géné.)  
Muller (quad.)  
Improvement of  
Initialization by  
“NEAR”  
Resumption of values  
No the capture  
some estimates  
the user  
clean estimated  
of multiplicity  
by another  
process.  
Cost calculation of this  
phase quasi-no one  
2nd phase*

*(method of  
powers properly  
said)  
Basic method  
Powers  
“DIRECT”  
Very good  
Not very robust  
opposite  
construction of  
clean vectors  
Option of acceleration  
Quotient of  
“RAYLEIGH”  
Improve  
Cost calculation  
Rayleigh  
convergence  
Not carried in  
quadratic*

## ***MODE\_ITER\_SIMULT***

*Calculation of part of  
Bathe & Wilson*

*“JACOBI”*

*Little*

*robust*

*spectrum*

*Not carried in*

*quadratic*

*Lanczos*

*“TRI\_DIAG”*

*Little*

*robust*

*(Newman- Pipano)*

*IRAM*

*(Sorensen)*

*“SORENSEN” increased Robustness.*

*Better*

*calculation complexities*

*and memory.*

*Control*

*quality of the modes.*

### ***Table 3.1-1: Summary of the modal methods of Code\_Aster***

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*When it is a question of determining some simple eigenvalues discriminated well or to refine some estimates, operator `MODE_ITER_INV`, is often clearly shown. On the other hand, for to capture a part significant of the spectrum, one A resorts to `MODE_ITER_SIMULT`, via the methods known as “of subspace”.*

*It is this class of method which will interest us here.*

*It consists in projecting advisedly the operator of work in order to obtain a modal problem standard of more reduced size and comprising a canonical matrix of form (tridiagonale or of Higher Hessenberg). It is on the latter that total modal solveurs will be able then to operate (algorithm **QR**, **QL** or Jacobi). They are in general very robust, but they provide all the spectrum of the treated operator and they are very expensive. From where the idea to fix quotas for their efforts on only one “projected” spectrum.*

*It is completely recommended besides to benefit from the strong points of the two classes from method by refining the clean vectors obtained by `MODE_ITER_SIMULT`, via `MODE_ITER_INV` (`OPTION=' PROCHE'`). That will make it possible to reduce the standard of the final residue (cf [§3.7.2]).*

**Note:**

*One strongly advises a preliminary reading of the reference materials [R5.01.01], [R5.01.02]. It gives to the user the properties and the limitations, theoretical and practical, modal methods approached while connecting these considerations, which can sometimes to appear a little éthérées, with a precise parameter setting of the options.*

**3.2 Operands****`MATR_A, _B, _C`**`MATR_A``= A`

*Stamp assembly of concept [`matr_asse_*_R/C`] system to be solved.*

`MATR_B``= B`

*Stamp assembly of concept [`matr_asse_*_R`] system to be solved.*

`MATR_C`

= C

Stamp assembly of concept [matr\_asse\_\*\_R] quadratic system to solve.

### 3.3 Word

key

**TYPE\_RESU**

**TYPE\_RESU = /“DYNAMIC”**  
**[DEFECT]**

**/“MODE\_FLAMB”**

*This key word makes it possible to define the nature of the modal problem to treat: search for frequencies of vibration (traditional case of dynamics with or without damping) or search for loads critical (case of the theory of linear buckling). According to this class of membership, them results are posted and stored differently in the structure of data:*

***In dynamics**, the frequencies are ordered by order ascending of the module of their variation with the shift (cf [§2.9], [§4.4] [R5.01.01]). It is the value of the variable of access NUM\_ORDRE of the structure of data. The other variable of access, NUM\_MODE, is equal to the true modal position in the spectrum of the eigenvalue (determined by the test of Sturm cf [§2.5], [§2.6] [R5.01.01]).*

***In buckling**, the eigenvalues are stored by order ascending algebraic. variables NUM\_ORDRE and NUM\_MODE take the same value equal to this order.*

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Operator **MODE\_ITER\_SIMULT**



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### **3.4 Word**

**key**

#### **METHOD**

*Three methods of resolution are available for the problem to the eigenvalues*

*.*

*The method WILL GO (known as of Sorensen), makes it possible to treat the two types of problems generalized and quadratic. It is the method by defect and is based on:*

*-*

*obtaining a matrix of Hessenberg by using a factorization of the Arnoldi type*

*-*

*the calculation of the eigenvalues of this problem projected by a method QR*

*-*

*a certain number of restartings allowing to refine the sought eigenvalues by the user, the other eigenvalues necessary to the method being used as values auxiliaries.*

*.*

*The method of Lanczos, makes it possible to treat the two types of problems generalized and quadratic. It is based on:*

*-*

*obtaining a matrix tridiagonale projected via the method of Lanczos,*

*-*

*the resolution of the system tridiagonal reduced by a method QR,*

*.*

*The iterative method of Bathe and valid Wilson only for the generalized problem, is based on:*

*-*

*construction with each iteration of a projected generalized problem of smaller size,*

*-*

*the calculation of the eigenvalues of this problem projected by a method of Jacobi.*

#### **METHOD**

**=**

**/“SORENSEN” [DEFECT]**

*One uses the method of Sorensen (cf [§5] [R5.01.01]) to calculate the values and vectors clean of the generalized or quadratic problem. This option cannot be used for one quadratic problem.*

*/“TRI\_DIAG”*

*One uses the method of Lanczos (then method **QR** on the projected system) to calculate them values and clean vectors of the generalized or quadratic problem (cf [§4] [R5.01.01]).*

*/“JACOBI”*

*One uses the method of Bathe & Wilson (cf [§6] [R5.01.01]) (then method of Jacobi on system projected) to calculate the values and clean vectors of the generalized problem. This option cannot be used for a quadratic problem.*

### **3.5 Word**

**key**

**OPTION**

**OPTION =**

**/“MODE\_RIGIDE”**

**/**

**“WITHOUT”**

**[DEFECT]**

*Key word usable only with the method of Lanczos for a generalized modal problem. It allows to detect and calculate as a preliminary, by an algebraic method the modes of body of rigid (modes associated with a null eigenvalue) (cf [§5.5.4] [R5.01.01]). They are used by the continuation to calculate the other modes with the algorithm of Lanczos. They are provided to the user*

*only if they belong to the modes requested. If the modes of rigid body are calculated without to use this option, the eigenvalues calculated by the algorithm of Lanczos are not null but very close to zero.*

### **3.6 Word**

**key**

**CALC\_FREQ**

**CALC\_FREQ**

**=\_F (...**

*Key word factor for the definition of the parameters of calculation of the eigenvalues and their number.*

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### **3.6.1 Operand**

#### **OPTIONS**

*OPTION*

=

**“BAND”**

*One seeks all the eigenvalues in a given band. This band is defined by the argument of **FREQ**: (F F) or by that of*

*1*

*2*

***CHAR\_CRIT**: ( ).*

*1*

*2*

*This option is not usable with a quadratic modal problem.*

**“CENTER”**

*One seeks the **NMAX\_FREQ** the eigenvalues closest to frequency F (argument of key word **FREQ**: F) or closest to the critical load (argument of key word **CHAR\_CRIT**: ).*

**“PLUS\_PETITE”** *One seeks the **NMAX\_FREQ** smaller eigenvalues.*

**[DEFECT]**

See [§2.9] and [§4.4] [R5.01.01].

### **3.6.2 Operand APPROACH**

**APPROACH**

= /

“**REAL**”

[**DEFECT**]

/

“**IMAG**”

/

“**COMPLEX**”

*This key word defines the type of approach (real, imaginary or complex) for the choice of pseudo scalar product of the quadratic problem (cf [§5.5.2] [R5.01.02]). In general the default value (reality) is valid.*

*This operand does not have a direction that for the analysis of the free vibrations of a deadened structure (modes proper complexes; key word **MATR\_C** must be indicated). In buckling, that does not have any interest.*

### **3.6.3 Operand FREQ**

**FREQ** =  $l_f$

*List frequencies (can be used only if **TYPE\_RESU** = “**DYNAMIC**”): its use depends on the selected **OPTION**.*

**OPTION** = “**BAND**”

*One awaits two values (**F F**) which define the band*

*1*

*2*

*of research,*

**OPTION** = “**CENTER**”

*Only one value of frequency is awaited,*

*The values stipulated under this key word must be positive.*

### **3.6.4 Operand AMOR\_REDUIT**

**AMOR\_REDUIT** =  $l_a$

*Value of the reduced damping which makes it possible to define the eigenvalue complexes around which one seeks the eigenvalues closest. (can be used only if TYPE\_RESU = "DYNAMIC" and well informed MATR\_C).*

**OPTION = "CENTER"**

*One awaits only one value of reduced damping,*

*The value stipulated under this key word must be positive and lie between 0 and 1. In buckling, that no interest has.*

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*Version*

*7.4*

*Titrate:*

*Operator MODE\_ITER\_SIMULT*

*Date:*

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*Author (S):*

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*:*

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### **3.6.5 Operand**

#### **CHAR\_CRIT**

$CHAR\_CRIT = l\_c$

*List critical loads (can be used only if TYPE\_RESU = "MODE\_FLAMB"): its use depends on the selected OPTION.*

**OPTION = "BAND"**

*One awaits two values () which define the band*

*1*

*2*

*of research,*

**OPTION = "CENTER"**

*One awaits only one value of critical load,*

*The values stipulated under this key word are positive or negative.*

### **3.6.6 Operand**

#### ***NMAX\_FREQ***

*NMAX\_FREQ*

= *nf*

( 10 )

**[DEFECT]**

*Numbers maximum eigenvalues to calculate.*

*This key word is ignored with the option “BANDAGES” because one calculates all the eigenvalues then contained in the stipulated band.*

*In the two cases, if *nf* is strictly higher than the number of “ddl active”, *nactif* (cf [§2.2] [R5.01.01]), then one forces it to take this value ceiling.*

### **3.6.7 Operand**

#### ***DIM\_SOUS\_ESPACE***

*DIM\_SOUS\_ESPACE*

= *of*

*COEF\_DIM\_ESPACE*

= *mse*

**EXCLUDE (“DIM\_SOUS\_ESPACE”, “COEF\_DIM\_ESPACE”)**

*If key word *DIM\_SOUS\_ESPACE* is not indicated or is initialized with a value strictly lower than the number of required frequencies *nf*, the operator calculates one automatically acceptable dimension for the subspace of projection (cf [§5.2] of this document and [§4.3], [§5.5.2], [§6.5.3], [§7.3.1] [R5.01.01]) with assistance *COEF\_DIM\_ESPACE*.*

*Thanks to given of this multiplicative factor, *mse*, one can project on a space whose size is proportional to the number of frequencies contained in the interval of study. In the encapsulation of *MODE\_ITER\_SIMULT*, *MACRO\_MODE\_MECA* [U4.52.02], one can thus optimize*

*the size of the subspaces which remains proportional to the number of required frequencies: subspaces rich in eigenvalues thus do not penalize poorest (in term of CPU).*

*One can however arbitrarily fix the size of this subspace, via the value of the catch by key word *DIM\_SOUS\_ESPACE* (which must be higher than *nf* to be taken into account).*

*In both cases, if the size of the subspace of projection *ndim* is strictly higher than number “active *ddl*”, *nactif* (cf [§2.2] [R5.01.01]), then one forces it to take this value ceiling.*

**Note:**

.  
*If one uses the method of Sorensen (IRAM) and that  $ndim - nf < 2$ , of the requirements numérico-data processing force to impose  $ndim = nf + 2$ .*

.  
*Into quadratic one works on a real problem of double size:  $2*nf, 2*ndim$ .*

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### ***3.6.8 Operands of IRAM (if METHOD = "SORENSEN")***

***PREC\_SOREN = pso***

***( 0. )***

***[DEFECT]***

***Note:***

***The method considers whereas it must work with the smallest possible precision, it "zero machine". To have an order of magnitude of it, in double precision double precision on the machines standards, this value is close to 2.22 .10-16)***

***NMAX\_ITER\_SOREN = nso***

( 20 )

**[DEFECT]**  
**PARA\_ORTHO\_SOREN**  
 = *porso*  
 ( 0.717 )  
**[DEFECT]**

*They are parameters of adjustment of the necessary precision on the modes (by defect, the precision machine is selected), of the number of restartings authorized of the method of Sorensen (cf [§5.4.2] and [§6.4] [R5.01.01]) and of the coefficient of orthogonalisation of the IGSM of Kahan-Parlett (cf [§11.4] [R5.01.01]).*

**Note:**

*At the time of the first passages, it is strongly advised not to modify these parameters which the mysteries of the algorithm concern rather and which are initialized empirically with values standards.*

### **3.6.9 Operands of the method of Lanczos (if METHOD = "TRI\_DIAG")**

**PREC\_ORTHO = Po**  
 (1.10-12) **[DEFECT]**  
**NMAX\_ITER\_ORTHO = nio**

( 5 )

**[DEFECT]**  
**PREC\_LANCZOS**  
 =  
*pl*  
 ( 1.10-8 )  
**[DEFECT]**  
**NMAX\_ITER\_QR**  
 = *nim*

( 30 )

**[DEFECT]**

*The first two parameters make it possible, respectively, to adjust the precision*



*of orthogonalisation and the number of réorthogonalisations in the method of Lanczos for to obtain independent vectors generating the subspace (cf [§5.5.1] [R5.01.01]).*

*The third is a parameter of adjustment to determine the nullity of a term on surdiagonale of the matrix tridiagonale characterizing the reduced problem obtained by the method of Lanczos. It is right a criterion of deflation and not, as opposed to what could let believe its name, a quality standard of the modes (cf [§5.4.1] [R5.01.01]).*

*The last fixes the maximum iteration count for the resolution of the system reduced by method **QR** ([§5.5.2] and [§10] [R5.01.01]).*

**Note:**

*At the time of the first passages, it is strongly advised not to modify these parameters which the mysteries of the algorithm concern rather and which are initialized empirically with values standards.*

**3.6.10 Operands of the method of Bathe & Wilson (if METHOD = "JACOBI")**

**PREC\_BATHE = pbat (1.10-10) [DEFECT]**

**NMAX\_ITER\_BATHE = nbat (40)**

**[DEFECT]**

**PREC\_JACOBI = pjaco (1.10-2)**

**[DEFECT]**

**NMAX\_ITER\_JACOBI**

**= njaco**

**( 12 )**

**[DEFECT]**

*The first two parameters make it possible, respectively, to adjust the precision of convergence and the maximum number of allowed iterations of the method of Bathe & Wilson (cf [§7] [R5.01.01]).*

*The two others make it possible to adjust the precision of convergence and the maximum number iterations permitted by the method of JACOBI (cf [§12] [R5.01.01]) who allows to exhume them clean modes of the matrix projected by the preceding method.*

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**Operator MODE\_ITER\_SIMULT****Date:****31/01/05****Author (S):****E. BOYERE, O. BOITEAU Key****:****U4.52.03-G Page****: 12/16****Note:**

*At the time of the first passages, it is strongly advised not to modify these parameters which the mysteries of the algorithm concern rather and which are initialized empirically with values standards.*

**3.6.11 Operands SEUIL\_FREQ, PREC\_SHIFT and NMAX\_ITER\_SHIFT****PREC\_SHIFT = PS****( 0.05 )****[DEFECT]****SEUIL\_FREQ = sf****( 0.01 )****[DEFECT]****NMAX\_ITER\_SHIFT = NS****( 5 )****[DEFECT]**

*For three possible options “PLUS\_PETITE”, “BAND” or “CENTER”, one carries out one*

**2**

*factorization LDLT of matrix  $(A - (2 f^*) B)$ .  $f^*$  depends on the method used. If  $f^*$  is*

*detected as being an Eigen frequency or being located near Eigen frequencies*

*(loss of more than decimal  $ndeci=8$  during the factorization of the matrices), the frequency  $f^*$  is then modified (cf [§2.6] and [§2.9] [R5.01.01]):*

**F -****F****(1 PS) or F +****=****× -****= F × (1+ PS****\***

\*  
\*  
\*  
)

2  
If  $(A - (2 f^*) B)$  is not factorisable LDLT and  $(F$

$sf$   
\*), one carries out  
following modification:  $F - = - sf$

. It is considered whereas  $f^*$  is associated a mode of body rigid. The modification of this frequency makes it possible a priori to enter all the modes of rigid body. One does not carry out more NS modifications of the value  $f^*$ .

In the case of linear buckling, the transposition is immediate by replacing  $f^*$  (frequency  
2  
2  
of vibration) by \* (critical load),  $(2 f^*)$  by \* and  $sf$  by  $(2 sf)$ .

**Note:**

At the time of the first passages, it is strongly advised not to modify these parameters which the mysteries of the algorithm concern rather and which are initialized empirically with values standards.

### 3.6.12 Operand NPREC\_SOLVEUR

**NPREC\_SOLVEUR**

= *ndeci*

( 8 )

**[DEFECT]**

*ndeci* represents the number of decimals which one is authorized to lose during the factorization of  
2  
stamp shiftée  $(A - (2 f^*) B)$  or  $(A - B)$ . If one loses more decimal *ndeci*, the matrix is regarded as noninvertible (cf [§2.6] and [§2.9] [R5.01.01]).

**Note:**

At the time of the first passages, it is strongly advised not to modify this parameter which rather relate to a mystery of the algorithm and which is initialized empirically with a value standard.

### **3.7 Word**

**key**

**VERI\_MODE**

*VERI\_MODE = \_F (...*

*Key word factor for the definition of the parameters of the checking of the clean modes ([§2.9] [R5.01.01]).*

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### **3.7.1 Operand**

**STOP\_ERREUR**

*STOP\_ERREUR =/*

**“YES”**

**[DEFECT]**

/

**“NOT”**

*Allows to indicate to the operator if it must stop (“YES”) or continue (“NOT”) if one of the THRESHOLD criteria or STURM is not checked.*

*By defect the concept of exit is not produced.*

### **3.7.2 Operand**

**THRESHOLD**

*THRESHOLD = R (1.10-6*

)

**[DEFECT]**

*Tolerance level for the standard of error relating of the mode to the top of which the mode is regarded as forgery.*

*The standard of relative error of the mode is:*

**(A -)**

***B X 2**, for 0 for the generalized problem and  
**Ax 2***

*(2B + C - A) X 2,  
**Ax**  
for the quadratic problem  
2*

### **3.7.3 Operand STURM**

*STURM =/  
“YES”*

*[DEFECT]  
/  
“NOT”*

*Checking known as of STURM (“YES”) allowing to make sure that the algorithm used in the operator determined the exact number of eigenvalues in the interval of research ([§2.5] [§2.6] [R5.01.01]).*

### **3.7.4 Operand PREC\_SHIFT**

*PREC\_SHIFT = prs  
( 0.05 )*

*[DEFECT]*

*This parameter (which is a percentage) makes it possible to define an interval containing the values clean calculated, for which the checking of Sturm will be carried out ([§2.6] [R5.01.01]).*

### **3.8 Operands SENSIBLITE**

*SENSITIVITY =*

*Activate the calculation of derived from the modes compared to a significant parameter of the problem. It is it should be noted that at present, the derivative of the multiple modes is not available, because it pose theoretical and practical problems particular.*

The document [U4.50.02] specifies the operation of the key word.

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### **3.9 Operand**

**STOP\_FREQ\_VIDE**

*STOP\_FREQ\_VIDE =/*

**“YES”**

**[DEFECT]**

/

**“NOT”**

*“YES” calculation stops if no eigenvalue is detected in the band stipulated by the user: an exception (named *BandeFrequenceVide*) is emitted. It can be treated to continue the course of the study. One can find an example under the case *SDLL11a* test:*

*try:*

*MODE1=MODE\_ITER\_SIMULT (MATR\_A=K\_ASSE, MATR\_B=M\_ASSE,*

*CALC\_FREQ=\_F (*

*OPTION = “BAND”,*

*FREQ = (100. , 200. )))*

*except aster.BandeFrequenceVideError:*

*MODE1=MODE\_ITER\_SIMULT (MATR\_A=K\_ASSE, MATR\_B=M\_ASSE,  
CALC\_FREQ=\_F (  
OPTION = "BAND",  
FREQ = (200. , 3500. , )))*

*"NOT" calculation (emission only of one ALARM) does not stop if no eigenvalue is detected in the band stipulated by the user.*

*This key word is used in macro-order MACRO\_MODE\_MECA [U4.52.02] in order to allow the absence of eigenvalues in a band of research.*

### **3.10 Operand INFORMATION**

*INFORMATION*

*= /  
1*

**[DEFECT]**

*/ 2*

*Indicate the level of impression in the file MESSAGE.*

*1 :*

*Impression on the file "MESSAGE" of the eigenvalues, their modal position, of reduced damping, of the standard of error a posteriori and certain useful parameters to follow the course of calculation (cf [§5.2])*

*2 :*

*Impression rather reserved for the developers.*

### **3.11 Operand TITRATE**

*TITRATE = Ti*

*Titrate attached to the concept produced by this operator [U4.03.01].*

**4**



## ***Phase of checking***

*One checks according to options':*

*OPTION = "BAND"*

*the argument of key word **FREQ** or key word **CHAR\_CRIT** must provide **two** values exactly,*

*OPTION = "CENTER"*

*the argument of key word **FREQ** or key word **CHAR\_CRIT** must provide **only one** value exactly,*

*OPTION = "PLUS\_PETITE"*

*the argument of key word **FREQ** or key word **CHAR\_CRIT**, is ignored.*

*If the maximum precise details and numbers of iterations are unrealistic (for example precise details lower than the precision machine or of the negative iteration counts), calculation is not carried out.*

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## ***5 Phase of execution***

### ***5.1 Checking***

***The matrices **A**, **B** (and **C**) arguments of key words **MATR\_A** and **MATR\_B** (and **MATR\_C**), must be coherent between them (i.e. to be based on the same classification and the same mode of***

*storage).*

## 5.2

### *Actions by defect*

*If key word DIM\_SOUS\_ESPACE is not indicated or is initialized with a value strictly lower than the number of required frequencies  $nf$  (operand NMAX\_FREQ), the operator calculates automatically an acceptable dimension for the subspace of projection via the formulas empirical (cf [§3.6.7]):*

**METHOD = "SORENSEN"**

*$ndim = \text{MIN} (\text{MAX} (2+nf, mse*nf), nactif)$  with  $mse = 2$  per defect.*

**METHOD = "TRI\_DIAG"**

*$ndim = \text{MIN} (\text{MAX} (7+nf, mse*nf), nactif)$  with  $mse = 4$  per defect.*

**METHOD = "JACOBI"**

*$ndim = \text{MIN} (\text{MAX} (7+nf, mse*nf), nactif)$  with  $mse = 2$  per defect.*

*where  $nactif$  of  $ddl$  active (i.e. the total number of  $ddl$  less the number of  $ddls$  is the number of LAGRANGE and less the number of linear relations which bind  $ddls$  between them, cf [§2.2] [R5.01.01])*

*and  $mse$  is the factor of proportionality fixed by COEF\_DIM\_ESPACE.*

*If one solves a quadratic problem with the eigenvalues, the dimension of the subspace is doubled.*

*The values of these various parameters are printed in the file MESSAGE.*

## 6

### *Modal parameters/Standard of the modes/modal Position*

*At exit of this operator, the real or complex clean modes are standardized with largest components which is not a multiplier of LAGRANGE. To choose another standard, it is necessary to use order NORM\_MODE [U4.52.11].*

*In the case of a dynamic calculation, the structure of data mode\_meca\_\*, contains, in addition to frequencies of vibration and the associated modal deformations, the modal parameters (mass generalized, generalized stiffness, factor of participation, mass effective). One will find the definition of these parameters in [R5.01.03].*

*In the case of a linear calculation of buckling, the structure of data mode\_flamb, only contains critical loads and associated deformations.*

*In the case of a dynamic calculation, the modal position of the modes corresponds to the position of the mode*

*in the whole of the spectrum defined by the initial matrices.*

*In the case of a linear calculation of buckling, the modal positions of the critical loads are allotted of 1 to nf (nf being the number of calculated critical loads) by classifying the loads critical by order ascending algebraic. All the modal positions are thus positive.*

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*Impression of the results*

*To post the modal parameters associated with each mode and the co-ordinates with the modes, it is necessary*

*to use operator IMPR\_RESU [U4.91.01] in the following way:*

*· Affichage of the modal parameters only in the form of table:*

*IMPR\_RESU*

*(*

*RESU*

*=*

*\_F (*

*RESULT = mode,*

*TOUT\_PARA*

*=*

**“YES”,  
TOUT\_CHAM**

=

**“NOT”))**

;

*· Affichage of the modal parameters and the clean vectors:*

**IMPR\_RESU**

**(RESU =\_F (RESULT = mode,**

**TOUT\_PARA**

=

**“YES”,**

**TOUT\_CHAM**

=

**“YES”))**

;

8

*Sorting of modes/Characterization of mode\_meca\_\**

*For example, at the time of seismic requests in modal analysis, the modal base used must contain the modes which have an important unit effective mass in the direction of the seism.*

*Order EXTR\_MODE [U4.52.12] makes it possible to extract in a structure of data of the type mode\_meca\_\* of the modes which check a certain criterion and of concaténer several structures of data of the mode\_meca\_\* type.*

*An macro-order, allowing to connect orders MODE\_ITER\_SIMULT, NORM\_MODE and EXTR\_MODE was created: MACRO\_MODE\_MECA [U4.52.02].*

## **9 Examples**

**9.1 Calculation of the 5 clean modes closest to a frequency data (100 Hz)**

**mode = MODE\_ITER\_SIMULT**

**(MATR\_A = rigid,**

**MATR\_B**

=  
*mass,*  
*CALC\_FREQ*  
*=\_F (*  
*OPTION*  
=  
*“CENTER”,*  
*FREQ*

=  
*100.,*  
*NMAX\_FREQ*  
=  
*5*  
*)*

*);*

## **9.2**

*Calculation of the critical loads contained in a band*

*mode = MODE\_ITER\_SIMULT*  
*(MATR\_A = rigid,*  
*MATR\_B*  
=  
*riggeo,*  
*TYPE\_RESU*  
=  
*“MODE\_FLAMB”,*  
*CALC\_FREQ*  
*=\_F (*  
*OPTION*  
=  
*“BAND”,*  
*CHAR\_CRIT*

=  
(- 1.E8  
,  
1.5E8))

);

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***Operator MODE\_ITER\_INV***

## ***1 Goal***

***To calculate clean values and vectors by the method of the iterations opposite. The case of the problem generalized (calculation of the dynamic type without damping or buckling type of Euler) and the case of quadratic problem (calculation of the dynamic type with damping) are dealt with. Product a concept mode\_meca\_\* (dynamic case) or mode\_flamb (case buckling of Euler).***

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## 2 Syntax

*mode*

[\*] = *MODE\_ITER\_INV*

# *MODAL FACT OF THE CASE*

(

*MATR\_A*

=

*With*

/

[*matr\_asse\_DEPL\_R*]

/

[*matr\_asse\_PRES\_R*]

/

[*matr\_asse\_GENE\_R*]

*MATR\_B*

=

*B*

/

[*matr\_asse\_DEPL\_R*]

/

[*matr\_asse\_PRES\_R*]

/

[*matr\_asse\_GENE\_R*]

*MATR\_C*

= *C*

[*matr\_asse\_DEPL\_R*]

# *STANDARD OF PROBLEM*

*TYPE\_RESU*

=

/

*“DYNAMIC”*

[*DEFECT*]

/



**“MODE\_FLAMB”**

**# PHASE HEURISTIC**

**# STANDARD OF MODAL CALCULATION**

**CALC\_FREQ = \_F (OPTION**  
**=/“NEAR”**

**/“SEPARATE”**

**/“ADJUSTS”**  
**[DEFECT]**

**NMAX\_FREQ**  
**=**  
**/**  
**0**  
**[DEFECT]**

/  
***nf***  
***[I]***  
  
#  
***IF TYPE\_RESU = "DYNAMIC"***

***FREQ***  
=  
***lfreq***  
***[l\_R]***  
***AMOR\_REDUIT = lamor***  
***[l\_R]***

#  
***IF TYPE\_RESU = "MODE\_FLAMB"***

***CHAR\_CRIT***  
=  
***lcharc***  
***[l\_R]***

#  
***IF OPTION = "SEPARATED" or "ADJUSTS"***

*NMAX\_ITER\_SEPARE*

=

/

30

[DEFECT]

/

*nis*

[I]

*PREC\_SEPARE*

=

/

1.E-4

[DEFECT]

/

*PS*

[R]

#

*IF OPTION = "ADJUSTS"*

*NMAX\_ITER\_AJUSTE*

=

/

15

[DEFECT]

/

*denied*

[I]

*PREC\_AJUSTE*

:

/

*1.E-4*

*[DEFECT]*

*/Pa*

*[R]*

*# SENSITIVITY*

*SENSITIVITY = (*

*... to see [U4.50.02]....*

)

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***# FOR PREPROCESSINGS***

***SEUIL\_FREQ***

*=*

*/*

***1.E-2***

***[DEFECT]***

*/*

***sf***

***[R]***

***PREC\_SHIFT***

*=*

/  
**0.05**  
**[DEFECT]**  
/  
**PS**  
**[R]**

**NMAX\_ITER\_SHIFT**  
**=/5 [DEFECT]**  
/  
**NS**  
**[I]**

**NPREC\_SOLVEUR**  
**=**  
/  
**8**  
**[DEFECT]**  
/  
**ndeci**  
**[I]**

)

**# PHASE ITERATIONS OPPOSITE**

***CALC\_MODE = \_F (OPTION  
=/"DIRECT"  
[DEFECT]***

***/"RAYLEIGH"***

***NMAX\_ITER  
=/30 [DEFECT]***

***/nim [I]***

***PREC***  
**=**  
***/1.E-5***  
***[DEFECT]***

***/pm***

***[R]***

**)**

***# FOR FINAL VERIFIVATION***

***VERI\_MODE = \_F (STOP\_ERREUR***  
**=**  
***/***  
***“YES”***  
***[DEFECT]***



/

**“NOT”**

***THRESHOLD***

= /

***1.E-2***

***[DEFECT]***

***/R***

***[R]***

)

***# OTHERS***

***INFORMATION***

=

/

***1***

***[DEFECT]***

/ 2

**TITRATE**

**= Ti**

**[l\_Kn]**

**);**

**# GIVEN RESULT**

**If TYPE\_RESU = "MODE\_FLAMB"**

**then [\*]**

**->**

**mode\_flamb**

**If MATR\_C= [matr\_asse\_DEPL\_R]**

**then [\*]**

**->**

**mode\_meca\_C**

**If MATR\_A= [matr\_asse\_DEPL\_R]**

**then [\*]**

**->**

**mode\_meca**

**If MATR\_A= [matr\_asse\_PRES\_R]**

**then [\*]**

**->**

**mode\_acou**

**If MATR\_A= [matr\_asse\_GENE\_R]**

**then [\*]**

**->**

**mode\_gene**

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**Operator MODE\_ITER\_INV**

**Date:**

**31/01/05**

**Author (S):**

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### **3 Operands**

#### **3.1 Principles**

**This operator solves the problem generalized with the eigenvalues according to [R5.01.01]: To find  $(, X)$  such as  $Ax = Bx, X \neq 0$ , where  $A$  and  $B$  are symmetrical matrices with coefficients realities. This type of problem corresponds, in mechanics, in particular with:**

**The study of the free vibrations of a not deadened and nonrevolving structure. For this structure, one seeks the smallest eigenvalues or those which are in one interval given to know if an exciting force can create a resonance. In this case, matrix  $A$  is the matrix of material rigidity, noted  $K$ , (possibly increased stamp geometrical rigidity noted  $k_g$ , if the structure is prestressed) and  $B$  is the matrix of mass or noted inertia  $M$ . the eigenvalues obtained are the squares of the pulsations associated the sought frequencies.**

**The system to be solved can be written:  $(K + K$**

**where  $\omega = (\omega)^2$**

**$\omega^2 F$  is the square of**

**$G) X = \{$**

**$MX$**

**4**

**1 4**

**2 3**

**B****With**

**pulsation,  $F$  the Eigen frequency and  $X$  the vector of associated clean displacement.**

**The search for linear mode of buckling.** Within the framework of the linearized theory, in supposing a priori that the phenomena of stability are suitably described by system of equations obtained by supposing the linear dependence of displacement by report/ratio at the level of critical load, the research of the mode of buckling  $X$  associated it level of critical load  $\mu = -$ , brings back itself to a problem generalized to the eigenvalues form:  $(\mathbf{K} + \mu \mathbf{K}$

$=$   
 $=$   
 with  $\mathbf{K}$  stamps material rigidity and

 $G) X$  $0$ 

{

 $\mathbf{K}x$  $\mathbf{K} X$ { $G$ **With****B**

**$\mathbf{K}g$  stamps geometrical rigidity.**

**Caution:**

In the code, one treats only the eigenvalues of the generalized problem, them. For to obtain the true critical loads, the  $\mu$ , it is necessary to multiply them by 1.

This operator allows also the study of the **dynamic stability of an involved structure gyroscopic depreciation and effects**. That led to the resolution of a modal problem of a nature higher, known as quadratic [R5.01.02]. Clean values and vectors then are sought complexes by the method of Lanczos after having carried out a linear reduction of the problem.

The problem consists in finding  $(, X) (C, C NR)$  such as  $(2B + C + A) X = 0$  where typically, in linear mechanics,  $A$  will be the matrix of rigidity,  $B$  the matrix of mass and  $C$  the matrix of damping. The matrices  $A$ ,  $B$  and  $C$  are matrices with coefficients realities. The eigenvalue complexes is connected to the Eigen frequency  $F$  and damping reduced by:  $= (2) \pm (2) 1 - 2$

 $F$  $I$  $F$

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*To solve these generalized or quadratic modal problems, Code\_Aster proposes various approaches. Beyond their numerical specificities and functional calculuses which are taken again in the document [R5.01.01], one can synthesize them in the shape of table below (the **values by defect are materialized in fat**).*

***Operator***

***Algorithm Key word Advantages***

***Disadvantages***

***Perimeter***

***of application***

***MODE\_ITER\_INV***

*1st phase*

*(heuristics)*

*Calculation of some*

*Bisection*

*“SEPARATE”*

*modes*

*Calculation of some*

*Bisection +*

*“ADJUSTS”*

*Better precision*

*Cost calculation*

*modes*

*Secant (gén.)*

*Muller (quad.)*

*Improvement of*

*Initialization by*

*“NEAR”*

*Resumption of values*

*No the capture*

*some estimates*

*the user*

*clean estimated*

*of multiplicity*

*by another*

*process.*

*Cost calculation of this*

*phase quasi-no one*

*2nd phase*

*(method of*

*powers properly*

*said)*

*Basic method*

*Powers*

*“DIRECT”*

*Very good*

*Not very robust*

*opposite*

*construction of*

*clean vectors*

*Option of acceleration*  
*Quotient of*  
*“RAYLEIGH”*  
*Improve*  
*Cost calculation*  
*Rayleigh*  
*convergence*  
*Not carried in*  
*quadratic*

### ***MODE\_ITER\_SIMULT***

*Calculation of part of*  
*Bathe & Wilson*  
*“JACOBI”*  
*Little*  
*robust*  
*spectrum*  
*Not carried in*  
*quadratic*  
*Lanczos*  
*“TRI\_DIAG”*  
*Little*  
*robust*  
*(Newman- Pipano)*  
*IRAM*  
*(Sorensen)*  
*“SORENSEN” increased Robustness. Not carried in*  
*Better*  
*quadratic*  
*calculation complexities*  
*and memory.*  
*Control*  
*quality of the modes.*

### ***Table 3.1-1: Summary of the modal methods of Code\_Aster***

*When it is a question of determining some simple eigenvalues discriminated well or to refine some estimates, operator *MODE\_ITER\_INV*, is often clearly shown. On the other hand, for to capture a part significant of the spectrum, one A resorts to *MODE\_ITER\_SIMULT*, via the methods*

known as “of subspace”.

*It is the first class of method which will interest us here.*

*It consists in coupling a heuristic phase of localization of the eigenvalues (determination of an approximate value of each eigenvalue contained in an interval given by one technique of bisection, refined or not, by a method of the secant, in generalized, or by a method of Muller into quadratic), with a phase of iterations opposite itself (accelerated by a quotient of Rayleigh or not), which will improve these estimates all in exhuming the associated clean vectors.*

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***It is completely recommended besides to benefit from the strong points of the two classes from method by refining the clean vectors obtained by **MODE\_ITER\_SIMULT**, via **MODE\_ITER\_INV** (**OPTION=' PROCHE'**). That will make it possible to reduce the standard of the final residue (cf [§3.6.2]).***

**Note:**

*One strongly advises a preliminary reading of the reference materials [R5.01.01] [R5.01.02]. It gives to the user the properties and the limitations, theoretical and practical, of modal methods approached while connecting these considerations, which can sometimes appear one little éthérées, with a precise parameter setting of the options.*

**3.2 Operands**

***MATR\_A, \_B, \_C***



*MATR\_A*

= A

*Stamp assembly of the type [matr\_asse\_\*\_R] system generalized or quadratic with to solve.*

*MATR\_B*

= B

*Stamp assembly of the type [matr\_asse\_\*\_R] system generalized or quadratic with to solve.*

*MATR\_C*

= C

*Stamp assembly of the type [matr\_asse\_\*\_R] quadratic system to solve.*

### **3.3 Word**

**key**

**TYPE\_RESU**

*TYPE\_RESU =/“DYNAMIC”*

**[DEFECT]**

*/“MODE\_FLAMB”*

*This key word makes it possible to define the nature of the modal problem to treat: search for frequencies of*

*vibration (traditional case of dynamics with or without damping) or search for loads critical (case of the theory of linear buckling). According to this class of membership, them results are posted and stored differently in the structure of data:*

.

***In dynamics**, the frequencies are ordered by order ascending of the module of their variation with the shift (cf [§2.9] [§4.4] [R5.01.01]). It is the value of the variable of access NUM\_ORDRE of the structure of data. The other variable of access, NUME\_MODE, is equal to the true modal position in the spectrum of the eigenvalue (determined by the test of Sturm cf [§2.5] [§2.6] [R5.01.01]).*

.

***In buckling**, the eigenvalues are stored by order ascending algebraic.*

*variables NUM\_ORDRE and NUM\_MODE take the same value equal to this order.*

### **3.4 Word**

*key*

***CALC\_FREQ***

***CALC\_FREQ***

***=\_F (...***

*Key word factor for the definition of the parameters of the first phase of calculation (localization of eigenvalues).*

*For the generalized problem, the localization of the eigenvalues is generally carried out by one dichotomic separation of the frequencies (for the options "ADJUSTS" and "SEPARATE"), followed of one*

*method of the secant (for the option: "ADJUSTS").*

*For the quadratic problem, this localization is carried out by a resolution of the problem not deadened (generalized problem) followed by a method of Muller (for the option: "ADJUSTS").*

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### **3.4.1 Operand**

#### **OPTION**

*OPTION*

=

“NEAR”

*One seeks the mode to which the eigenvalue is closest to a given value. This value is indicated by:*

.  
*the argument *lfreq* of key word *FREQ* for a generalized problem of dynamic type (*TYPE\_RESU* = “DYNAMIC”).*

.  
*the argument *lcharc* of key word *CHAR\_CRIT* for a generalized problem of type linear buckling (*TYPE\_RESU* = “MODE\_FLAMB”).*

.  
*the arguments *lfreq* and *lamor* of key word *FREQ* and *AMOR\_REDUIT* for a problem quadratic of dynamic type (*TYPE\_RESU* = “DYNAMIC”).*

*There is as many research of modes than of terms in this list (or these lists). If one wish to calculate a multiple mode, one should not use this option because only one will be found only mode.*

“SEPARATE”

*One separates the eigenvalues by a method of bisection based on the criterion of Sturm. The terminals of the interval of research are:*

arguments of the list *lfreq* of key word *FREQ* for a generalized problem or quadratic of dynamic type (*TYPE\_RESU* = "DYNAMIC").

arguments of the list *lcharc* of key word *CHAR\_CRIT* for a problem generalized of linear buckling type (*TYPE\_RESU* = "MODE\_FLAMB").

## **"ADJUSTS"** **[DEFECT]**

After having separated the Eigen frequencies, as for the option "SEPARATE" one carries out additional iterations either by the method of the secant (generalized problem) or by method of Muller (quadratic problem) to obtain a better precision on the value clean.

### **3.4.2 Operand** **FREQ**

*FREQ* = *lfreq*

For a problem of search for eigenvalue of dynamic type (*TYPE\_RESU* = "DYNAMIC"), this key word corresponds to the list of the frequencies of which the use depends on the selected *OPTION*.

If "CLOSE" option: it is the list of the frequencies whose one seeks the mode nearest. The list has at least 1 element and is ordered by ascending order.

If option "SEPARATE" or "ADJUSTS": they are the terminals of the intervals of research  
*FREQ*: (*f1*, *f2*, ..., *fn-1*, *fn*)

One will seek to separate the frequencies in the intervals  
*[f1, f2]*, *[f2, f3]*, ..., *[fn-2, fn-1]*, *[fn-1, fn]*

The list has at least 2 elements. The frequencies are positive. It is checked that the frequencies are given in the ascending order.

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### **3.4.3 Operand**

#### **AMOR\_REDUIT**

*AMOR\_REDUIT = lamor*

*For the quadratic problem of dynamic type ( $TYPE\_RESU = "DYNAMIC"$ ), and if the option  $CLOSE$  was chosen, one can initialize the method of the iterations opposite starting from a value clean initial complex. To build this complex value, the list of the arguments is used given under key words  $FREQ$  (list of frequencies) and  $AMOR\_REDUIT$  (list of depreciation). These two lists must have the same number of arguments.*

### **3.4.4 Operand**

#### **CHAR\_CRIT**

*CHAR\_CRIT = lcharc*

*For a problem of search for eigenvalue of buckling type of Euler ( $TYPE\_RESU = "MODE\_FLAMB"$ ), this key word corresponds to the list of the critical loads of which the use depends on the selected  $OPTION$ .*

*If " $CLOSE$ " option: it is the list of the critical loads whose one seeks the mode more near. The list has at least 1 element.*

*If option " $SEPARATE$ " and " $ADJUSTS$ ": they are the terminals of the intervals of research*

*CHAR\_CRIT: (1, 2, ..., n-1, N)*

*One will seek to separate the critical loads in the intervals*

*[1, 2], [2, 3].... [N2, n-1], [n-1, N]*

*The list has at least 2 elements. The critical loads are negative or positive. One checks that the critical loads are given in the ascending order.*

### **3.4.5 Operand**

#### **NMAX\_FREQ**

*NMAX\_FREQ = nf*

*( 0 )*

**[DEFECT]**

*Numbers maximum eigenvalues to calculate. This operand is ignored for the option “NEAR”.*

*For the other options, if the user does not inform this key word, all eigenvalues contained in the intervals specified by the user are calculated. If not, NMAX\_FREQ first eigenvalues, therefore lowest, are calculated*

### **3.4.6 Operands of the bisection (if OPTION = “SEPARATED” or “ADJUSTS”)**

*NMAX\_ITER\_SEPARE = nis*

*( 30 )*

**[DEFECT]**

*PREC\_SEPARE*

*= PS*

*( 1.10-4 )*

**[DEFECT]**

*Parameters of adjustment of the iteration count and the precision of separation for dichotomizing search. These operands are ignored for the “CLOSE” option (cf [R5.01.01 §3.2.1]).*

**Note:**

*At the time of the first passages, it is strongly advised not to modify these parameters which the mysteries of the algorithm concern rather and which are initialized empirically with values standards.*

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**3.4.7 Operands of the secant (if OPTION = "ADJUSTS")**

**NMAX\_ITER\_AJUSTE**

**=**

**denied**

**( 15 )**

**[DEFECT]**

**PREC\_AJUSTE =**

**Pa (1.10-4)**

**[DEFECT]**

**Parameters of adjustment of the iteration count and the precision of separation for the method secant. These operands are not useful that with the option "ADJUSTS" (cf [R5.01.01 §3.2.2]).**

**Note:**

**At the time of the first passages, it is strongly advised not to modify these parameters which the mysteries of the algorithm concern rather and which are initialized empirically with values standards.**

**3.4.8 Operands**

**SEUIL\_FREQ, PREC\_SHIFT and NMAX\_ITER\_SHIFT**

**PREC\_SHIFT = PS**

**( 0.05 )**

**[DEFECT]**

**SEUIL\_FREQ = sf**

**( 0.01 )**

**[DEFECT]**

**NMAX\_ITER\_SHIFT = NS**

( 5 )

**[DEFECT]**

*For three possible options “PLUS\_PETITE”, “BAND” or “CENTER”, one carries out one*  
*2*  
*factorization LDLT of matrix  $(A - (2 f^*) B)$ .  $f^*$  depends on the method used. If  $f^*$  is*  
*detected as being an Eigen frequency or being located near Eigen frequencies*  
*(loss of more than decimal ndeci=8 during the factorization of the matrices), the frequency  $f^*$  is*  
*then modified (cf §2.6 and 2.9 [R5.01.01]):*

***F -******F******(1 PS) or F +******=******× -******= F × (1+ PS******\*******\*******\*******\*******)******2******If  $(A - (2 f^*) B)$  is not factorisable LDLT and  $(F$*** ***sf******\*******), one carries out******following modification:  $F - = - sf$*** ***\****

***. It is considered whereas  $f^*$  is associated a mode of body***  
***rigid. The modification of this frequency makes it possible a priori to enter all the modes of***  
***rigid body. One does not carry out more NS modifications of the value  $f^*$ .***

***In the case of linear buckling, the transposition is immediate by replacing  $f^*$  (frequency***

***2******2******of vibration) by  $*$  (critical load),  $(2 f^*)$  by  $*$  and  $sf$  by  $(2 sf)$ .******Note:***

***At the time of the first passages, it is strongly advised not to modify these parameters which***  
***the mysteries of the algorithm concern rather and which are initialized empirically with values***  
***standards.***



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### **3.4.9 Operand**

**NPREC\_SOLVEUR**

**NPREC\_SOLVEUR**

**= ndeci**

**( 8 )**

**[DEFECT]**

**ndeci represents the number of decimals which one is authorized to lose during the factorization of**  
**2**

**stamp shiftée (A - (2 f\*) B) or (A - B). If one loses more decimal ndeci, the matrix**  
**is regarded as noninvertible (cf [§2.6] and [§2.9] [R5.01.01]).**

**Note:**

**At the time of the first passages, it is strongly advised not to modify this parameter which**  
**rather relate to a mystery of the algorithm and which is initialized empirically with a value**  
**standard.**

### **3.5 Word**

**key**

**CALC\_MODE**

## **CALC\_MODE**

**=\_F (...**

***Key word factor for the definition of the parameters of calculation of the second phase of calculation (method of the powers opposite).***

### **3.5.1 Operand**

#### **OPTION**

#### **OPTION**

**=**

***Definition of alternative for the opposite iteration itself (cf [R5.01.01 §3.3]):***

#### **“DIRECT”**

***Iteration reverses standard (only allowed option for the problem***

***[DEFECT]***

***quadratic),***

#### **“RAYLEIGH”**

***Iteration reverses with quotient of Rayleigh (without effect on the problem***

***quadratic).***

### **3.5.2 Operand**

#### **NMAX\_ITER**

***NMAX\_ITER = nim***

***( 30 )***

***[DEFECT]***

***Numbers maximum iterations for the research of the clean vectors.***

### **3.5.3 Operand**

#### **PREC**

***PREC = pm***

***( 1.10-5 )***

***[DEFECT]***

***The iteration continues as much as the relative variation of standard on the clean modes, between two reiterated, is higher than pm.***

### **3.6 Operands**

#### **SENSIBLITE**

**SENSITIVITY =**

*Activate the calculation of derived from the modes compared to a significant parameter of the problem.*

*It is it should be noted that at present, the derivative of the multiple modes is not available, because it pose theoretical and practical problems particular.*

*The document [U4.50.02] specifies the operation of the key word.*

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### **3.7 Word**

**key**

**VERI\_MODE**

**VERI\_MODE = \_F (...**

**Key word factor for the definition of the parameters of the checking of the clean modes ([§2.9] [R5.01.01]).**

**Note:**

At the time of the first passages, it is strongly advised not to modify these parameters which the mysteries of the algorithm concern rather and which are initialized empirically with values standards.

Contrary to its alter-ego, *MODE\_ITER\_SIMULT*, this key word factor does not comprise key word of type *STURM* and *PREC\_SHIFT*. The phase of postprocessing and checking do not comprise indeed a test of Sturm which would be redundant with the first part heuristics. Methods of the type “power” being less robust than those of type “subspace”, the default value of the threshold *R* is less demanding (10-2 instead of 10-6).

### 3.7.1 Operand *STOP\_ERREUR*

*STOP\_ERREUR* =/  
“YES”

[DEFECT]  
/  
“NOT”

Allows to indicate to the operator if it must stop (“YES”) or continue (“NOT”) if one of the *THRESHOLD* criteria or *STURM* is not checked.  
By defect the concept of exit is not produced.

### 3.7.2 Operand *THRESHOLD*

-2  
*THRESHOLD*  
= *R* (1.10  
)  
[DEFECT]

Tolerance level for the standard of error relating of the mode to the top of which the mode is regarded as forgery.  
The standard of relative error of the mode is:

(A -)  
 $B \times 2$ , for 0 for the generalized problem and  
 $A \times 2$

$(2B + C - A) X^2,$   
 $Ax$   
*for the quadratic problem*  
2

### **3.8 Operand INFORMATION**

**INFORMATION**

= /  
1

**[DEFECT]**

/ 2

*Indicate the level of impression in the file MESSAGE.*

**1 :**  
*Impression on the file "MESSAGE" of the eigenvalues, their modal position, of reduced damping, of the standard of error a posteriori and certain useful parameters to follow the course of calculation.*

**2 :**  
*Impression rather reserved for the developers.*

### **3.9 Operand TITRATE**

**TITRATE =  $T_i$**

*Titrate attached to the concept produced by this operator [U4.03.01].*

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### **4 Phase of execution**

#### **4.1 Checking**

**The matrices *A* and *B* (and *C*), arguments of key words *MATR\_A* and *MATR\_B* (and *MATR\_C*), must to be coherent between them (i.e. to be based on the same classification and the same mode of storage).**

**The operator checks that for the options “SEPARATE” and “ADJUSTS”, the list of the values of arguments of key word *FREQ* has, at least, two terms.**

**It checks also a certain coherence of the parameters of the various algorithms.**

#### **4.2 Execution**

**For the option “ADJUSTS”, if separation is not possible and that in a given interval there is more than one value of Eigen frequency, one does not apply the method of adjustment with this interval.**

**On the other hand, one will carry out during the calculation of the modes of the réorthogonalisations compared to modes preceding contents in the interval (this makes it possible to calculate modes associated with one multiple frequency).**

**For the option “SEPARATED”, having obtained an interval determining an Eigen frequency, one takes for the calculation of the mode medium of the interval. During the calculation of the mode, the value of the Eigen frequency is still refined. It is the result of the opposite iteration itself.**

## **5 Modal parameters/Standard of the modes/modal Position**

*At exit of this operator, the real or complex clean modes are standardized with largest components which is not a multiplier of Lagrange. To choose another standard, it is necessary to use order NORM\_MODE [U4.52.11].*

*In the case of a dynamic calculation, the structure of data mode\_meca\_\*, contains, in addition to frequencies of vibration and the associated modal deformations, the modal parameters (mass generalized, generalized stiffness, factor of participation, mass effective). One will find the definition of these parameters in [R5.01.03].*

*In the case of a linear calculation of buckling, the structure of data mode\_flamb, only contains critical loads and associated deformations.*

*In the case of a dynamic calculation, the modal position of the modes corresponds to the position of the mode*

*in the whole of the spectrum defined by the matrices A and B.*

*In the case of a linear calculation of buckling, the modal positions of the critical loads are allotted of 1 to nf (nf being the number of calculated critical loads) by classifying the loads critical by order ascending in absolute value. All the modal positions are thus positive.*

*For the CLOSE option, the modal positions are allotted of 1 to nf (nf being the number of values clean calculated), by taking the eigenvalues in the order of the list indicated under FREQ or CHAR\_CRIT.*

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**6*****Impression of the results***

*To post the modal parameters associated with each mode and the co-ordinates with the modes, it is necessary*

*to use operator IMPR\_RESU [U4.91.01] in the following way:*

.

*Posting of the modal parameters only in the form of table:*

**IMPR\_RESU**

**(RESU = \_F (RESULT = mode,**

**TOUT\_PARA**

**=**

**“YES”,**

**TOUT\_CHAM**

**=**

**“NOT”**

**)**

**)**

**;**

.

*Posting of the modal parameters and the clean vectors:*

**IMPR\_RESU**

**(RESU = \_F (RESULT = mode,**

**TOUT\_PARA**

**=**

**“YES”,**

**TOUT\_CHAM**

**=**

**“YES”**

**)**

**)**

**;**

***7 Examples***

*Are mass and rigidity two matrices beforehand assembled by operator ASSE\_MATRICE starting from elementary matrices of mass (OPTION = “MASS\_MECA”) and of rigidity (OPTION = “RIGI\_MECA”).*



*One calculates the modes of Eigen frequency included/understood in band 50 Hz with 150 Hz with the operator*

*MODE\_ITER\_INV as follows:*

*mode*  
*= MODE\_ITER\_INV*

*(MATR\_A= rigidity,*  
*MATR\_B= masses,*  
*CALC\_FREQ=\_F*  
*(*  
*OPTION = “ADJUSTS”,*  
*FREQ = (50. , 150. ))*

*);*

*One calculates the modes of Eigen frequency closest to frequencies 20 Hz and 50 Hz with operator MODE\_ITER\_INV as follows:*

*mode*  
*= MODE\_ITER\_INV*

*(MATR\_A= rigidity,*  
*MATR\_B= masses,*  
*CALC\_FREQ=\_F*  
*(*  
*OPTION = “NEAR”,*  
*FREQ = (50. , 150. )),*  
*CALC\_MODE = \_F (OPTION = “RAYLEIGH”)*

);

*The acceleration of convergence by using the coefficient of Rayleigh was selected.*

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*Version*

*7.4*

*Titrate:*

*Operator MODE\_ITER\_INV*

*Date:*

*31/01/05*

*Author (S):*

*E. BOYERE, O. BOITEAU Key*

*:*

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*8 Remarks*

*of use*

*The cost of this operator can be high bus:*

*.*

*each dichotomy requires a factorization (if OPTION = "SEPARATE"),*

*.*

*each iteration of secant (if OPTION = "ADJUSTS") requires also a factorization.*

*It can be more judicious to make:*

*.*

*a search for eigenvalues by operator MODE\_ITER\_SIMULT [U4.52.03],*

*.*

*then to refine the results obtained by MODE\_ITER\_INV by using the option "CLOSE" to*

***CALC\_FREQ and the option “RAYLEIGH” of CALC\_MODE to improve the clean vectors.***

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***Version***

***7.4***

***Titrate:***

***Operator MODE\_ITER\_CYCL***

***Date:***

***08/03/05***

***Author (S):***

***O. NICOLAS, E. BOYERE Key***

***:***

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***Organization (S): EDF-R & D /AMA***

***Instruction manual***

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***Document: U4.52.05***

***Operator MODE\_ITER\_CYCL***

## **1 Goal**

*To calculate the clean modes of a structure with cyclic symmetry.*

*One calculates the generalized components of the clean modes of the whole structure, by a method of cyclic under-structuring, starting from the modal base of a sector of reference. The axis of symmetry is axis OZ. The modal base of sector must be of the TRADITIONAL type. The interfaces RIGHT-HAND SIDE, LEFT and possibly AXIS must be in the same way standard. The sides right and left are defined by the trigonometrical direction in plan OXY.*

*Product a structure of data of the mode\_cycl type.*

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**Author (S):**

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## **2 Syntax**

*mocy [mode\_cycl] = MODE\_ITER\_CYCL*

(  
*BASE\_MODALE*  
=  
*bamo,*  
*[base\_modale]*

*NB\_MODE =*  
/  
*nbmo,*  
*[I]*

/ 999  
,  
*[DEFECT]*

*NB\_SECTEUR*  
=  
*nbsec,*  
*[I]*

*CONNECTION = \_F (*  
*RIGHT-HAND SIDE*  
=  
*“nom\_int”,*  
*[KN]*

**LEFT**  
=  
“*nom\_int*”,  
[kN]

**CENTER**  
=  
“*nom\_int*”, [kN]

),

**CALCULATION = \_F (**  
**TOUT\_DIAM**  
**=/“YES”,**

***NB\_DIAM = Li, [l\_I]***

***OPTION =/"PLUS\_PETITE",  
[DEFECT]***

***/***

***"CENTER",***

***/***

***"BAND",***

***FREQ = lifreq,***

***[l\_R]***

***NMAX\_FREQ =/nbfreq,***

***[I]***

/  
10,  
**[DEFECT]**

**PREC\_SEPARE =**  
/  
**pre\_sep,**  
**[R]**

/  
**1.E+2,**  
**[DEFECT]**

**PREC\_AJUSTE =**  
/  
**pre\_ajus,**



**[R]**

/  
**1.E-6,**  
**[DEFECT]**

**NMAX\_ITER**  
=  
/  
**niter,**  
**[I]**

/  
**50,**  
**[DEFECT]**

),

***VERI\_CYCL = \_F (***  
***PRECISION***  
***=/prec, [R]***  
***/***  
***1.D-3,***  
***[DEFECT]***

***CRITERION =***  
***/"RELATIVE", [DEFECT]***

***DIST\_REFE =***  
***dist\_ref, [R]***

),

***INFORMATION =***

/  
1,  
***[DEFECT]***

/ 2,

)  
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7.4

Titrate:

Operator *MODE\_ITER\_CYCL*

Date:

08/03/05

Author (S):

**O. NICOLAS, E. BOYERE** Key

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### **3 Operands**

#### **3.1 Operand**

***BASE\_MODAL***

***BASE\_MODAL = bamo***

***Name of the modal base of the sector built by *DEFI\_BASE\_MODAL* [U4.64.02].***

#### **3.2 Operand**

***NB\_MODE***

***NB\_MODE = nbmo***

***A number of modes clean of the sector to be used for cyclic calculation. By defect, if the key word does not appear, all the clean modes of the modal base are used.***

#### **3.3 Operand**

***NB\_SECTEUR***

***NB\_SECTEUR = nbsec***

***A number of basic sectors necessary to the construction of the total structure.***

#### **3.4 Word**

***key***

***CONNECTION***

## **CONNECTION**

*Key word factor for the definition of the connections between the sectors.*

### **3.4.1 Operands**

**LEFT RIGHT-HAND SIDE//AXIS**

*See [Figure 3.6-a].*

**RIGHT-HAND SIDE = “nom\_int”**

*Name of the right interface of the sector.*

**LEFT = “nom\_int”**

*Name of the left interface of the sector.*

**CENTER = “nom\_int”**

*Name of the interface of the axis of the sector.*

*They are points common to all the sectors.*

### **3.5 Word**

*key*

**CALCULATION**

**CALCULATION**

*Key word factor to define it mode of research of the clean modes.*

### **3.5.1 Operands**

**TOUT\_DIAM/NB\_DIAM**

**TOUT\_DIAM = “YES”**

*The modes associated with all the numbers of nodal diameters will be calculated.*

**NB\_DIAM = Li**

*List numbers of nodal diameters to calculate. By defect, all the numbers of possible nodal diameters are studied.*

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*3.5.2 Operand*

*OPTION*

*OPTION =*

*“PLUS\_PETITE”*

*: to calculate by a method of iteration reverses the clean modes corresponding to the smallest frequencies for each number of diameters requested.*

*“CENTER”:*

*to calculate the clean modes centered around a frequency requested by key word LIST\_FREQ.*

*“BAND”*

*:*

*to calculate the clean modes between two frequencies given by the user by key word LIST\_FREQ.*

*The Eigen frequencies are separated by dichotomy then the modes clean calculated by iterations opposite centered on the frequencies exits of the stage of separation.*

### 3.5.3 Operands

#### ***FREQ/NMAX\_FREQ***

***FREQ = lifreq***

*List frequencies of which the use depends on the selected option:*

***OPTION***

***=***

***“BAND”***

*One awaits 2 values (F F*

***1***

***2) which defines the band.***

***OPTION***

***=***

***“CENTER”***

*1 is awaited value which is the centre frequency of the interval.*

***OPTION***

***=***

***“PLUS\_PETITE”***

*One calculates the smallest Eigen frequencies of the structure. By defect, one calculates them 10 first. Key word FREQ then does not have a direction in this case, it does not have to be informed.*

***NMAX\_FREQ = nbfreq***

*A number of frequencies to be calculated for each number of nodal diameters asked. If it key word does not appear, one calculates as many frequencies, for each nodal diameter, that there is clean modes used in the modal base (key word NB\_MODE).*

### 3.5.4 Operands

#### ***PREC\_SEPARE/PREC\_AJUSTE/NMAX\_ITER***

***PREC\_SEPARE = pre\_sep***

***Precision of separation of the frequencies for option "BANDAGES".***

***PREC\_AJUSTE = pre\_ajus***

***Precision used for the calculation of the modes (all OPTIONS).***

***NMAX\_ITER = niter***

***Numbers maximum iterations opposite (all OPTIONS).***

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***3.6 Word***

***key***

***VERI\_CYCL***

***VERI\_CYCL***

***Key word for checking of the coherence of the interfaces given in cyclic term of repetitivity.***



***Interface left***

***Y***

***Interface axis***

***Z***

***X***

***Interface right***

***Appear 3.6-a***

### ***3.6.1 Operands***

***PRECISION/DIST\_REFE***

***PRECISION = prec***

***DIST\_REFE = dist\_ref***

***The test of coherence between 2 contiguous sectors will be determined by the product  $prec \cdot dist\_ref$ . If  $DIST\_REFE$  is not indicated, it will be automatically calculated proportionally with  $prec$  and with a maximum value of co-ordinate of a sector.***

### ***3.7 Operand***

***INFORMATION***

***INFORMATION =***

***Level of impression***

***1***

***no impression,***

***2***

***writing of the frequencies and generalized parameters obtained and the participations relative of the various modes of the base.***

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**4**  
**Cyclic under-structuring example**

**ANNULAR PLATE ENCASTREE ON A HUB - METHOD OF CRAIG-BAMPTON**

**sector = LIRE\_MAILLAGE**

**(**  
**)**

**model = AFFE\_MODELE**

**(**  
**MAILLAGE=**  
**sector,**  
**AFFE**

**=\_F (ALL**  
**= ' OUI',**

**PHENOMENON = ' MECANIQUE',**

**MODELISATION=' DKT')**

**)**

**to subdue = DEFIN\_MATERIAU**  
**(ELAS =\_F (E=2.E11, NU=0.3, RHO=7800.0)**

```

)
chammat = AFFE_MATERIAU

(MAILLAGE= sector,
AFFE =_F (ALL = ' OUI', MATER= MATER)
)
chamcar = AFFE_CARA_ELEM
(MODEL = model,
HULL = (ALL = ' OUI', EPAIS= 0.001)
)
charge = AFFE_CHAR_MECA
(MODEL = model
DDL_IMPO= (TOUT=' OUI', DX=0., DY=0., DRZ=0.),

DDL_IMPO= (GROUP_NO=' AXE', DZ=0., DRX=0., DRY=0.),

DDL_IMPO= (GROUP_NO=' DROIT', DZ=0., DRX=0., DRY=0.),
DDL_IMPO= (GROUP_NO=' GAUCH', DZ=0., DRX=0., DRY=0.))
#
#
CONSTRUCTION OF THE MATRICES OF RIGIDITY AND MASS OF THE BASIC SECTOR
#
rigiele = CALC_MATR_ELEM (MODEL = model, LOAD = load,

CHAM_MATER= chammat, CARA_ELEM = chamcar,
OPTION = "RIGI_MECA"
)
massele = CALC_MATR_ELEM (MODEL = model,
CHARGE = load,
CHAM_MATER= chammat, CARA_ELEM = chamcar,
OPTION = ' MASS_MECA')
numerot = NUME_DDL

(MATR_RIGI
=
rigiele)
matrigi = ASSE_MATRICE

(MATR_ELEM = rigiele, NUME_DDL = numerot

```

```
)  
matmass = ASSE_MATRICE  
  
(MATR_ELEM = massele, NUME_DDL = numerot  
)  
#  
#
```

### **CALCULATION OF THE DYNAMIC MODES OF THE BASIC SECTOR**

```
#  
modes = MODE_ITER_SIMULT  
(MATR_A = matrigi, MATR_B = matmass,  
  
CALC_FREQ= _F (NMAX_FREQ= 15)
```

```
)  
#  
#  
DEFINITION OF THE INTERFACES AND THE STATIC MODES ASSOCIATE
```

```
#  
lint = DEFI_INTERF_DYNA  
(NUME_DDL = numerot, IMPR= 2,  
INTERFACE= _F (NOM=' DROITE', TYPE=' CRAIGB',  
GROUP_NO=  
“RIGHT”,
```

```
MASQUE= (“DX”, “DY”, “DRZ”),),
```

```
INTERFACE= _F (NOM=' GAUCHE', TYPE=' CRAIGB',  
GROUP_NO=  
“GAUCH”,
```

```
MASQUE= (“DX”, “DY”, “DRZ”)))
```

```
#  
#  
CALCULATION OF THE BASE OF PROJECTION = RECOVERY OF THE DYNAMIC MODES  
# AND CALCULATION OF THE STATIC MODES  
bamo = DEFI_BASE_MODALE
```

(CLASSIQUE= \_F (INTERF\_DYNA= lint, IMPR= 2,

MODE\_MECA = modes,

NMAX\_MODE=

15

)

)

#

#

CALCULATION

MODES

CYCLIC

#

modcyc = **MODE\_ITER\_CYCL** (BASE\_MODAL= bamo, NB\_MODE=15, NB\_SECTEUR=18,

LIAISON=\_F ("RIGHT" DROITE=,

"LEFT" GAUCHE=),

CALCULATION =\_F (NB\_DIAM= (0, 1, 2, 3), NMAX\_FREQ=2))

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**Code\_Aster** ®

Version

7.4

Titrate:

Operator **NORM\_MODE**

Date:

21/01/05

Author (S):

**E. BOYERE, O. BOITEAU** Key

:

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Organization (S): **EDF-R & D /AMA, SINETICS**

***Instruction manual  
U4.5- booklet: Methods of resolution  
Document: U4.52.11***

***Operator NORM\_MODE***

***1 Goal***

***To normalize clean modes according to a criterion chosen by the user.***

***Operators of modal calculation MODE\_ITER\_INV [U4.52.04] and MODE\_ITER\_SIMULT [U4.52.03]***

***a concept of the mode\_meca type or mode\_meca\_c produces of which real clean modes or complexes are standardized in such way that largest of the components which is not one multiplier of LAGRANGE, is equal to one.***

***Operator NORM\_MODE allows the user to choose another method of standardization by example masses generalized, generalized rigidity...***

***According to standardization chosen, the modal parameters (factor of participation, masses effective,...) are reactualized.***

***Réentrant operator.***

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**Operator NORM\_MODE**

**Date:**

**21/01/05**

**Author (S):**

**E. BOYERE, O. BOITEAU Key**

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**2 Syntax**

***m\_out* = NORM\_MODE (**

***reuse* = *m\_out***

**MODE**

**=**

***m\_in***

**/**

**[*mode\_meca*]**

**/**

**[*mode\_meca\_C*]**

**/STANDARD =/"MASS\_GENE"**

**/**

**"RIGI\_GENE"**

/

**“TRAN”**

/

**“TRAN\_ROTA”**

/

**“EUCL”**

/

**“EUCL\_TRAN”**

/

**NODE**

=

**N**

**[node]**

**NOM\_CMP = cmp**

**[KN]**

/

**SANS\_CMP**

=

**s\_cmp**

**[l\_Kn]**

/

**AVEC\_CMP**

=

**a\_cmp**

**[l\_Kn]**

**MASS\_INER= masstru [tabl\_mass\_iner]**

**MODE\_SIGNE = \_F (**



***NODE***

=

***N***

***[node]***

***NOM\_CMP =***

***cmp,***

***[KN]***

***SIGN***

=

/

***“POSITIVE”***

***[DEFECT]***

/

***“NEGATIVE”***

)

***SENSITIVITY = (***

... to see [U4.50.02]....

)

**TITRATE**

= **T**

[***l\_Kn***]

**INFORMATION**

=

/

**1**

[***DEFECT***]

/ **2**

);

***m\_in***

=

*if m\_in is of type [mode\_meca] then m\_out is of type [mode\_meca]*

*idem with [mode\_meca\_c]*

*idem with [mode\_flamb]*

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*3 Operands*

*3.1 Operand*

*MODE*

*MODE*

*=*

*m\_in*

*Name of the concept of the mode\_\* type which one wants to change the standardization of the clean modes. If*

*m\_out is identical to m\_in and if the key word “reuse” is activated with the value m\_out renormalisation is done in place.*

### **3.2 Operand**

***NORMALIZES*** (*cf* [§5])

***/STANDARD***

=

***Reference symbol of the selected standard.***

**“*MASS\_GENE*”:**

*The modes are standardized with the unit generalized mass.*

**“*RIGI\_GENE*”:**

*The modes are normalized with unit generalized rigidity.*

**“*TRAN*”:**

*The modes are normalized to 1. for largest of the components of translation:  
(components: *DX, DY, DZ*).*

**“*TRAN\_ROTA*”:**

*The modes are normalized to 1. for largest of the components of translation and of  
rotation (components: *DX, DY, DZ, DRX, DRY, DRZ*).*

**“*EUCL*”:**

*The modes are standardized to the euclidian norm of the components which are not  
multipliers of LAGRANGE (component: *LAGR*).*

**“*EUCL\_TRAN*”:**

*The modes are standardized to the euclidian norm of the components which are  
components of translation (component: *DX, DY, DZ*).*

### **3.3 Operands**

***NODE* and *NOM\_CMP***

***NODE* = *N***

*Name of the node of standardization*

***NOM\_CMP* = *cmp***

*Name of the component of standardization to node N*

*The modes are normalized to 1. for the component cmp of node N.*

### **3.4 Operands**

#### ***AVEC\_CMP/SANS\_CMP***

*/AVEC\_CMP = a\_cmp*

*a\_cmp list of the names of the components used for standardization.*

*The modes are normalized to 1. for largest of the components of the list a\_cmp some is the node.*

*/SANS\_CMP = s\_cmp*

*s\_cmp list of the names of the components which are not used for standardization.*

*The modes are normalized to 1. for largest of the components which is not in the list s\_cmp.*

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### **3.5 Key word**

***factor***

***MODE\_SIGNE***

*This key word factor makes it possible to impose for all the modes the sign of a component of a node*

*stipulated by the user. This key word factor can be used only for the real modes (problem generalized).*

*NODE = Nd*

*Name of the node where the sign of a component is imposed.*

*NOM\_CMP = cmp*

*Name of the component of node N where the sign is imposed.*

*SIGN =  
/“POSITIVE”  
/  
“NEGATIVE”*

*Sign imposed component: “POSITIVE” or “NEGATIVE”.*

### **3.6 Operand MASS\_INER**

*MASS\_INER = masstru*

*Key word allowing the calculation of modal parameters MASS\_EFFE\_UN\_DX, MASS\_EFFE\_UN\_DY and MASS\_EFFE\_UN\_DZ (unit effective masses in the three directions).*

*The mass of the structure must be calculated as a preliminary by operator POST\_ELEM and the key word factor MASS\_INER [U4.81.22] which produces a structure of data which is indicated under key word MASS\_INER of the type counts.*

### **3.7 Operands SENSIBLITE**

*SENSITIVITY =*

*The derivative of the modes normalizes according to the same coefficient of standardization as the*

*modes.*

*The document [U4.50.02] specifies the operation of the key word.*

### **3.8 Operand**

#### **TITRATE**

*TITRATE =*

*T*

*Titrate associated with the concept produced by this operator [U4.03.01].*

### **3.9 Operand**

#### **INFORMATION**

*INFORMATION = 1 or 2*

*For each mode, the name of the old standard and the name of the new standard are indicated in the file MESSAGE.*

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*Titrate:*

*Operator NORM\_MODE*

*Date:*

*21/01/05*

*Author (S):*

*E. BOYERE, O. BOITEAU Key*

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**4**

***Formulation of the rules of standardization***

The various standards used as well as the definition of the various modal parameters are listed in the reference material [R5.01.03].

#### 4.1

##### **Real clean modes**

For the modes of the type *MODE\_MECA\_R* (real clean modes) the problem generalized with the values

$$\mathbf{K} - \mathbf{M} \mathbf{X} = (\mathbf{K} - 2$$

$\mathbf{F}$

$\mathbf{M})$

clean associated is: (

)

(

)

$$\mathbf{X} = 0$$

where  $\mathbf{K}$ ,  $\mathbf{M}$  are respectively the matrix of mass and the matrix of rigidity of the mechanical system.

For modelings "MECHANICS", one defines the components of the clean vector:

.

components of translation  $\mathbf{C}$

.

components of rotation  $\mathbf{uR}$

.

components of the multipliers of LAGRANGE

.

other components (pressure and fluid potential)  $p$

$\mathbf{F}$

One calls:

.

$\mathbf{uTR}$  component of translation and rotation,

.

$\mathbf{U}$  components other than multiplying of LAGRANGE.

what leads to

$\mathbf{C}$



***U***  
***U***  
***uR***  
***\* =***

***=***

***p F***

*For the models with components of translation and rotation, the clean mode I provided by algorithms of modal analysis is by defect:*

***\****  
***\****  
***U***  
***U***  
***=***  
***TR***

***=***  
***=***

***I***  
***I***  
***max U***  
***max uTR***

*what is equivalent to the standardization obtained by key word "TRAN\_ROTA".*

*With key word "TRAN" the mode obtained is defined by:*

***u\****  
***=***  
***= T***  
***I***  
***I***  
***max C***

*For the models with components of translation only, standardization is by defect:*

$u^*$

$u^*$

$T =$

$=$

$I$

$\max U$

$\max T$

$U$

what is equivalent to the standardization obtained by key word "TRAN".

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Version

7.4

Titrate:

Operator NORM\_MODE

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Author (S):

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Standardization by defect led to the following generalized parameters:

.  
generalized rigidity  $T I K I = I$

.  
mass generalized  $T I M I = I$

$\mu$

.  
from where the own pulsation 2

$I$

$=$

*I*  
*μi*

*Standardization with the unit generalized mass is obtained by key word "MASS\_GENE":*

*M*  
*I*  
*M*  
*M*  
*M*  
*M*  
*I*  
*=*  
***M** I = 1. and **T I K** I = I*  
*2*  
*I*  
*μ from where T I*

*That with unit generalized rigidity is obtained by key word "RIGI\_GENE":*

*1.*  
*K*  
*I*  
*K*  
*K*  
*K*  
*K*  
*K*  
*I =*  
***M** =*  
***K** = 1.*  
*from where T I*  
*I*  
*2 and T*  
*I*  
*I*  
  
*I*  
*I*

*The standardization of the mode suitable for euclidian norm "EUCL" is obtained naturally by:*

\*

\*

 $U$  $U$  $U =$  $=$  $I$  $U$  $2$  $(U J)$  $J$ 

The standardization of the mode suitable for euclidian norm "EUCL\_TRAN" is:

\*

\*

 $T$  $U$  $U$  $U$  $I$  $=$  $=$  $T$  $U$  $2$  $(T$  $U J)$  $J$ 

## 4.2

### *Complex clean modes*

For the modes of the type *MODE\_MECA\_C* (complex clean modes) resulting from a resolution of one quadratic problem with the eigenvalues  $2 \mathbf{M} + \mathbf{C} + \mathbf{K} = \mathbf{0}$  where  $\mathbf{C}$  is the matrix of damping of the mechanical system, one normalizes the modes compared to the linearized problem associated:

$$\mathbf{0 M} - \mathbf{M 0}$$

+

= 0

**MR. C**

**0**

**K**

*The clean mode is normalized with the unit generalized mass ("MASS\_GENE"), if I satisfied:*

(

**0 M**

*T*

*T*

*I*

*I*

*I*)

= 1.

**MR. C**

*I*

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Operator *NORM\_MODE*

Date:

21/01/05

Author (S):

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with unit generalized rigidity ("*RIGI\_GENE*"), if *I* satisfied:

$$\begin{aligned}
 & ( \\
 & - \mathbf{M} \mathbf{0} \\
 & T \\
 & T \\
 & I \\
 & I \\
 & I) \\
 & = I. \\
 & \mathbf{0} \\
 & \mathbf{K}
 \end{aligned}$$

*I*

For the other standards, the definitions are equivalent to those defined for the real modes, it is enough to replace the scalar product by the square product.

5

**Real modes examples**

For the modes of the type *mode\_meca* (real clean modes) resulting from a resolution of a problem generalized with the eigenvalues (**K - M**)

**X = 0:**

to normalize a clean vector  $X$  with unit generalized rigidity is equivalent so that  $X$  satisfies

$$\begin{aligned} \mathbf{x}^T \mathbf{K} \\ \mathbf{X} = \mathbf{1} \end{aligned}$$

Standardization with duplication of the concept *mode\_meca*:

$$\begin{aligned} mo\_2 \\ = \\ NORM\_MODE \\ (MODE \\ = \\ mo\_1, \\ NORME= \\ "RIGI\_GENE" \end{aligned}$$

);

to normalize a clean vector  $X$  with the unit generalized mass is equivalent so that  $X$  satisfies

$$\begin{aligned} \mathbf{x}^T \mathbf{M} \\ \mathbf{X} = \mathbf{1} \end{aligned}$$

Standardization "places from there" at the unit generalized mass:

$$\begin{aligned} Mo \\ = \\ NORM\_MODE \end{aligned}$$

(reuse = Mo,  
MODE

=

Mo,  
NORMALIZES

=

“MASS\_GENE”

);

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*Organization (S): EDF-R & D /AMA, SINETICS*

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***Operator EXTR\_MODE***

***1 Goal***

***To extract selectively from the modes of the structures of data modal. The modes are selected according to a criterion of value of modal parameter higher than a certain threshold, then are concaténés in only one final structure of data.***

***One can also print in the file RESULT a summary table on the office pluralities of unit effective modal masses or of the generalized masses of the modes selected.***

***Product a structure of data of the mode\_meca type or mode\_gene according to the type of the modes in entry.***

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## **2 Syntax**

**resu\_mod [\*]**

**= EXTR\_MODE**

**(**

**FILTRE\_MODE=\_F (MODE =**

**MOD**

**/**

**[mode\_gene]**

**/**

**[mode\_meca]**

**/**

**[mode\_meca\_C]**

*/NUME\_MODE = l\_mode*

*[l\_I]*

*/*

*NUME\_MODE\_EXCLU*

*=*

*l\_mod\_ex*

*[l\_I]*

*/*

*NUME\_ORDRE*

*=*

*l\_ordre*

*[l\_I]*

*/TOUT\_ORDRE = "YES" or "NOT"*

*/*

*FREQ\_MIN*

*=*

*f\_min*

*[R]*

***FREQ\_MAX***

=

***f\_max***

**[R]**

***PRECISION***

=

/

***prec***

**[R]**

/

***0.001***

**[DEFECT]**

/

***CRIT\_EXTR =/"MASS\_GENE"***

***/"MASS\_EFFE\_UN" [DEFECT]***

***/ THRESHOLD***  
***= rseuil***

***[R]***

***/ SEUIL\_X = rseuil***

***[R]***

***/ SEUIL\_Y = rseuil***

***[R]***

***/ SEUIL\_Z = rseuil***

***[R]***

***)***

***IMPRESSION=\_F (***

***OFFICE PLURALITY = “YES”***

***“NOT”***

***[DEFECT]***

***CRIT\_EXTR***

=  
/  
"MASS\_EFFE\_UN"  
[DEFECT]  
/  
"MASS\_GENE"

)

***TITRATE***

=  
*titrate*  
[l\_Kn]

);

*If MOD is of type [mode\_gene] then resu\_mod is of type [mode\_gene].  
If MOD is of type [mode\_meca] then resu\_mod is of type [mode\_meca].  
If MOD is of type [mode\_meca\_c] then resu\_mod is of type [mode\_meca\_c].*

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### **3 Operands**

#### **3.1 Word**

**key**

**FILTRE\_MODE**

*One repeats this key word as many once as there are structures of data of the mode\_meca\_\* type or mode\_gene to be filtered and with concaténer.*

#### **3.2 Operand**

**MODE**

*Name of the structure of data mode\_meca\_\* or mode\_gene with sorting and concaténer with the others.*

#### **3.3**

**Filtering of the modes**

*To filter the modes, three possibilities are offered to the user.*

##### **3.3.1 Operands**

**NUME\_MODE/NUME\_ORDRE/TOUT\_ORDRE**

*List sequence numbers or modal positions of the modes which one wishes to preserve.*

##### **3.3.2 Operands**

**NUME\_MODE\_EXCLU**

*List modal positions of the modes which one wishes to remove.*

##### **3.3.3 Operands**

**FREQ\_MIN/FREQ\_MAX/PRECISION**

*One keeps all the modes which correspond to frequencies ranging between f\_min and f\_max to relative precision prec. One must have f\_min lower than f\_max.*

##### **3.3.4 Operand**

**CRIT\_EXTR**



***Choice of the parameter which is used as criterion for the filtering of the modes. If the criterion is “MASS\_EFFE\_UN” a mode will be retained as soon as one of its directional unit effective masses modal is higher than a threshold fixed by the user.***

***If the criterion is “MASS\_GENE” a mode will be retained as soon as the report/ratio of the mass generalized on summon generalized masses of the modes of the filtered structure is higher than a threshold fixed by the user.***

***Criterion “MASSE\_EFFE\_UN” has direction only for the structures of data of the type mode\_meca\_\****.

### ***3.3.5 Operands***

***THRESHOLD, SEUIL\_X, SEUIL\_Y, SEUIL\_Z***

***Limiting value of the criterion in lower part of which it is considered that one can filter the mode.***

***This value, in the case of the parameters currently taken into account, is a relative value adimensional.***

***One can apply the same threshold in all the directions (keyword THRESHOLD) or only differentiate according to directions X, Y or Z (SEUIL\_X, SEUIL\_Y, SEUIL\_Z)***

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***3.4 Word***

*key*

## **IMPRESSION**

*This key word makes it possible to print a table of office plurality of certain parameters. These parameters can to be different from those selected in key words **FILTRE\_MODE**.*

### **3.4.1 Operand**

#### **OFFICE PLURALITY**

*Impression or not impression of the office pluralities of the modal parameter retained by **CRIT\_EXTR** for structure of data **resu\_mod** result.*

### **3.4.2 Operand**

#### **CRIT\_EXTR**

*Choice of the parameter of impression for which one carries out the operation of office plurality. If the criterion is*

*“**MASS\_EFFE\_UN**”, one cumulates separately the values of parameters '**MASS\_EFFE\_DX**, **MASS\_EFFE\_DY**, **MASSE\_EFFE\_DZ** of the extracted modes.*

*If the criterion is “**MASS\_GENE**” one cumulates the values of parameter **MASS\_GENE** of the extracted modes.*

### **3.5 Word**

*key*

#### **TITRATE**

*Titrate attached to the concept produced by this operator [U4.03.01].*

## **4 Execution**

*It is checked that the parameter for which one carries out filtering exists well in the structure of data **MOD** (parameters **MASS\_EFFE\_UN\_\*** are only indicated in the structure of data **MOD** if one used key word **MASS\_INER** of order **NORM\_MODE** when one renorme the modes). If this parameter is not indicated, one leaves in fatal error. On the other hand, for the key word **IMPRESSION**, if parameters **MASS\_EFFE\_UN\_\*** are not indicated, one emits only one alarm.*

*At exit, the concept produced **resu\_mod** should not be empty, if not one leaves in fatal error.*

*It is also checked that all the concepts **mode\_meca\_\*** or **mode\_gene** are in the same way standard and*

*that they come from the same initial problem (same matrices).*

*After having filtered the interesting modes, one checks that they have a whole a different modal position. In*

*the contrary case, one transmits a message of alarm. To remove these duplicated modes, it is necessary to re-use*

*order EXTR\_MODE and to activate operand NUME\_MODE\_EXCLU.*

*To date, it is not checked that the structures of data of the mode\_meca\_\* type correspond to one even standard.*

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## *5 Example*

*Here an example presenting the various possibilities of order EXTR\_MODE for one analyze modal realized by 5 research of successive modes:*

*massestr = POST\_ELEM (... MASS\_INER = (...));*

*% Calculation of the first 17 frequencies (NUME\_ORDRE from 1 to 17; NUME\_MODE from 1 to 17)*

*mode1 = MODE\_ITER\_SIMULT*

*(MATR\_A = rigidity, MATR\_B = mass,*

*CALC\_FREQ*

```
=  
_F  
(  
OPTION  
=  
"PLUS_PETITE",  
NMAX_FREQ  
=  
17  
));
```

```
mode1  
=  
NORM_MODE  
(  
MODE  
=  
mode1,  
reuse = mode1,  
MASS_INER  
=  
massestr,  
NORMALIZES  
=  
"TRAN_ROTA"
```

```
);
```

*% Calculation of other frequencies (NUME\_ORDRE from 1 to 5; NUME\_MODE from 18 to 22)*

```
mode2 = MODE_ITER_SIMULT
```

```
(MATR_A = rigidity, MATR_B = mass,  
CALC_FREQ
```

```
=  
_F  
(  
OPTION
```

```
=  
"BAND",  
FREQ  
=  
(20.  
,  
25.)  
)
```

```
);
```

```
mode2  
= NORM_MODE  
(MODE = mode2, reuse = mode2,  
MASS_INER  
=  
massestr,  
NORMALIZES  
=  
"TRAN_ROTA"
```

```
);
```

*% Calculation of other frequencies (NUME\_ORDRE from 1 to 6; NUME\_MODE from 23 to 28)*

```
mode3 = MODE_ITER_SIMULT  
(MATR_A = rigidity, MATR_B = mass,  
CALC_FREQ  
=  
_F  
(
```

**OPTION**

=

**“BAND”,**

**FREQ**

=

**(25.**

**30.)**

**)**

**);**

**mode3**

= **NORM\_MODE**

**(MODE = mode3, reuse = mode3,**

**MASS\_INER**

=

**massestr,**

**NORMALIZES**

= **' TRAN\_ROTA',**

**);**

**% Calculation of other frequencies (NUME\_ORDRE from 1 to 3; NUME\_MODE from 28 to 30)**

**mode4 = MODE\_ITER\_SIMULT**

**(MATR\_A = rigidity, MATR\_B = mass,**

**CALC\_FREQ**

=

**\_F**

**(**

**OPTION**

```
=  
"BAND",  
FREQ  
=  
(29.  
,  
32.)  
)
```

```
);  
  
mode4  
= NORM_MODE  
(MODE = mode4, reuse = mode4,  
MASS_INER  
=  
massestr,  
NORMALIZES  
= 'TRAN_ROTA',
```

```
);  
  
% Calculation of other frequencies (NUME_ORDRE from 1 to 6; NUME_MODE from 31 to 34)
```

```
mode5 = MODE_ITER_SIMULT  
  
(MATR_A = rigidity, MATR_B = mass,  
CALC_FREQ  
=  
_F  
(  
OPTION
```

=  
"BAND",  
FREQ  
=  
(32.  
,  
35.)  
)

);  
  
*mode5*  
= *NORM\_MODE*  
(*MODE = mode5, reuse = mode5,*  
*MASS\_INER*  
=  
*massestr,*  
*NORMALIZES*  
=  
"TRAN\_ROTA"

);  
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*Titrate:*



## ***Operator EXTR\_MODE***

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***% Extraction of the modes***

***mode = EXTR\_MODE***

***(FILTRE\_MODE***

***=***

***\_F***

***(MODE = mode1,***

***TOUT\_ORDRE =***

***“YES”***

***),***

***(***

***MODE***

***=***

***mode2,***

***NUME\_MODE***

***=***

***(18,19,20,21,22))***

***(***

***MODE***

***=***

***mode3,***

***FREQ\_MIN***

***=***

***25.,***

***FREQ\_MAX***

***=***

***30.***

***),***

***(***

***MODE***

***=***

***mode4,***

**NUME\_MODE\_EXCLU**

=

**28**

),

(

**MODE**

=

**mode5,**

**CRITERION =**

**“MASS\_EFFE\_UN”,**

**THRESHOLD**

=

**0.005**

),

**=\_F IMPRESSION**

**(OFFICE PLURALITY**

**= “YES”**

)

);

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**Titrate:**

**Operator CALC\_AMOR\_MODAL**

**Date:**

**08/02/05**

**Author (S):**

**G. DEVESA, Y. PONS Key**

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**Organization (S): EDF-R & D /AMA**

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**Document: U4.52.13**

**Operator CALC\_AMOR\_MODAL**

**1 Goal**

**To create a list of modal depreciation calculated according to the rule of the RCC-G. Calculation is carried out in postprocessing of the modal calculation of a structure of the building type whose foundation raft rests on a ground modelled by springs.**

**The principle of calculation is based on weighting by the rates of potential energy (compared to the total energy) of the reduced depreciation affected by groups of meshes constitutive of the structure (in fact of the parameters of entry of the table of potential energy created by POST\_ELEM) and of depreciation radiated in the ground, by degree of freedom, functions of the frequency [bib1] [bib2].**

**The list created is usable thereafter in order DYNA\_TRAN\_MODAL [U4.53.21] behind key word LIST\_AMOR.**

***Product a concept of the listr8 type.  
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***2 Syntax***

***listr8 [listr8] = CALC\_AMOR\_MODAL (***

***ENER\_SOL =\_F (MODE\_MECA***

***=***

***MOD,***

***[mode\_meca]***

***METHOD =/"DEPL", [DEFECT]***

***/***

***"RIGI\_PARASOL",***

$$\mathbf{KX} = \mathbf{kx},$$

**[R]**

$$\mathbf{KY} = \mathbf{ky},$$

**[R]**

$$\mathbf{KZ} = \mathbf{kz},$$

**[R]**

$$\mathbf{KRX} = \mathbf{krx}$$

,

**[R]**

***KRY = kry***

,

**[R]**

***KRZ = krz***

,

**[R]**

***/GROUP\_NO\_RADIER***

=

***l\_grno,***

***[l\_group\_no]***

/

***GROUP\_MA\_RADIER***

=

***l\_grma,***

**[l\_group\_ma]**

**/FONC\_GROUP =**  
**l\_fonc,**  
**[l\_fonction]**

**/**  
**COEF\_GROUP =**  
**l\_coef,**  
**[l\_R]**

**/GROUP\_NO\_CENTRE**  
**=**  
**grno, [group\_noeud]**

**/**  
**NOEUD\_CENTRE**  
**=**  
**node,**  
**[node]**

/  
**COOR\_CENTRE**  
= (X, y, Z),  
[l\_R]

)  
**AMOR\_INTERNE**  
= \_F  
(

**ENER\_POT**  
=  
*epot, [tabl\_ener\_pot]*

**GROUP\_MA**  
=  
*l\_grma,*  
*[l\_group\_ma]*

**AMOR\_REDUIT**  
=  
*l\_amor,*  
*[l\_R]*



)  
*AMOR\_SOL = \_F*  
(

*AMOR\_REDUIT =*  
*/*  
*0.,*  
*[DEFECT]*  
*/*  
*amor, [R]*

*FONC\_AMOR\_GEO*  
*=*  
*l\_f\_amor,*  
*[l\_fonction]*

*HOMOGENEOUS =*  
*/*  
*“YES”,*  
*[DEFECT]*  
*/*  
*“NOT”,*

***THRESHOLD =***

***/***

***0.3,***

***[DEFECT]***

***/***

***threshold,***

***[R]***

***)***

***)***

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### **3 Operands**

#### **3.1 Word**

**key**

**ENER\_SOL**

*This key word factor used only once is used to introduce the data necessary to calculation of potential energy in the ground per degree of freedom for all the frequencies of a concept of the type mode\_meca.*

#### **3.1.1 Operand**

**METHOD**

*This operand makes it possible to define the method of calculation of energy in the ground by frequency.*

*With value "DEPL", one calculates energy starting from the displacements realised on the nodes of*

*to erase for each mode:  $E =$*

*$K U^2 (Fr$*

*$I$*

*$I$*

*), where  $K$  represent 6 components  $KX, KY,$*

*$I$*

*$2$*

*$I$*

*$i=1,6$*

*$KZ, KRX, KRY$  and  $KRZ$  of the total rigidity within the competences of ground (cf [§3.1.3]).*

*With value “RIGI\_PARASOL”, one calculates energy starting from the efforts realised on the nodes of*  
*I*  
*F 2*  
*to erase for each mode: E*  
*I*  
*=*

*(Fr).*

*2*

*K*

*I*

*i=1,6*

*I*

*The efforts with the nodes with this method are given starting from the values of rigidity distributed with the nodes under the foundation raft as by option RIGI\_PARASOL of AFFE\_CARA\_ELEM [U4.42.01].*

### **3.1.2 Operand**

**MODE\_MECA**

*Allows to introduce the concept of the mode\_meca type containing the frequencies of calculation of energy potential.*

### **3.1.3 Operands**

**KX/KY/KZ/KRX/KRY/KRZ**

*The values of the components of the total rigidity within the competences of ground represent.*

*Intervene in the calculation of the terms K. U2, I*

*I*

*I*

*= 1, NCmp.*

*NCmp is the component count (3 or 6) determined by the presence or the absence of the operands KRX, KRY, KRZ used (if they are it) obligatorily together. NCmp and the number of ddls increased by the nodes of the foundation raft can be different.*

### **3.1.4 Operand**

**GROUP\_NO\_RADIER**

*This operand is related to value “DEPL” of the operand METHOD.*

*List groups of nodes constituting the foundation raft of the structure posed on the ground. One calculates thereafter the displacement realised in these nodes  $U$  of  $U_i$  components for each mode calculated of frequency  $Fr$  in order to be able to determine energy in the ground by ddl and frequency:*

*1  
2  
K. U (Fr  
1  
1  
)  
2*

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Version  
7.4*

*Titrate:  
Operator CALC\_AMOR\_MODAL*

*Date:  
08/02/05  
Author (S):  
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*3.1.5 Operand  
GROUP\_MA\_RADIER*

*This operand is related to value “RIGI\_PARASOL” of the operand METHOD.*

*List groups of meshes constituting the foundation raft of the structure posed on the ground. Allows to calculate effort realised with the nodes of these meshes  $F$  of  $F_i$  components for each mode calculated of  
1  
2  
 $F$   
frequency  $Fr$  in order to determine energy in the ground by ddl and frequency:*

*I (Fr).*

*2 ki*

### **3.1.6 Operand**

**FONC\_GROUP/COEF\_GROUP/GROUP\_NO\_CENTRE/NOEUD\_CENTRE/  
COOR\_CENTRE**

*These operands are also related to value “RIGI\_PARASOL” of the operand METHOD.*

*These are the same ones as in option RIGI\_PARASOL of AFFE\_CARA\_ELEM [U4.42.01]. They allow*

*also to obtain the values of rigidity distributed with the nodes under the foundation raft being used to determine them*

*nodal efforts by mode then their average  $F$  of  $F_i$  component.*

*An operand chosen among FONC\_GROUP/COEF\_GROUP makes it possible to determine weightings,*

*real functions of the X-coordinate or, each group of meshes constitutive of the foundation raft.*

*formulas remain with the choice of the user. By defect, one considers that the function of distribution is*

*constant and unit, i.e. that each surface is affected same weight [bib2].*

*One thus needs as many terms in the corresponding list than in the list of the groups of meshes data by operand GROUP\_MA\_RADIER.*

*An operand chosen among GROUP\_NO\_CENTRE/NOEUD\_CENTRE/COOR\_CENTRE makes it possible to provide*

*that is to say the central node of the foundation raft by a group of nodes of only one name or by a single name of node,*

*that is to say directly its co-ordinates.*

### **3.2 Word**

*key*

**AMOR\_INTERNE**

*Used only once.*

*The contribution to the reduced damping of each mode is established starting from the distribution of potential energy in the structure for the mode considered. This distribution is obtained using*

*order POST\_ELEM [U4.81.22] starting from the concept of the mode\_meca type (cf [§3.1.1]) which produces*

*a table.*

*The parameters of entry of this table are names of groups of meshes, defined by the user according to the distributions of material damping in the structure.*

### **3.2.1 Operand**

#### ***ENER\_POT***

*Name of the table of potential energy produced by order POST\_ELEM [U4.81.22].*

### **3.2.2 Operand**

#### ***GROUP\_MA***

*The list of names of groups of meshes from which one will point in the table defined by ENER\_POT (cf [§3.2.1]).*

### **3.2.3 Operand**

#### ***AMOR\_REDUIT***

*The list of the actual values of material damping corresponding, term for term, with the list of names of groups of meshes defined by GROUP\_MA (cf [§3.2.2]).*

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### **3.3 Word**

*key*

***AMOR\_SOL***

*Used only once.*

*It makes it possible to determine the contribution of geometrical damping due to the reflexion of the*

**waves**

**rubber bands. These directional values of damping are obtained while interpolating for each**

(  
 **$Im K ()$**   
**calculated Eigen frequency geometrical functions of damping**  
**(cf § [3.3.1]) where**  
 **$2 Re (K ())$**   
 **$K ()$**   
**is the complex impedance of the ground determined using one of software MISS3D, CLASSI or**  
**PARASOL:**

(  
 **$Im K ()$**   
 **$I$**   
 **$amor () =$**   
 **$I$**   
**,  $I$**

**$2 Re (K ())$**   
 **$I$**

### **3.3.1 Operand** **FONC\_AMOR\_GEO**

**Defines the list of functions of the frequency of geometrical depreciation, one by ddl (3 or 6).**

### **3.3.2 Operand** **AMOR\_REDUIT**

**Correction in the calculation of geometrical damping due to the reduced material damping of the ground.**

**Note:**

**The value of reduced damping is necessary only if the impedance of the ground is produced by PARASOL. If the impedance of the ground is produced by MISS3D, this value is not necessary that if the ground is homogeneous (see HOMOGENEOUS operand [§3.3.3]).**

### **3.3.3 Operand** **HOMOGENEOUS**



*If the ground is homogeneous (“YES”), one balances the calculation of damping in the ground (material more geometrical) by factor 0.5. Then if the impedance of the ground is produced by MISS3D, one must introduce for operand AMOR\_REDUIT (cf [§3.3.2]) the half-value of material damping tiny room of the ground.*

### **3.3.4 Operand THRESHOLD**

*Value defined in the RCC-G [bib1] (0.3 per defect) for the threshold beyond which one truncates possibly modal damping. This threshold operates after the possible preceding corrections.*

## **4 Bibliography**

[1]

*RCC-G: Rules of design and construction of the nuclear small islands REFERENCE MARK. EDF - Direction  
equipment Edition July 1988*

[2]

*Fe. Seismic WAECKEL Response by transitory analysis [R4.05.01]  
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## 5 Example of use

The use of *CALC\_AMOR\_MODAL* requires the calculation of the clean modes of the structure on springs of ground in the form of a concept of the *mode\_meca* type and a concept of the type *tabl\_ener\_pot* of these modes calculated by means of order *POST\_ELEM* [U4.61.04].

The following example is extracted from test *SDLL109B*.

**# CALCULATION OF THE MODAL QUANTITIES -----**

```
MODE0=MODE_ITER_SIMULT (MATR_A=RIGIDITE,
MATR_B=MASSE,
CALC_FREQ=_F (OPTION = "PLUS_PETITE",
DIM_SOUS_ESPACE = 125,
NMAX_FREQ = 33))
```

```
MODE0=NORM_MODE (reuse=MODE0, MODE=MODE0, NORME=' TRAN_ROTA',
MASS_INER=MASSESTR)
```

```
EPOT=POST_ELEM (MODELE=STICKMOD,
RESULTAT=MODE0,
CHAM_MATER=CHAMPMAT, CARA_ELEM=CARA_ELE,
ENER_POT=_F (ALL = "YES",
GROUP_MA = ("POU_D_T", "MASSES", "LIAI_NOE", "LIAI_SOL"),)
)
```

```
#
FT=DEFI_FONCTION (NOM_PARA=' FREQ',
VALE= (0. , 0.0, 10. , 0.3, 30. , 1.5, 100. , 1.5,))
```

```
#
FR=DEFI_FONCTION (NOM_PARA=' FREQ',
VALE= (0. , 0.0, 10. , 0.05, 30. , 0.75, 100. , 0.75,))
```

```
L_AMOR=CALC_AMOR_MODAL (
ENER_SOL=_F (MODE_MECA = MODE0,
GROUP_NO_RADIER = "PI",
KX = 6.295E11, KY = 6.295E11, KZ = 6.864E11,
KRX = 3.188E14, KRY = 3.188E14, KRZ = 3.2E14),
AMOR_INTERNE=_F (
ENER_POT = EPOT,
GROUP_MA = ("POU_D_T", "MASSES", "LIAI_NOE"),)
AMOR_REDUIT = (0.07, 0.07, 0.02,)),
```

**AMOR\_SOL=\_F (**  
**FONC\_AMOR\_GEO = (FT, FT, FT, FR, FR, FR),**  
**HOMOGENEOUS = "NOT")**  
**)**

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***Operator MODE\_STATIQUE***

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***Organization (S): EDF-R & D /AMA***

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## ***Operator MODE\_STATIQUE***

### ***1 Goal***

***To calculate static modes for a displacement, a force or a unit acceleration imposed.***

***A static mode is the static deformation of an isostatic or hyperstatic structure to which one impose:***

***.  
in a ddl blocked (node - component) a unit imposed displacement,***

***.  
in a free ddl (node - component) a unit nodal force,***

***.  
in a ddl (node - component) a unit imposed acceleration,***

***.  
in a direction, a unit imposed acceleration.***

***The operator allows to calculate the whole of the static modes corresponding to several couples node - component. The matrix of rigidity must be assembled by using a whole of conditions with the limits sufficient kinematics so that all the solid modes of body are removed (operators AFFE\_CHAR\_MECA [U4.44.01] or AFFE\_CHAR\_CINE [U4.44.03]). It is possible of to ask that part of the static modes corresponding to these conditions kinematics.***

***The produced concept can be used to supplement a modal base of clean modes of vibration (operator DEFI\_BASE\_MODAL [U4.64.02] or DYNA\_ALEA\_MODAL [U4.53.22]) or to determine loadings necessary to the calculation of the movement of drive under a seismic excitation (operator CALC\_CHAR\_SEISME [U4.63.01]).***

***Product a concept of the mode\_stat\_depl type, mode\_stat\_acce or mode\_stat\_forc according to the selected option of calculation.***

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## *2 Syntax*

*R [mode\_stat\_xxx] = MODE\_STATIQUE*

(  
*MATR\_RIGI*  
=  
*rigi*  
*[matr\_asse\_DEPL\_R]*

*MATR\_MASS*  
=  
*mass*  
*[matr\_asse\_DEPL\_R]*

*/MODE\_STAT*  
=*\_F (*  
*/ALL =*  
*“YES”*  
*/*  
*NODE*  
=  
  
*noeu*  
*[l\_Kn]*

/

**GROUP\_NO**

=

**g\_noeu [l\_Kn]**

**/TOUT\_CMP = "YES"**

/

**AVEC\_CMP**

=

**l\_cmp**

**[l\_Kn]**

/

**SANS\_CMP**

=

**l\_cmp**

**[l\_Kn]**

)

/

**FORCE\_NODALE**

**=\_F (**

**/ALL = "YES"**

/

**NODE**

=

**noeu**

**[l\_noeud]**

/

**GROUP\_NO**

=

**g\_noeu [l\_gr\_noeud]**

**/TOUT\_CMP = "YES"**

/

**AVEC\_CMP**

=

**l\_cmp**

**[l\_Kn]**

/

**SANS\_CMP**

=

**l\_cmp**

**[l\_Kn]**

)

/

**PSEUDO\_MODE**

= **\_F (**

**/AXIS**

**= **I "X"****

***I “Y”***

***I “Z”***

***/DIRECTION***  
***= to l\_dir [l\_R]***

***NOM\_DIR***  
***= to n\_dir***



**[l\_Kn]**

```
//ALL =  
"YES"  
/  
NODE  
=  
noeu  
[l_noeud]  
/  
GROUP_NO  
=  
g_noeu [l_gr_noeud]
```

```
/TOUT_CMP = "YES"
```

```
/  
AVEC_CMP  
=
```

***l\_cmp***  
***[l\_Kn]***  
/  
***SANS\_CMP***  
=  
***l\_cmp***  
***[l\_Kn]***

)

***TITRATE***  
= ***title***  
***[l\_Kn]***

***INFORMATION***  
=  
/  
***1***  
***[DEFECT]***

/ 2

);

*xxx = depl if the option of calculation is MODE\_STAT  
= acce if the option of calculation is PSEUDO\_MODE  
= forc if the option of calculation is FORCE\_NODALE*

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*3 Operands*

*3.1 Operand*

*MATR\_RIGI*

*MATR\_RIGI*

*= rigi*

*Stamp rigidity of the isostatic or hyperstatic structure.*

*3.2 Operand*

*MATR\_MASS*

*MATR\_MASS = mass*

***Stamp of mass of the isostatic or hyperstatic structure.***

### **3.3**

***Nature of the requests applied***

#### **3.3.1 Word**

***key***

***MODE\_STAT***

***/MODE\_STAT***

***Key word factor for the definition of the static modes with imposed displacement.***

#### **3.3.1.1 Operands**

***TOUT/NOEUD/GROUP\_NO***

***/ALL = "YES"***

***Calculation of the modes on all the nodes of the system which have blocked ddl.***

***/  
NODE = noe***

***Calculation of the modes on all the nodes noe (subset of the blocked nodes).***

***/  
GROUP\_NO = g\_noe***

***Calculation of the modes on the groups of nodes g\_noe (subset of the nodes blocked).***

#### **3.3.1.2 Operands**

***TOUT\_CMP/AVEC\_CMP/SANS\_CMP***

***/TOUT\_CMP = "YES"***

***Calculation of the modes on all the components blocked with the definite nodes previously.***

/  
***AVEC\_CMP = l\_cmp***

***Calculation of the modes on the components only quoted.***

/  
***SANS\_CMP = l\_cmp***

***Calculation of the modes by excluding the quoted components.***

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### ***3.3.2 Word***

***key***

***FORCE\_NODALE***

/

***FORCE\_NODALE***

***Key word factor for the definition of the static modes with imposed force.***

#### ***3.3.2.1 Operand***

***TOUT/NOEUD/GROUP\_NO***

*/ALL = "YES"*

*Calculation of the modes on all the nodes of the system which have **free** ddl.*

*/  
NODE = noeu*

*Calculation of the modes on all the nodes noeu.*

*/  
GROUP\_NO = g\_noeu*

*Calculation of the modes on the groups of nodes g\_noeu.*

### **3.3.2.2 Operands**

**TOUT\_CMP/AVEC\_CMP/SANS\_CMP**

*/TOUT\_CMP = "YES"*

*Calculation of the modes on all the **free** components with the nodes defined previously.*

*/  
AVEC\_CMP = l\_cmp*

*Calculation of the modes on the components only quoted.*

*/  
SANS\_CMP = l\_cmp*

*Calculation of the modes by excluding the quoted components.*

### **3.3.3 Word**

**key  
PSEUDO\_MODE**

*/PSEUDO\_MODE*

*Key word factor for the definition of the static modes with imposed acceleration.*

### **3.3.3.1 Operands**

#### ***AXE/DIRECTION/NOM\_DIR***

*/AXIS = l\_axe*

*Calculate modes along the axes of the total reference mark given (l\_axe), these axes being “X”, “Y” and “Z”.*

*/DIRECTION = to l\_dir*

*Calculate the mode according to the direction given (to l\_dir)  
(to l\_dir): directing vector with 3 components.*

*NOM\_DIR = to n\_dir*

*Name user which one wishes to give to the mode calculated in the direction (to n\_dir).  
By defect the name is DIR\_N, NR being the number of the static mode.*

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### **3.3.3.2 Operands**

#### **TOUT/NOEUD/GROUP\_NO**

/  
/ALL = "YES"

*Calculation of the modes on all the nodes of the system.*

/  
NODE  
=  
noeu

*Calculation of the modes on all the nodes noeu.*

/  
GROUP\_NO  
=  
g\_noeu

*Calculation of the modes on the groups of nodes g\_noeud.*

### **3.3.3.3 Operands**

#### **TOUT\_CMP/AVEC\_CMP/SANS\_CMP**

/TOUT\_CMP = "YES"

*Calculation of the modes on all the components with the nodes defined previously.*

/  
AVEC\_CMP  
=  
l\_cmp

*Calculation of the modes on the components only quoted.*

/  
SANS\_CMP  
=  
l\_cmp

*Calculation of the modes by excluding the quoted components.*



### **3.4 Operand TITRATE**

*TITRATE = title*

*Attache with the concept produced by this operator [U4.03.01].*

### **3.5 Operand INFORMATION**

*INFORMATION*

*Indicate the level of impression of information on the file "MESSAGE":*

*1: no impression*

*2: impression of the calculated static modes.*

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**4 Phase  
of execution**

.

for option *MODE\_STAT* or *PSEUDO\_MODE* (on groups of nodes), the operator checks that the couple node - component is well a blocked ddl,

.

for option *FORCE\_NODALE*, the operator checks that the couple node - component is a ddl free,

.

for option *PSEUDO\_MODE* (on a direction), the operator normalizes the directing vector given under the key word *DIRECTION*,

.

the matrix of mass is necessary for the calculation of options *PSEUDO\_MODE*,

.

if a couple node - component appears more once, one makes calculation required only one only time.

## 5 Examples

### 5.1 Calculation of the static modes in unit constant acceleration in 3 directions

*% calculation of the static modes in unit constant acceleration in the 3 directions.*

*1*  
*mode\_ I*  
 =  
 -  
***K*** (*Mr. Ui*) with ***K***: stamp rigidity  
***M m***  
 : atrice of mass

*Ui* unit vector in direction *I*

:

*mstat* = *MODE\_STATIQUE* (*MATR\_RIGI* = rigidity,  
*MATR\_MASS*  
 =  
*mass*,  
*PSEUDO\_MODE*=\_F (*AXE*= ("X", "Y", "Z"),),

);

## 5.2

### *Calculation of the static modes in unit imposed displacement*

*% calculation of the static modes in unit imposed displacement.*

*-1*

*mode = K*

*VI*

*with*

*K: stamp rigidity*

*VI*

*:*

*vector being worth 1. for the components DX and DY*

*group of nodes bases.*

*mstat = MODE\_STATIQUE (*

*MATR\_RIGI = rigidity,*

*MODE\_STAT*

*=\_F (*

*GROUP\_NO*

*=*

*“bases”,*

*(*

*AVEC\_CMP*

*=(*

*“DX”, “DY”),),*

);  
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*Operator DYNA\_NON\_LINE*

*Date:*

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**G. DEVESA** Key

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*Organization (S): EDF-R & D /AMA*

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***Operator DYNA\_NON\_LINE***

## ***1 Goal***

***To calculate the dynamic evolution of a structure whose material or geometry has a behavior nonlinear. They can be for example nonlinearities of material (plasticity or geometry (great displacements)) [R5.05.05]. The syntax of this order is very similar to that of operator STAT\_NON\_LINE [U4.51.03].***

***The dynamic evolution is studied starting from an initial state, configuration of reference, which can be produced by a quasi-static analysis (operator STAT\_NON\_LINE [U4.51.03]) or dynamics former (operator DYNA\_NON\_LINE).***

***The dynamic evolution can be studied in several successive work, by a continuation to be left from one moment already calculated, if a data base were defined in the profile of study of the user.***

***Product a concept of the evol\_noli type.***

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***Operator DYNA\_NON\_LINE***

***Date:***

***22/02/06***

***Author (S):***

***G. DEVESA Key***

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***matters***

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## 2 Syntax

***dynanl [evol\_noli] = DYNA\_NON\_LINE***

(  
***reuse = dynanl,***

***MODEL***  
***= Mo,***  
***[model]***

***CHAM\_MATER***  
***=***  
***chmat,***  
***[cham\_mater]***

***MODE\_STAT***  
***=***  
***modestat,***  
***[mode\_stat\_depl]***

***CARA\_ELEM***  
***=***  
***carac,***  
***[cara\_elem]***

***EXCIT =\_F (TYPE\_CHARGE***  
***=***  
***/"FIXE\_CSTE"***  
***, [DEFECT]***  
***/***  
***"FIXE\_PILO",***  
***/***

**“SUIV”,**  
**/**  
**“DIDI”,**

**CHARGE**  
**=**  
**chi**  
**,**  
**[char\_meca]**

**/FONC\_MULT**  
**= fi**  
**, [function]**  
**/**  
**DEPL**  
**=**  
**depl,**  
**[function]**  
**QUICKLY**  
**=**  
**quickly,**  
**[function]**  
**ACCE**  
**=**  
**acce,**  
**[function]**

**MULT\_APPUI =/“YES”,**

/  
“NOT”,  
[DEFECT]

**DIRECTION**  
= (d1, d2, d3),  
[l\_R]

**NODE**  
=  
lno  
,  
[l\_noeud]

**GROUP\_NO**  
=  
lgrno,  
[l\_gr\_noeud]

),

*SOUS\_STRUC* = *\_F* (

*CAS\_CHARGE*

=

*nocas*,

[*K8*]

*/ALL* = "YES",

/

*NET*

=

*lmail*,

[*l\_maille*]),

*AMOR\_MODAL*

= *\_F* (

*MODE\_MECA* = *mode*,  
[*mode\_meca*]

*AMOR\_REDUIT*  
=  
*l\_amor*, [*l\_R*]

*NB\_MODE* =/*nbmode*, [*I*]  
/  
9999,  
[*DEFECT*]

*REAC\_VITE*  
=/"YES",  
[*DEFECT*]

/“NOT”,

),  
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| *COMP\_INCR =\_F (*

*RELATION =/“VMIS\_ISOT\_TRAC”,*  
*[DEFECT]*

*/other relations [U4.51.11]*

*RELATION\_KIT =/"ELAS",*

*/other relations [U4.51.11]*

*COQUE\_NCOU*

*=  
cncouch,  
[I]*



*TUYAU\_NCOU*

=  
*tncouch,*  
*[I]*

*TUYAU\_NSEC*

=  
*tnsec,*  
*[I]*

*DEFORMATION*

=  
/  
*“SMALL”, [DEFECT]*  
/  
*“PETIT\_REAC”,*  
/  
*“SIMO\_MIEHE”,*

*/ALL =*  
  
*“YES”,*  
*[DEFECT]*  
/  
/

*GROUP\_MA*

=

*lgrma,*

*[l\_gr\_maille]*

/

*NET*

=

*lma*

,

*[l\_maille]*

*ALGO\_C\_PLAN*

=

/

*“DEBORST”,*

*[DEFECT]*

*RESI\_INTE\_RELA =/1.E-6,*

*[DEFECT]*

/

*resint, [R]*

*ITER\_INTE\_MAXI =/10,*

*[DEFECT]*

/

*iteint, [I]*

*ITER\_INTE\_PAS*

=

/

0,

[DEFECT]

/

itepas,

*RESO\_INTE*

=

/

“IMPLICIT”,

[DEFECT]

/

“RUNGE\_KUTTA\_2”,

/

“RUNGE\_KUTTA\_4”,

),

/

*COMP\_ELAS = \_F*

(

*RELATION*

=

/

“ELAS”, [DEFECT]

/other relations [U4.51.11]

COQUE\_NCOU =  
cncouch,  
[I]

TUYAU\_NCOU =  
tncouch,  
[I]

TUYAU\_NSEC =  
tnsec,  
[I]

*DEFORMATION*

=

/

“SMALL”,  
[DEFECT]

/

“GREEN”,

/

“GREEN\_GR”,

/ALL =

“YES”,  
[DEFECT]

/

/  
GROUP\_MA

=

lgrma,  
[l\_gr\_maille]

/

NET

=

lma

,

[l\_maille]

RESI\_INTE\_RELA =/1.E-6,

[DEFECT]

/

resint, [R]

*ITER\_INTE\_MAXI* =/10,  
[DEFECT]  
/  
*iteint*, [I]

*ITER\_INTE\_PAS*  
=  
/  
0,  
[DEFECT]  
/  
*itepas*,

*RESO\_INTE*  
=  
/  
"IMPLICIT",  
[DEFECT]  
/  
"RUNGE\_KUTTA\_2",  
/  
"RUNGE\_KUTTA\_4",

),  
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*ETAT\_INIT = \_F*

(

*/] SIGM = sig, [cham\_elem\_SIEF\_R]*

*[carte\_SIEF\_R]*

/

*VARI*

=

*vain,*

*[cham\_elem\_VARI\_R]*

/

*DEPL*

=

*depl,*

[*cham\_no\_DEPL\_R*]  
/  
*QUICKLY*  
=  
*quickly*,

[*cham\_no\_DEPL\_R*]  
/  
*VARI\_NON\_LOCAL*  
=  
*vanolo*  
, [*cham\_no\_VANL\_R*]

/  
*EVOL\_NOLI*  
=  
*evol*,  
[*evol\_noli*]

/  
*NUME\_ORDRE = nuini*,  
[*I*]  
/  
*INST*  
=  
*instini*,  
[*R*]



*PRECISION*

=/1.0E-3, [DEFECT]

/

*prec,*

[R]

*CRITERION* =/"RELATIVE", [DEFECT]

/

"ABSOLUTE",

*NUME\_DIDI*

= *nudidi,*

[I]

*INST\_ETAT\_INIT*

=

*istetaini, [R]*

),

*INCREMENT*

=\_F

(

*LIST\_INST*

=

*litps,*

*[litr8]*

*EVOLUTION*

=/"*CHRONOLOGICAL*",

*[DEFECT]*

/

"*RETROGRESSES*"

,

/

“WITHOUT”,

/  
*NUME\_INST\_INIT*  
=  
*nuini*,  
[I]  
/  
*INST\_INIT*  
=  
*instini*,  
[R]

*/NUME\_INST\_FIN*  
  
= *nufin*,  
  
[I]  
/  
*INST\_FIN*  
=  
*instfin*,  
[R]

*PRECISION*  
=  
/  
*1.0E-3, [DEFECT]*  
/  
*prec*,  
[R]

*SUBD\_PAS*

=

/

1,

[DEFECT]

/

*subpas*

,

[I]

*SUBD\_PAS\_MINI*

=

*submini,*

[R]

*COEF\_SUBD\_PAS\_1*

= / 1.,

[DEFECT]

/

*coefsub,*

[R]

*OPTI\_LIST\_INST* =/"INCR\_MAXI",

*[DEFECT]*

*NOM\_CHAM*

=

*nomch,*

*[kN]*

*NOM\_CMP =*

*nomcmp, [kN]*

*VALUE*

=

*valley*

,

*[R]*

),

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*NEWTON*

*=\_F (*

*PREDICTION =*

*/*

*“TANGENT”*

*,*

*[DEFECT]*

*/“ELASTIC”,*

*STAMP*

*=/“TANGENT”,*

*[DEFECT]*

*REAC\_INCR =/1*

,  
*[DEFECT]*

/  
*MF,*  
*[I]*

*REAC\_ITER =/0*

,  
*[DEFECT]*

/  
*it,*  
*[I]*

*REAC\_ITER\_ELAS*

=  
/  
*0,*  
*[DEFECT]*

/  
*it,*  
*[I]*

*PAS\_MINI\_ELAS=*

*pasmini,*  
*[I]*

*/“ELASTIC”,*

*),*

*RECH\_LINEAIRE*  
*=\_F (*

*RESI\_LINE\_RELA =/1.E-1,*  
*[DEFECT]*

*/*  
*reslin*  
*,*  
*[R]*

*ITER\_LINE\_MAXI =/3,*  
*[DEFECT]*

*/*  
*itelin, [I]*



*PAS\_MINI\_CRIT*

=

/

0.

[DEFECT]

/

*pmicri*

[R]

*ITER\_LINE\_CRIT*

=

/

20

[DEFECT]

/

*itelic*

[I]

*RHO\_MIN*

=

/

1.E-2

[DEFECT]

/

*rmin*

[R]

*RHO\_MAX*  
=  
/  
*1.E+1*  
*[DEFECT]*  
/  
*rmax*  
*[R]*

*RHO\_EXCL*  
=  
/  
*9.E-3*  
*[DEFECT]*  
/  
*rexc*  
*[R]*

),

*PARM\_THETA =/1. ,*  
*[DEFECT]*  
/  
*theta,*  
*[R]*

*PILOTING =\_F (STANDARD =/"DDL\_IMPO",*

/

“LONG\_ARC”,

/

*NODE*

= *No*,

[*node*]

/

*GROUP\_NO*

=

*grno*,

[*gr\_noeud*]

*NOM\_CMP* = *nomcmp*, [*kN*]

/“DEFORMATION”,

*/“PRED\_ELAS\_INCR”,*

*/“PRED\_ELAS”,*

*/ALL =*

*“YES”,  
[DEFECT]  
/  
GROUP\_MA  
=  
lgrma,  
[l\_gr\_maille]  
/  
NET  
=  
lma,  
[l\_maille]*

*COEF\_MULT*

=  
/  
1.,  
[DEFECT]  
/  
cmult,  
[R]

*ETA\_PILO\_MAX*

= eta  
max  
,  
[R]

*ETA\_PILO\_MIN*

= eta  
min  
,  
[R]

*ETA\_PILO\_R\_MAX*

=  
etarmax,  
[R]

*ETA\_PILO\_R\_MIN*

=

*etarmin,*

*[R]*

*PROJ\_BORNES*

=

/

*“YES” [DEFECT]*

/

*“NOT”*

*SELECTION =*

*/“NORM\_INCR\_DEPL”,*

*[DEFECT]*

/

*“ANGL\_INCR\_DEPL”,*

/

*“RESIDUE”,*

*),*

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*SOLVEUR =\_F (see the document [U4.50.01]),*

*CONVERGENCE =\_F (*

*/RESI\_GLOB\_RELA = 1.E-6, [DEFECT]*

*/|*

*RESI\_GLOB\_MAXI = resmax,*

*[R]*

*/ RESI\_GLOB\_RELA = resrel,*

*[R]*

*SIGM\_REFE*

*=*

*sigref, [R]*

*EPSI\_REFE*

*=*

*sigref, [R]*

*FLUX\_THER\_REFE*

*=*

*sigref, [R]*

*FLUX\_HYD1\_REFE*

*=*

*sigref, [R]*



*FLUX\_HYD2\_REFE*

=

*sigref, [R]*

*ITER\_GLOB\_ELAS =/25,*

*[DEFECT]*

/

*maxelas,*

*[I]*

*ITER\_GLOB\_MAXI =/10,*

*[DEFECT]*

/

*maglob, [I]*

*STOP*

=

/

*“YES”,*

*[DEFECT]*

/

*“NOT”,*

),

*SENSITIVITY* (see the document [U4.50.02]),

*FILING*

=\_F

(

/

*LIST\_INST*

=

*list\_r8,*

[*listr8*]

/

*INST*

=

*l\_r8,*

[*R*]

/

*PAS\_ARCH*

=

*npas,*

[*I*]

*PRECISION*

=

/

*1.E-3,*

[*DEFECT*]

/

*prec*

,

*[R]*

*/ARCH\_ETAT\_INIT = "YES",*

*/*

*NUME\_INIT*

*=*

*nuinit, [I]*

*DETR\_NUME\_SUIV*

*=*

*"YES",*

*CHAM\_EXCLU = /*

*"DEPL",*

*/*

*"QUICKLY",*

*/*

*"ACCE",*

*/*

*"SIEF\_ELGA",*

*/*

*"VARI\_ELGA",*

*/*

*"VARI\_NON\_LOCAL",*

*/*

*"LANL\_ELGA",*

),  
/  
*NEWMARK =\_F (*

*ALPHA*  
=  
/  
*0.25,*  
*[DEFECT]*  
/  
*alph,*  
*[R]*

*DELTA*  
=  
/  
*0.5*  
,  
*[DEFECT]*  
/  
*delt,*  
*[R]*

),  
/  
*HHT =\_F (*

*ALPHA*  
=  
-0.3,  
[DEFECT]  
/  
*alph*,  
[R]  
  
),  
/TETA\_METHODE=\_F (

*TETA*  
=  
/  
*teta*  
[R]

),  
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*OBSERVATION*

=\_F

(

*NOM\_CHAM=*

/

*“DEPL”,*

/

*“QUICKLY”,*

/  
“ACCE”,

/  
“DEPL\_ABSOLU”,

/  
“VITE\_ABSOLU”,

/  
“ACCE\_ABSOLU”,

/  
“SIEF\_ELGA”,

/  
“VARI\_ELGA”,

*NOM\_CMP =  
lnocmp,*

*[l\_Kn]*

*/LIST\_ARCH  
= larch,  
[listis]  
/  
LIST\_INST*



=

*linst*

,

*[listr8]*

/

*INST =*

*linst*

,

*[l\_R]*

/

*PAS\_OBSE*

=

*not*

,

*[I]*

*/| NODE = lno*

,

*[l\_noeud]*

*| GROUP\_NO = lgmo,*

*[l\_gr\_noeud]*

/

*NET*

=

*lma*

,

*[l\_maille]*

*NOT*  
=  
*lpoint*  
,  
*[l\_I]*  
,  
*POSTING*  
=  
*\_F*  
(

*/LIST\_INST*  
=  
*list\_r8, [listr8]*  
/  
*INST*

=  
*l\_r8,*  
*[R]*  
/  
*PAS\_ARCH*

=  
*npas,*  
*[I]*

*UNIT*  
=  
*unit*  
  
*[I]*

*LONG\_R*

= / 12 [DEFECT]

/  
*long\_r*  
[I]

*PREC\_R*

= / 5

[DEFECT]

/  
*prec\_r*  
[I]

*LONG\_I*

= / 6

[DEFECT]

/  
*long\_i*  
[I]

*NOM\_COLONNE*  
= / “*STANDARD*”,  
/  
“*MINIMUM*”,  
/  
“*ITER\_NEWT*”,  
/  
“*INCR\_TPS*”,  
/  
“*RESI\_RELA*”,  
/  
“*RELA\_NOEU*”,  
/  
“*RESI\_MAXI*”,  
/  
“*MAXI\_NOEU*”,  
/  
“*RESI\_REFE*”,  
/  
“*REFE\_NOEU*”,  
/  
“*RELI\_ITER*”,  
/  
“*RELI\_COEF*”,  
/  
“*PILO\_PARA*”,  
/  
“*LAGR\_ECAR*”,  
/  
“*LAGR\_INCR*”,  
/  
“*LAGR\_ITER*”,  
/  
“*MATR\_ASSE*”,  
/  
“*ITER\_DEBO*”,

/  
“CTCD\_ITER”,  
/  
“CTCD\_INFO”,  
/  
“CTCD\_GEOM”,

/  
“CTCD\_NOEU”,  
/  
“CTCC\_CONT”,  
/  
“CTCC\_FROT”,  
/  
“CTCC\_GEOM”,

*INFO\_RESIDU*

=  
“YES”,  
[DEFECT]

“NOT”

),

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*Date:*

22/02/06

*Author (S):*

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*LAGR\_NON\_LOCAL =\_F*

(

*ITER\_PRIM\_MAXI =/10,*

*[DEFECT]*

*/iterprimmax,*

*[I]*

*RESI\_PRIM\_ABSO = resiprimab,*

*[R]*

*ITER\_DUAL\_MAXI =/50,*

*[DEFECT]*

*/*

*iterdmax,*

*[I]*

*RESI\_DUAL\_ABSO*

*=*

*residabso, [R]*

*R*

=  
/  
1000.,  
[DEFECT]

/rho  
,  
[R]  
,

SOLV\_NON\_LOCAL = \_F (  
to see the document [U4.50.01]  
,

INFORMATION =  
/ 1  
,  
[DEFECT]

/ 2  
,

TITRATE  
=  
tx,  
[KN]



)

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Operator *DYNA\_NON\_LINE*

Date:

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Author (S):

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### **3 Operands**

#### **3.1 Operands**

***MODEL/CHAM\_MATER/CARA\_ELEM/MODE\_STAT***

***MODEL = Mo***

*Name of the model whose elements are the subject of mechanical calculation.*

***CHAM\_MATER = chmat***

*Name of the affected material field on the model Mo.*

***CARA\_ELEM = carac***

*Name of the characteristics of the elements of hull, beam, bars, discrete cable, and elements affected on the model Mo, if necessary.*

***MODE\_STAT = modestat***

*Name of the static mode necessary in the case of a seismic calculation with excitations multi-supports [R4.05.01].*

#### **3.2 Word**

***key***

***EXCIT***

***EXCIT = \_F***

*This key word factor makes it possible to describe with each occurrence a load (requests and conditions with the limits), and possibly a multiplying coefficient and/or a type of load.*

### **3.2.1 Operands**

#### **CHARGE/FONC\_MULT**

*CHARGE =  $chi$*

*CH is the mechanical loading (possibly comprising the evolution of a field of temperature) specified with the  $i$ ème occurrence of EXCIT.*

*Only one load can comprise the evolution of a field of temperature, which will have previously be defined thanks to key word TEMP\_CALCULEE of the order AFFE\_CHAR\_MECA.*

*FONC\_MULT =  $f_i$*

*F is the multiplying function of the time of the loading specified with the  $i$ ème occurrence of EXCIT.*

*The loading and boundary conditions for N occurrences of the key word factor EXCIT are:*

$$\begin{aligned}
 &N \\
 &CH = F CH \\
 &I \\
 &I \\
 &I \\
 &= 1
 \end{aligned}$$

*For the conditions of DIRICHLET, of course, only the specified value is multiplied by F.*

*By defect:  $F = 1$ .*

*The field of temperature is not multiplied by F.*

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### 3.2.2 Operand

#### **TYPE\_CHARGE**

 $TYPE\_CHARGE = tchi$ 

By defect, *tchi* is worth “*FIXE\_CSTE*”: that corresponds to a loading applied to initial geometry and not controlled. It can however be a function, and depend in particular time.

If *tchi* is worth “*FIXE\_PILO*”, the loading is always fixed (independent of the geometry) but will be controlled thanks to the key word *PILOTING* [§3.11].

The loads controllable must result from *AFFE\_CHAR\_MECA* or *AFFE\_CHAR\_MECA\_F* and not to be affected key word *FONC\_MULT*. One cannot to control the loadings of gravity, the centrifugal force, the forces of Laplace, them thermal loadings or of initial or anelastic deformations, and conditions of connection.

If *tch* is worth

*I*

“*SUIV*”, the loading is known as “*follower*”, i.e. it depends on the value unknown factors: for example, pressure, being a loading applying in the direction normal with a structure, depends on the geometry brought up to date of this one, and thus of displacements. A following loading is revalued with each iteration of the algorithm of resolution. A fixed loading is revalued only at each new moment, and only if *chi*

*depends on time (defined in AFFE\_CHAR\_MECA\_F and parameterized by the moment).*

*Currently the loadings which can be qualified “SUIV” are the loading of gravity for the element of CABLE\_POULIE, the pressure for modelings 3D, 3D\_SI, D\_PLAN, D\_PLAN\_SI, AXIS, AXIS\_SI, C\_PLAN, C\_PLAN\_SI and for all them modelings THM (3D\_HHM, 3D\_HM, 3D\_JOINT\_CT, 3D\_THH, 3D\_THHM, 3D\_THM, AXIS\_HHM, AXIS\_HM, AXIS\_THH, AXIS\_THHM, AXIS\_THM, D\_PLAN\_HHM, D\_PLAN\_HM, D\_PLAN\_THH, D\_PLAN\_THHM, D\_PLAN\_THM) and the centrifugal force into large displacements (key word ROTATION in AFFE\_CHAR\_MECA).*

*If tchi is worth “DIDI then” the conditions of DIRICHLET (imposed displacements, conditions linear) will apply to the increment of displacement as from the moment given under ETAT\_INIT/NUME\_DIDI (by defect the moment of resumption of calculation) and not on displacement total. For example for an imposed displacement (key word DDL\_IMPO of AFFE\_CHAR\_MECA) the condition will be form:  $U - U = D$*

*0  
where  $u_0$  is the displacement defined by  
NUME\_DIDI and not:  $U = D$ .*

### **3.2.3 Operands**

**MULT\_APPUI /ACCE /VITE /DEPL /DIRECTION /NOEUD /GROUP\_NO**

*In the case of an excitation multi-supports (MULT\_APPUI = “YES”), the other operands have exactly same significance as in the key word factor EXCIT of the operator DYNA\_TRAN\_MODAL [U4.53.21]. In this case, fields “DEPL”, “QUICKLY”, “ACCE” correspond respectively with displacements, speeds and accelerations of the relative movement compared to movement of drive multi-supports. New fields “DEPL\_ABSOLU”, “VITE\_ABSOLU”, “ACCE\_ABSOLU” are then created and respectively correspond at displacements, the speeds and accelerations of the absolute movement, summons movement of drive multi-supports and relative movement compared to this movement of drive multi-supports.*

### **3.3 Word**

**key**

**SOUS\_STRUC**

**SOUS\_STRUC**

*This key word factor makes it possible to specify which are the loadings to be used for static substructures which then form obligatorily part of the model. In its absence, them loadings on under structures are null.*

*These loadings are added to the loadings “finite elements” which can be applied to remain model.*

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### **3.3.1 Operand**

**CAS\_CHARGE**

*CAS\_CHARGE = nocas*

*nocas is the name of the loading case to be used. See operator MACR\_ELEM\_STAT [U4.62.01].*

### **3.3.2 Operands**

**ALL/MESH**

*/ALL = "YES"*

*This key word makes it possible to affect the loading nocas to all under structures of the model.*

*/*

*NET*

*=*

*l\_mail*

*This key word factor makes it possible to assign the loading nocas only to certain substructures.*

## **3.4 Word**

**key****COMP\_INCR**

/ COMP\_INCR =\_F

*This key word factor gathers the relations of behavior connecting of the rates of deformations to rates of constraints (incremental behavior). One can have in same calculation certain parts of the structure obeying with various incrémentaux behaviors (COMP\_INCR) and other parts obeying with various elastic behaviors (COMP\_ELAS). All the incremental relations of behavior supported by STAT\_NON\_LINE are available also in DYNA\_NON\_LINE, provided that the calculation of the matrix of mass elements concerned is envisaged. One will thus refer to the document [U4.51.11] for a description of the relations of behavior available (operand RELATION) thus that other operands of key word COMP\_INCR.*

**3.5 Word****key****COMP\_ELAS**/  
COMP\_ELAS =\_F

*This key word factor gathers the relations of behavior connecting the deformations (taken by report/ratio in an initial state of reference) and the constraints (elastic behavior). All them incremental relations of behavior supported by STAT\_NON\_LINE are available also in DYNA\_NON\_LINE, provided that the calculation of the matrix of mass of the elements concerned either envisaged. One will thus refer to the document [U4.51.11] for a description of relations of behavior available (operand RELATION) as well as other operands of key word COMP\_ELAS.*

**3.6 Word****key****ETAT\_INIT**

ETAT\_INIT =\_F

*Under this key word the initial conditions of the problem are defined. If key words EVOL\_NOLI, DEPL, and QUICKLY miss, one supposes that the initial state is with displacements, speeds and constraints null, and one calculates accelerations corresponding to the loading at the moment instini defined by operand INST. The other operands of key word ETAT\_INIT have the same one significance that in the document [U4.51.03].*

**3.7 Word****key**

## ***INCREMENT***

*INCREMENT =\_F*

*The list of the moments of calculation defines. The operands of the key word INCREMENT have the same one significance that in the document [U4.51.03].*

## ***3.8 Word***

*key*

***NEWTON***

*NEWTON*

*=\_F*

*Specify the characteristics of the method of resolution of the nonlinear incremental problem (method of NEWTON-RAPHSON). The operands of the key word NEWTON have the same significance that in the document [U4.51.03].*

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## ***3.9 Word***

*key*

***RECH\_LINEAIRE***

*RECH\_LINEAIRE =\_F*



*Linear research can make it possible to improve convergence of the method of Newton (Cf [R5.03.01] for more details).*

### **3.9.1 Operand**

#### ***RESI\_LINE\_RELA/ITER\_LINE\_MAXI***

*RESI\_LINE\_RELA =/  
1.E-1 [DEFECT]  
/  
reslin*

*ITER\_LINE\_MAXI  
=  
/  
3  
[DEFECT]  
/  
itelin*

*They are the parameters of linear research. The maximum iteration count is given itelin to be carried out and the precision reslin to reach to carry out the convergence of linear research.*

*It is not necessary to specify a precision nor an iteration count very high, practical showing that 2 or 3 iterations of linear research are sufficient. One can thus to be satisfied to ask 3 iterations with the precision by defect.*

### **3.9.2 Operand**

#### ***PAS\_MINI\_CRIT/ITER\_LINE\_CRIT***

*PAS\_MINI\_CRIT  
=  
/  
0.  
[DEFECT]*

*/*

*pmicri  
[R]*

*ITER\_LINE\_CRIT =/20*  
*[DEFECT]*

/

*itelic*  
*[I]*

*At the time of step of time when convergence is delicate, one can want to increase the number maximum of iterations of required linear. It is what the key words allow PAS\_MINI\_CRIT and ITER\_LINE\_CRIT. When the step of time (directly fixed by the user or consequence of cuttings of step of time) becomes lower than the value pmicri, the iteration count of linear search for research passes from itelin (informed by ITER\_LINE\_MAXI) with itelic (informed by ITER\_LINE\_MAXI).*

### **3.9.3 Operands**

***RHO\_MIN/RHO\_MAX/RHO\_EXCL***

*RHO\_MIN =/1.E-2*  
*[DEFECT]*

/

*rmin*  
*[R]*  
*RHO\_MAX =/1.E+1*  
*[DEFECT]*

/

*rmax*  
*[R]*  
*RHO\_EXCL*

=

/

*9.E-3*

[DEFECT]

/rexc

[R]

*These key words fix interval I of linear research, in the form*

:

$I = [R \text{ min}, R \text{ max}] - [- \text{rexc}, \text{rexc}]$

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### **3.10 Operand**

**PARAM\_THETA**

*PARAM\_THETA*

=

/

1.

[DEFECT]

/

*theta*

*For modelings THM, the argument theta is the parameter of the theta-method used for to solve the evolutionary equations of thermics and hydraulics (cf [R5.03.60] for more details). Its value must lie between 0 (explicit method) and 1 (method completely implicit).*

*For the laws of behaviors ROUSS\_VISC, ASSE\_COMBU, ZIRC\_CYRA2 and ZIRC\_EPRI, the argument theta is used for integration of the law of behavior (for model ASSE\_COMBU, it is used to integrate the law of Lemaitre in 1D). It can take values 0.5 or 1.*

### **3.11 Word**

**key**

#### **PILOTING**

*PILOTING =\_F*

*When the intensity of part of the loading is not known a priori (loading known as of reference defined in AFFE\_CHAR\_MECA or AFFE\_CHAR\_MECA\_F with load of the type FIXE\_PILLO), the key word PILOTING makes it possible to control this loading via one node (or node groups) on which one can impose various modes of piloting (key word TYPE). The operands of the key word PILOTING have the same significance as in the document [U4.51.03]. However, this option also activates with DYNA\_NON\_LINE is to be used there with reserve owing to the fact that time has a physical and nonvirtual significance: it is not useful primarily with indicer increments of load as with STAT\_NON\_LINE.*

#### **Caution:**

*With FIXE\_PILLO, one cannot use for the loading of reference the key word FONCT\_MULT.*

#### **Caution:**

*When the loading of reference is defined by AFFE\_CHAR\_MECA\_F, this loading can be a function of the variables of space but not of time.*

### **3.12 Word**

**key**

#### **SOLVEUR**

*The syntax of this key word common to several orders is described in the document [U4.50.01].*

### **3.13 Word**

**key**

#### **CONVERGENCE**

### **CONVERGENCE =\_F**

*This key word describes the parameters making it possible to appreciate the convergence of the method of NEWTON used to solve the nonlinear mechanical problem. Operands of the key word CONVERGENCE have the same significance as in the document [U4.51.03].*

### **3.14 Word key FILING**

#### **FILING =\_F**

*Allows to file or certain results with all or certain moments of calculation. In the absence of this key word all the steps of time are filed, including the moments of calculations lately created by automatic recutting of the step of time. Operands of the key word FILING have the same significance as in the document [U4.51.03].*

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### **3.15 Word key AMOR\_MODAL**

*This key word makes it possible to take into account a damping equivalent to modal damping broken up on a basis of modes precalculated in the form of concept of the mode\_meca type. This damping is taken overall into account in the dynamic equilibrium equation like one correct force with the second member - CX&.*

### **3.15.1 Operands MODE\_MECA/AMOR\_REDUIT/NB\_MODE**

*MODE\_MECA*

*= mode*

*AMOR\_REDUIT = l\_amor*

*NB\_MODE = nbmode*

*The concept mode of the mode\_meca type (entered by operand MODE\_MECA) represents the base of modes precalculated on which one breaks up modal damping. This base must imperatively to have the same profile of classification as that of the dynamic system defined by parameters of key word SOLVEUR [§3.12]. It be possible to truncate the modal base with one a number of modes defined by NB\_MODE. Failing this, one takes all the modes of the modal base.*

*Modal depreciation in reduced form is given in the form of a list of realities of which the number of terms is lower or equal to the number of modes taken into account. If the number of terms of the list is strictly lower, one extends this list with the value of its last term until its size reaches the number of calculated modes.*

### **3.15.2 Operand REAC\_VITE**

*If its value is “YES”, one modifies the correct force of modal damping to each iteration intern of NEWTON defined in the key word NEWTON [§3.8].*

*If its value is “NOT”, one updates this term only to the beginning of each step of time.*

## **3.16 Word**

**key**

### **OBSERVATION**

*This key word makes it possible post-to treat certain fields with the nodes or the elements on parts of model at moments of a list (known as of observation) generally more refined than the list of moments filed defined in the key word FILING [§3.14] (where one stores all the fields on all it model). It is used primarily for economies of storage.*

*This key word is répétable and allows the creation of a table of of the same observation name than the concept result of DYNA\_NON\_LINE.*

### **3.16.1 Operands LIST\_ARCH/LIST\_INST/INST/PAS\_OBSE**

*These operands make it possible to define in the choices a list of moments of observation. They have the same one significance that of the same operands name being used to define a list of filing. PAS\_OBSE playing the same part as NOT in FILING [§3.14].*

### **3.16.2 Operands NOM\_CHAM/NOM\_CMP**

*These operands make it possible to define the fields post-to be treated like their components given by their name (by NOM\_CMP).*

### **3.16.3 Operands NODE/GROUP\_NO**

*These operands make it possible to define the nodes of postprocessing for fields in the nodes (“DEPL”, “QUICKLY”, “ACCE”, “DEPL\_ABSOLU”, “VITE\_ABSOLU”, “ACCE\_ABSOLU”).*

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### **3.16.4 Operands NETS/NOT**

*These operands which go hand in hand make it possible to define the meshes of postprocessing and their points of extraction for fields with the elements (“SIEF\_ELGA” or “VARI\_ELGA”).*

## **3.17 Description of the diagram of integration in time**

*One can use a method of NEWMARK, HILBER-HUGHES-TAYLOR (HHT) or one TETA\_METHODE.*

### **3.17.1 Key word NEWMARK**

**/NEWMARK=\_F (**

**ALPHA**

**= /**

**0.25**

**[DEFECT]**

**/**

**alph**

**DELTA =**

**/ 0.5**

**/**

**delt**

**[DEFECT]**

**)**

*The method of integration in time is that of NEWMARK, with the values given of parameters alph and delt.*

*When neither alph is specified, nor delt, one with the method known as “regulates trapezoid” (alph = 0.25; delt = 0.5) which, into linear, is unconditionally stable and does not bring any dissipation parasite (i.e numerical damping), but which, into nonlinear, can be unstable [bib1].*

### **3.17.2 Key word HHT**

**/**

**HHT=\_F (**

**ALPHA**

**= /**

**-0.3**

**[DEFECT]**

**/**



**alph****[R]**

)

*The method of integration in time (implicit diagram of integration) is that of HILBER-HUGHES-TAYLOR (HHT) [bib1], with the negative value of alph given. More |alph| is large, more the numerical damping brought by calculation is important. But this dissipation is sometimes necessary, into nonlinear, to ensure stability (less to assign a damping by material to the structure).*

### 3.17.3 Key word TETA\_METHODE

**/TETA\_METHODE =\_F (**

**TETA**

=

/

**teta****[R]**

)

*The diagram of integration in time is an implicit theta-diagram of order 1, of speed. It can be used that with loads of contact. And in this case, it must also call upon CONTINUOUS method (AFFE\_CHAR\_MECA/CONTACT/METHOD = "CONTINUOUS") and formulation of speed (FORMULATION = "QUICKLY").*

*teta must lie between 0,5 and 1: 0,5 corresponds to a minimum of dissipation numerical, 1 orrespond with a maximum of numerical dissipation. tet = 1 allows to find the diagram of Euler.*

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### ***3.18 Word key POSTING***

*This keyword factor makes it possible to personalize the posting of the table of convergence in STAT\_NON\_LINE or DYNA\_NON\_LINE.*

#### ***POSTING:***

*If this keyword is not indicated, the table is posted in “STANDARD” mode and with INFO\_RESIDU='NON'.*

*Each occurrence of POSTING relates to the posting of a column and its format. The order of columns given by the succession of the NOM\_COLONNE is respected.*

#### ***3.18.1 Operand UNIT***

***UNIT =  
links***

*The table of convergence will be duplicated in the file of unit links.*

#### ***Note:***

*The unit can be repeated with each occurrence of the keyword factor but only first is taking into account (with posting of an alarm).*

#### ***3.18.2 Operand NOM\_COLONNE***

***NOM\_COLONNE  
=  
/  
“STANDARD”,  
/  
“MINIMUM”,  
/  
“ITER\_NEWT”,  
/  
“INCR\_TPS”,***

/  
“RESI\_RELA”,  
/  
“RELA\_NOEU”,  
/  
“RESI\_MAXI”,  
/  
“MAXI\_NOEU”,  
/  
“RESI\_REFE”,  
/  
“REFE\_NOEU”,  
/  
“RELI\_ITER”,  
/  
“RELI\_COEF”,  
/  
“PILO\_PARA”,  
/  
“LAGR\_ECAR”,  
/  
“LAGR\_INCR”,  
/  
“LAGR\_ITER”,  
/  
“MATR\_ASSE”,  
/  
“ITER\_DEBO”,  
/  
“CTCD\_ITER”,  
/  
“CTCD\_INFO”,  
/  
“CTCD\_GEOM”,  
  
/  
“CTCD\_NOEU”,  
/  
“CTCC\_CONT”,  
/  
“CTCC\_FROT”,

/ "CTCC\_GEOM",

*Type of the column to be posted (each value corresponds to a posted column):*

*ITER\_NEWT: number of the iteration of Newton in progress. The column is marked by "X" as long as it*

*convergence there on all the criteria did not have.*

*INCR\_TPS: moment of current calculation.*

*RESI\_RELA and RELA\_NOEU: value of RESI\_GLOB\_RELA and posting of the node where it is maximum.*

*The column is marked by X as long as the residue is larger than that specified by the user (operand RESI\_GLOB\_RELA).*

*RESI\_MAXI and MAXI\_NOEU: value of RESI\_GLOB\_MAXI and posting of the node where it is maximum.*

*The column is marked by X as long as the residue is larger than that specified by the user (operand RESI\_GLOB\_MAXI).*

*RESI\_REFE and REFE\_NOEU: value of RESI\_REFE\_RELA and posting of the node where it is maximum.*

*The column is marked by X as long as the residue is larger than that specified by the user (operand RESI\_REFE\_RELA).*

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**RELI\_ITER and RELI\_COEF:** iteration count and linear coefficient of research.

**PILO\_PARA:** value of the parameter of piloting.

**LAGR\_ECAR, LAGR\_INCR and LAGR\_ITER:** parameters of Lagrangian increased (see LAGR\_NON\_LOCAL)

**MATR\_ASSE:** option of assembly for the matrix (elastic, tangent, secant)

**ITER\_DEBO:** indicate an iteration of Borst for the plane constraints or the behaviors unidimensional (see COMP\_INCR)

**CTCD\_ITER:** iteration count intern contact/friction, methods discrete. The column is marked by X as long as the contact did not converge on the geometry.

**CTCD\_INFO:** information on the state of contact for the discrete methods:

.

**ALGO:** resolution of the problem of contact (iterations intern)

.

**ALGO/REAC\_GEOM:** resolution of the problem of contact (internal iterations) and updated of geometry for reactualization

.

**INIT\_GEOM/ALGO:** initialization of the geometry for the contact and resolution of the problem of contact

.

**ATT\_PT\_FIXE:** do not make an attempt fixes for the contact discrete methods

**CTCD\_GEOM:** value of maximum displacement for the geometrical reactualization of the contact, discrete methods.

**CTCD\_NOEU:** node where the value of displacement is maximum during the geometrical reactualization

contact, discrete methods.

**CTCC\_GEOM:** number of the iteration of contact continuous method at the time of the loop on the geometry.

column is marked by X as long as one did not converge.

**CTCC\_FROT:** number of the iteration of contact continuous method at the time of the loop on the threshold of

friction. The column is marked by X as long as one did not converge.

**CTCC\_CONT:** number of the iteration of contact continuous method at the time of the loop on the state of contact

(active constraints). The column is marked by X as long as one did not converge.

**Composite types (posts several columns):**

**STANDARD:** standard posting (by defect) of the table of convergence. Contains:

The number of the iteration of Newton (ITE\_NEWT)

All columns necessary according to functionalities' activated (linear research, contact, piloting,...)

.

The value of residues (RESI\_MAXI and RESI\_RELA)

**MINIMUM: minimum posting of the table of convergence. Contains:**

•  
**The number of the iteration of Newton (ITER\_NEWT)**

•  
**The value of residues (RESI\_MAXI and RESI\_RELA)**

**Note:**

•  
**One cannot ask more than sixteen columns (16 columns of 16 characters, that is to say a width total of 256).**

•  
**The columns are cumulable: one can ask for MINIMUM posting and add one unspecified column.**

•  
**One can have several times the same column.**

•  
**As long as “X” is posted in column ITER\_NEWT, calculation did not converge. This depends of course on the value of the residues but also of the convergence of the contact or on De Borst.**

•  
**For the method of contact continues, the iterations of Newton constitutes an internal loop with three other loops (CTCC\_GEOM, CTCC\_FROT and CTCC\_CONT). ITER\_NEWT is not thus not in first position in “STANDARD” mode and it is the marking of columns CTCC\_\* who exploits the part of final Justice of the Peace convergence.**

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### **3.18.3 Operand *INFO\_RESIDU***

***INFO\_RESIDU***

**=**  
**“NOT”,**  
**[DEFECT]**

**“YES”**

*This operand makes it possible to add a column for each residue evaluated (RESI\_RELA, RESI\_MAXI and RESI\_REFE). This column will indicate the node where the residue is maximum, which can help the user when there are difficulties of convergence. For example, to see whether the material were badly definite with an incorrect value on an element.*

*This option is strictly equivalent to the addition of columns RELA\_NOEU, RELA\_MAXI or RELA\_REFE when one completely describes the posting of the table of convergence but allows to post information on the nodes when one is in STANDARD” or “MINIMUM” mode “, without needing to describe all the other columns.*

### **3.18.4 Operands *LONG\_R*, *PREC\_R* and *LONG\_I***

***LONG\_R* =**

**/ 12**

**[DEFECT]**

**/**

***long\_r***

**[I]**

***PREC\_R* =**

**/ 5**

**[DEFECT]**

/

**prec\_r****[I]****LONG\_I =**

/ 6

**[DEFECT]**

/

**long\_i****[I]**

*These operands make it possible to modify the posting of information in the table of convergence. All the columns have a fixed width of 16 characters. When information is a reality, one can require a personalized posting: the length long\_r of posted reality (maximum 16) and numbers it significant figures.*

*When it is an entirety, one can regulate the length by long\_i. For a it, character string format is always of 16 characters.*

### **3.19 Operand**

**SOLV\_NON\_LOCAL**

*The syntax of this key word is identical to key word SOLVEUR describes in the document [U4.50.01]. To use for a nonlocal model.*

### **3.20 Operand**

**LAGR\_NON\_LOCAL**

*The integration of nonlocal laws of behavior imposes the resolution of a total problem (on all the structure): the minimization of a functional calculus energy (the expression of Lagrangian increased) by*

*report/ratio with a scalar nodal variable.*

*The resolution of this problem is carried out by means of an algorithm primal newton and dual BFGS compound, which consists of two phases:*

.

*Resolution of the primal problem:*

*Minimization compared to the variable interns nonlocal and its gradient (cham\_elem)*

*Minimization compared to the variable interns with the nodes (cham\_no)*



*Primal test of convergence: the largest component of the assembled residue*

.

*Resolution of the dual problem: (Maximization compared to the multipliers of Lagrange)*

*Calculation of a direction of descent BFGS*

*Linear research by method of Wolfe*

*Dual test of convergence: the largest component of the gradient*

*Reactualization of the multipliers of Lagrange*

*ITER\_PRIM\_MAXI = iterprimmax (10 per defect)*

*Iteration count maximum for the resolution of the primal problem.*

*RESI\_PRIM\_ABSO = resiprimab*

*Precision for the test of convergence for the primal problem.*

*ITER\_DUAL\_MAXI = iterdmax (50 per defect)*

*Iteration count maximum for the resolution of the dual problem.*

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*RESI\_DUAL\_ABSO* = *residabso*

*Precision for the test of convergence for the dual problem.*

*R = rho (1000 per defect)*

*Coefficient of penalization of Lagrangian increased.*

**Note:**

*as the precision of the dual problem strongly depends on that of the primal problem, one advise to choose a better precision for the primal problem, for example 100 or 1000 times more than for the dual problem.*

### **3.21 Operands**

#### ***SENSITIVITY***

*SENSITIVITY*

=

*sensitive parameter list*

*[l\_para\_sensi]*

*Activate the calculation of derived from the fields from displacement, speed and acceleration compared to a significant parameter of the problem.*

*The document [U4.50.01] specifies the operation of the key word.*

### **3.22 Operand INFORMATION**

*INFORMATION*

=  
*inf*

*Allows to carry out in the file message various intermediate impressions in the presence of unilateral contact treaty by the method of the active constraints.*

*inf =  
1 impression of the list of the nodes in contact after convergence with each iteration of Newton.*

= 2  
*idem 1 plus impression of associations/dissociations of nodes enters iterations of the method of the active constraints.*

*Other impressions are made systematically during nonlinear calculation, independently value assigned to the key word INFORMATION: they are the impressions of the residues and the increments relative of displacement during iterations of Newton.*

### **3.23 Operand TITRATE**

*TITRATE = tx*

*tx is the title of calculation. It will be printed at the head results. See [U4.03.01].*

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**4**

**Example: movement of a pendulum of great amplitude**

*# TITRATES simple Pendulum in great oscillation*

*#*

*# CLOCK CONSTITUTES Of an ELEMENT OF CABLE (test SDNL100A).*

*#*

*BEGINNING*

*(*

*#*

*my = LIRE\_MAILLAGE ();*

*Mo = AFFE\_MODELE (MAILLAGE= my,*

*AFFE=\_F*

*(*

*GROUP\_MA=*

*“CABLE”,*

*PHENOMENE=*

*“MECHANICAL”,*

*MODELISATION=*

*“CABLE”)*

*);*

*chechmate = DEFI\_MATERIAU*

*(CABLE=\_F (E= 1.E8, EC\_SUR\_E= 1.E0, RHO= 1.) );*

*chmat =AFFE\_MATERIAU*

*(MAILLAGE= my,*

*AFFE=\_F (TOUT=*

*“YES”,*

*MATER=*  
*chechmate)*  
*);*

*cha1 = AFFE\_CHAR\_MECA (MODELE= Mo,*

*DDL\_IMPO= (*  
*\_F (NOEUD=*  
*“N1”, DX=0.,*  
*DY=*  
*0.,*  
*DZ=*  
*0.),*  
*\_F (NOEUD=*  
*“N2”, DY=0.,*  
*)*  
*)*  
*);*

*cha2 = AFFE\_CHAR\_MECA (MODELE= Mo,*  
*PESANTEUR=*  
*(9.81,*  
*0.,*  
*0., -1.) );*

*= AFFE\_CARA\_ELEM (MODELE= Mo will cara,*  
*CABLE=\_F*  
*(TOUT=*  
*“YES”,*  
*SECTION= 1.) );*

*l\_archi = DEFI\_LIST\_REEL (DEBUT= 0. ,*  
*INTERVALLE= (*

*\_F (JUSQU\_A= 0.4186,*  
*=1 NUMBERS),*  
*\_F (JUSQU\_A=*  
*0.8372,*  
*NUMBERS*  
*=2),*

*\_F (JUSQU\_A=  
1.6744,  
NUMBERS  
=5))*

*);*

*l\_inst1 = DEFI\_LIST\_REEL (DEBUT= 0. ,  
INTERVALLE=\_F (JUSQU\_A=  
1.6744, NOMBRE=40)*

*);*

*resu = DYNA\_NON\_LINE  
(MODELE= Mo, CHAM\_MATER= chmat, CARA\_ELEM= will cara,  
EXCIT= (  
\_F (CHARGE=  
cha1),  
\_F (CHARGE=  
cha2)),  
INCREMENT=\_F  
(LIST\_INST=  
l\_inst1),  
ARCHIVAGE=\_F  
(LIST\_INST=  
l\_archi),  
NEWMARK=\_F  
(  
),  
COMP\_ELAS=\_F (RELATION=*

“CABLE”,  
DEFORMATION=  
“GREEN”),  
CONVERGENCE=\_F (RESI\_GLOB\_RELA=  
1.e-  
2, ITER\_GLOB\_MAXI=100)

);

.  
*the load cha1 forces on node 1 to remain fixed and node 2 to move in the plan vertical XZ,*

.  
*the load cha2 is gravity,*

.  
*order DYNA\_NON\_LINE specifies that:*

-  
*the method of integration of time will be that of “NEWMARK”, “rule of the trapezoid”, because there is not no argument under “NEWMARK”,*

-  
*the initial state, at moment 0, is with null displacement, i.e. displacements will be evaluated starting from the initial position, and at null speed,*

-  
*iterative calculation will continue as much as the relative residue will be  $> 10^{-2}$ , but the number of iterations will be limited to 100,*

-  
*finally the tangent matrix of the linear system to solve will be revalued with each iteration (by defect since the key word NEWTON misses).*

## **5 Bibliography**

[1]  
**Mr. AUFAURE: Direct methods of dynamic analysis of the structures into non-linear.**  
**Note HI-70/93/124.**  
**Instruction manual**  
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**Version**

**7.4**

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**Date:**

**08/02/05**

**Author (S):**

**E. BOYERE, D. GIRARDOT Key**

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**Organization (S): EDF-R & D /AMA, SINETICS**

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**Document: U4.53.02**

**Operator DYNA\_LINE\_TRAN**



## ***1 Goal***

***To calculate the transitory dynamic response to an unspecified temporal excitation.***

***The temporal loading must be given in the form of a linear combination of vectors forces assembled constant in time. They can be provided directly in the form of vectors assembled or in the form of loads which will be assembled in the algorithm.***

***Only the coefficients of the linear combination are a function of time.***

***The implicit methods of integration available are Wilson-theta and NEWMARK, and the methods of integration explicit available are the diagram with the differences centered, and a version with step adaptive of this same diagram.***

***Moments of filing can be specified.***

***Product a concept result of the dyna\_trans type.***

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## ***2 Syntax***

***dyn [dyna\_trans] = DYNA\_LINE\_TRAN***

*(reuse*  
*= dyn,*

***MODEL = Mo, [model]***

***CHAM\_MATER***  
***=***  
***chmat,***  
***[cham\_mater]***

***CARA\_ELEM***  
***=***  
***carac,***  
***[cara\_elem]***

***MODE\_STAT***  
***=***  
***modestat,***  
***[mode\_static]***

***MATR\_MASS***  
***=***  
***m,***  
***[matr\_asse\_DEPL\_R]***

***MATR\_RIGI***  
***=***  
***K,***  
***[matr\_asse\_DEPL\_R]***

***MATR\_AMOR***

=  
**C,**  
**[matr\_asse\_DEPL\_R]**

**/NEWMARK**

=  
**\_F (**  
**ALPHA**  
**=/0.25, [DEFECT]**  
**/**  
**Al,**  
**[R]**

**DELTA =**  
**/ 0.5,**  
**[DEFECT]**  
**/**  
**of,**  
**[R]**

**),**

**/WILSON = (THETA**  
**=/1.4, [DEFECT]**  
**/**  
**HT,**  
**[R]**  
**),**  
**/**  
**DIFF\_CENTRE**

=  
*\_F ()*,  
/  
*ADAPT*

=  
*\_F ()*,

*/ETAT\_INIT = \_F (*

*/DYNA\_TRANS = Dy, [dyna\_trans]*

*/NUME\_INIT = nuini,*  
*[I]*

*/INST\_INIT = to,*

**[R]**

**PRECISION =**

**/1.E-03, [DEFECT]**

**/**

**prec**

**,**

**[R]**

**CRITERION =**

**/**

**“RELATIVE”,**

**[DEFECT]**

*/“ABSOLUTE”,*  
*/*

*DEPL\_INIT*  
*=*  
*depl,*

*[cham\_no\_DEPL\_R]*

*VITE\_INIT = quickly, [cham\_no\_DEPL\_R]*

*),*

*EXCIT =\_F*  
*(/LOAD = chi,*

*[char\_meca]*

*FONC\_MULT = fi,*  
*[function]*

*/VECT\_ASSE = goes,*  
*[cham\_no\_DEPL\_R]*

*/COEF\_MULT*  
*=*  
*I, [R]*  
*/*  
*FONC\_MULT*  
*=*  
*fi,*  
*[function]*  
*/*  
*DEPL*  
*=*  
*depl,*  
*[function]*  
*QUICKLY*  
*=*  
*quickly,*  
*[function]*

***ACCE***

=

***acce,***

***[function]***

***MULT\_APPUI =/"YES",***

***/***

***"NOT",***

***[DEFECT]***

***DIRECTION***

***= (d1, d2, d3), [l\_R]***

***NODE***

=

***lno,***

***[l\_noeud]***

***GROUP\_NO***

=



*lgrno,*  
*[l\_gr\_noeud]*

),

*AMOR\_MODAL = \_F (*

*AMOR\_REDUIT= l\_amor, [l\_R]*

*MODE\_MECA = mode, [mode\_meca]*

*NB\_MODE =/*  
*nbmode,*  
*[I]*  
*/*  
*9999, [DEFECT]*

),  
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**SENSITIVITY =**  
**\_F (see [U4.50.02]),**

**SOLVEUR =\_F (see the document [U4.50.01]),**

**INCREMENT =\_F (/LIST\_INST = litps,**  
**[litr8]**  
**/**

***FONC\_INST***

=

***fonc***

***, [function]***

/

***NOT***

=

***dt,***

***[R]***

***INST\_INIT = Ti, [R]***

***/INST\_FIN=***

***tf,***

***[R]***

/

***NUME\_FIN=***

***nufin,***

***[I]***

**PAS\_CALCUL**

=

/

**1,**

**[DEFECT]**

/

**ipas,**

**[I]**

**VITE\_MIN =/"MAXIMUM",**

**/"NORM",**

**[DEFECT]**

**COEF\_MULT\_PAS =/cmp,**

**[R]**

/

**1.1,**

**[DEFECT]**

***COEF\_DIVI\_PAS =/cdp, [R]***

***/***

***1.3334,***

***[DEFECT]***

***PAS\_LIMI\_RELA =/plr,***

***[R]***

***/***

***1.D-06,***

***[DEFECT]***

***NB\_POIN\_PERIODE =/npp, [I]***

***/***

***50,***

***[DEFECT]***

***NMAX\_ITER\_PAS = nip, [I]***

***16,***

***[DEFECT]***

),

***SENSITIVITY = (***

*... to see [U4.50.02],...*

)

***FILING***  
***=\_F (/LIST\_ARCH = list***  
***[listis]***  
***/***  
***PAS\_ARCH***

***=***  
***ipa***  
***[I]***

*CHAM\_EXCLU = (/ “DEPL”,*

*/ “QUICKLY”,*

*/ “ACCE”*

*),*

**TITRATE**

=

*titrate,*  
*[l\_Kn]*

**INFORMATION =/1,**

/ 2,

)

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**3**

***Equations of behaviour under transitory excitation***

***The operator carries out the direct temporal integration of a transitory linear mechanical problem of form:***



$$M\dot{X} + C\dot{X} + KX = (T) F (X)$$

*I*

*I*

*I*

*O matrices M, C*

*, K*

*are the assembled real matrices of the problem finite elements (respectively) of mass, damping and rigidity of the system.*

*I are functions of time (cf DEFI\_FONCTION [U4.31.02]) and Fi are vectors assembled resulting from loadings in imposed force (cf AFFE\_CHAR\_MECA [U4.44.01]); they can to be provided directly in the form of assembled vectors or loads which will be assemblies in the algorithm.*

*The solution (X, X, & X&) is calculated on a temporal discretization Ti of the specified interval of study by the user.*

## **4 Operands**

### **4.1 Operand**

**MODEL**

**MODEL = Mo**

*Name of the model whose elements are the subject of dynamic calculation.*

*This operand is obligatory when one applies an excitation of the type charges with the key word EXCIT (cf [§4.8]).*

### **4.2 Operand**

**CHAM\_MATER**

**CHAM\_MATER = chmat**

*Name of the affected material field on the model Mo, necessary when one is applied excitation of the type charges with key word EXCIT.*

### **4.3 Operand**

**CARA\_ELEM**

*CARA\_ELEM = carac*

*Name of the characteristics of the elements of beam, hull etc, necessary when one applies an excitation of the type charges with key word EXCIT.*

#### **4.4 Operand**

**MODE\_STAT**

*MODE\_STAT = modestat*

*Name of the static mode necessary in the case of a seismic calculation with excitations multi-supports [R4.05.01].*

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#### **4.5**

**Matrices of the problem**

*MATR\_MASS = m*

*Concept stamps assembled of matr\_asse\_DEPL\_R type corresponding to the matrix of mass system.*

*MATR\_RIGI = K*

*Concept stamps assembled of matr\_asse\_DEPL\_R type corresponding to the matrix of rigidity*

*system.*

*MATR\_AMOR = C*

*Concept stamps assembled of matr\_asse\_DEPL\_R type corresponding to the matrix of damping of the system.*

*The three matrices must be based on same classification and be built with the same mode of storage.*

#### ***4.6 Diagrams of integration***

*/"WILSON"*

*Implicit diagram of integration of WILSON type.*

*Key word factor allowing to specify the parameters of integration.*

*THETA = HT*

*Value of the parameter for the method of WILSON.*

*By defect = 1 4*

*, .*

*This diagram should not be used when one imposes nonnull displacements by the intermediary of an assembled vector.*

*See [R5.05.02].*

*/*

*"NEWMARK"*

*Implicit diagram of integration of type NEWMARK.*

*Key word factor allowing to specify the parameters of integration and.*

*ALPHA = Al*

*Value of the parameter for the method of NEWMARK. By defect = 0.25.*

*DELTA = of*

*Value of the parameter for the method of NEWMARK. By defect = 0.5.*

*See [R5.05.02].*

*/“DIFF\_CENTRE”*

*Diagram of integration clarifies by centered differences. The use of this diagram imposes certain enumerated restrictions of use on [§6.3]. The theoretical description of the diagram is made in [bib 2].*

*/“ADAPT”*

*Diagram of integration clarifies with step of adaptive time, alternative of the diagram of the differences centered. The use of this diagram imposes certain restrictions of use enumerated on [§6.3] (see [bib 2]).*

#### **4.7 Key word**

##### **ETAT\_INIT**

*This functionality allows a continuation of a transitory calculation, by taking as initial state one result obtained by a preceding calculation with DYNA\_LINE\_TRAN. It also makes it possible to define initial conditions of fields type to the nodes.*

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#### **4.7.1 Operands**

##### **DYNA\_TRANS**

*/DYNA\_TRANS = Dy*

Concept of the *dyna\_trans* type resulting from a preceding calculation with *DYNA\_LINE\_TRAN*, and defining the initial conditions for new calculation.

#### 4.7.2 Operands

##### **DEPL\_INIT/VITE\_INIT**

*/DEPL\_INIT = C*

Concept of the *cham\_no\_DEPL\_R* type, displacements initial.

*VITE\_INIT = vo*

Concept of the *cham\_no\_DEPL\_R* type, initial speeds.

#### 4.7.3 Operands

##### **NUME\_INIT/INST\_INIT**

*/NUME\_INIT = nuini*

*nuini* indicates the number of filing of preceding calculation to extract and take as state initial in the case of a recovery.

*/INST\_INIT = to*

Moment of preceding calculation to in the case of extract and take as initial state one recovery.

In the absence of *NUME\_INIT* and *INST\_INIT*, the moment of recovery is taken equal to the last moment of filed preceding calculation.

#### 4.7.4 Operand

##### **CRITERION**

*CRITERION =*

Indicate with which precision the research of the moment must be done:

“RELATIVE”: interval of research [(1-prec) .instant, (1+prec) .instant]

“ABSOLUTE”: interval of research [moment-prec, instant+prec]

The default value of the search criterion is “RELATIVE”.

#### 4.7.5 Operand

## **PRECISION**

*PRECISION* =/1.E-03  
[DEFECT]  
/  
*prec* [R]

*Indicate with which precision the research of the moment must be done.*

### **4.8 Key word**

#### **EXCIT**

*EXCIT* =

*Operand allowing to define several space-time excitations. Maybe by indicating one vector assembled correspondent with a loading, is loads which will lead to calculation and to assembly of a second member. The assembled vector can be associated a function of temporal evolution or a constant multiplying coefficient.*

*The total loading is the sum of the loadings defined by all the occurrences of the key word EXCIT (cf [§4.8.2]).*

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### **4.8.1 Operands**

#### **VECT\_ASSE/LOAD**

*/VECT\_ASSE = vecti*

*Vector assembled correspondent with a loading (concept of the cham\_no\_DEPL\_R type).*

*/COEF\_MULT = Ci*

*Multiplicative coefficient of the vector assembled vecti.*

*/*  
*FONC\_MULT*  
*= I*

*See [§4.8.2].*

*/LOAD = chi*

*chi is the loading possibly comprising the evolution of a field of temperature specified by the ième occurrence of EXCIT.*

*See [§4.8.2].*

#### **4.8.2 Operand**

***FONC\_MULT***

*FONC\_MULT = I*

*I is the multiplicative function of the time of the assembled vector or the loading specified with ième occurrence of EXCIT.*

***The CH loading and boundary conditions for N occurrences of the key word factor EXCIT are:***

*N*  
***CH (T) = (T) CH***  
*I*  
*I*  
*I = 1*

*The fields of temperature are not multiplied by I in thermomechanical analysis.*

***Important remark:***

*The boundary conditions of the displacement type imposed not no one can be imposed with an assembled vector or a load; it is then necessary to use it imperatively diagram of Newmark.*

### **4.8.3 Operands *MULTI\_APPUI/ACCE/QUICKLY/DEPL/DIRECTION/NODE/ GROUP\_NO***

*In the case of an excitation multi-supports (*MULT\_APPUI* = "YES"), the other operands have exactly same significance as in the key word factor *EXCIT* of the operator *DYNA\_TRAN\_MODAL* [U4.53.21].*

### **4.9 Key word *AMOR\_MODAL***

*This key word makes it possible to take into account a damping equivalent to modal damping broken up on a basis of modes precalculated in the form of concept of the *mode\_meca* type. This damping is taken overall into account in the dynamic equilibrium equation like one correct force with the second member - *CX&*.*

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### **4.9.1 Operands**

***MODE\_MECA/AMOR\_REDUIT/NB\_MODE***

*MODE\_MECA*

*= mode*

*AMOR\_REDUIT = *l\_amor**



*NB\_MODE = nbmode*

*The concept mode of the mode\_meca type (entered by operand MODE\_MECA) represents the base of modes precalculated on which one breaks up modal damping. This base must imperatively to have the same profile of classification as that of the dynamic system defined by parameters of key word SOLVEUR [§4.10]. It be possible to truncate the modal base with one a number of modes defined by NB\_MODE. Failing this, one takes all the modes of the modal base.*

*Modal depreciation in reduced form is given in the form of a list of realities of which the number of terms is lower or equal to the number of modes taken into account. If the number of terms of the list is strictly lower, one extends this list with the value of its last term until its size reaches the number of calculated modes.*

#### **4.10 Key word SENSITIVITY**

*SENSITIVITY = \_F (...)*

*Activate the calculation of derived from the field from displacement, speed and acceleration compared to one significant parameter of the problem.*

*The document [U4.50.02] specifies the operation of the key word.*

#### **4.11 Key word SOLVEUR**

*The syntax of this key word common to several orders is described in the document [U4.50.01].*

#### **4.12 Key word INCREMENT**

*Key word factor defining the moments of calculation.*

##### **4.12.1 Operands LIST\_INST/FONC\_INST/NOT**

*For the diagrams of Newmark and Wilson:*

*/LIST\_INST = l\_temp*

*Concept lists realities of the listr8 type.*

*List realities defining the moments  $T_i$  of calculation of the solution*

*/FONC\_INST = fonc*

*Concept of function the defining type of an unspecified variable with constant step evolution in time*

.

*For the diagrams of the centered differences and with step in adaptive time:*

*/NOT = dt*

*Indicate the step of time used by the algorithm. This key word is obligatory for diagram of the centered differences and for the diagram adaptive and nonavailable for diagrams of Newmark and Wilson.*

*For the adaptive diagram, it indicates at the same time the step of initial time and the step of time maximum used by the algorithm.*

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7.4

Titrate:

Operator *DYNA\_LINE\_TRAN*

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08/02/05

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*This parameter must be sufficiently weak:*

.

*to allow the calculation of the static phases (which always use the step maximum),*

.

*to start the algorithm correctly.*

*It must however be sufficiently high not to penalize the whole of calculation.*

#### **4.12.2 Operand *PAS\_CALCUL***

*PAS\_CALCUL = ipas*

*Entirety usable for the diagrams Newmark and Wilson, and defining the periodicity of calculation of the solution: one carries out calculation all the urgent ipas of the function of time *fonc* or of the list of moments *l\_temp*.*

#### **4.12.3 Operands *INST\_INIT/INST\_FIN/NUME\_FIN***

*For the diagrams of the centered differences and with step in adaptive time:*

*INST\_INIT =  $T_i$*

*In the event of recovery one uses key word *ETAT\_INIT* [§4.7]: under this key word, the initial moment is recovered*

with operand *INST\_INIT* or taken equal to the last moment of filed preceding calculation.

Operand *INST\_INIT* under *INCREMENT* must thus be used only if it did not begin again there of one preceding calculation.

*/INST\_FIN = tf*

Moment of end of transitory calculation. Obligatory for the diagrams of the differences centered and with step of adaptive time.

*/*  
*NUME\_FIN*  
*=*  
*nufin*

Number of the moment of end of calculation in *LIST\_INST* (only for diagrams of Newmark and Wilson).

#### **4.12.4 Operands *VITE\_MIN/COEF\_MULT\_PAS/COEF\_DIV\_PAS/PAS\_LIMI\_RELA/NB\_POIN\_PERIODE/NMAX\_ITER\_PAS***

These operands relate to only the diagram with step of adaptive time.

*VITE\_MIN*  
*= /*  
*“NORM”*  
*[DEFECT]*  
*/*  
*“MAXIMUM”*

Method of calculation the speed of reference used to evaluate the apparent frequency.

When the denominator of the apparent frequency ( $x_n - x_{n-1}$ ) becomes weak, the frequency connect can become very high, which leads to an unjustified refinement of the step of time. To cure it, the algorithm uses the following criterion for each ddl *I*:

$x_i - x_{i-1}$   
*I*  
*I*  
*N*  
*n-1*  
*I*  
*X*  
& - *X*

&  
VI  
F  
N  
N  
=  
-1  
T  
min  
APn

2

VI  
T

min  
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*imin can be calculated in two ways different according to the value from VITE\_MIN:*

Max (xk  
&  
, xl

$n+ /$   
 $1 2 \&n+ /)$

$1 2$

$I$   
 $-15$   
 $-1$

**“NORM”**:  $v \min (T) = \max$

$, 10$   
 $ms$

$N$   
where  $K$  and  $L$  are the degrees of  
 $100$

freedom of comparable nature that the ddl  $I$  closest to  $I$  in classification ( $DX$  or  $DY$  or  $DZ...$ ).

$VI (T$

$p)$   
 $I$   
 $-15$   
 $-1$

**“MAXIMUM”**:  $v$

$T) = \max$   
 $, 10$   
 $ms$   
 $\min (N$

for the ddl  $I$ .

$<$   
 $0 T < t$   
 $100$

$p$   
 $N$

Can be used if the order of magnitude speed does not vary too much in the course of time.

$COEF\_MULT\_PAS = cmp$

**Coefficient of déraffinement of the step of time ( $>1$ ) when the error is sufficiently weak:**

0.7

.5

$T <$

since more than 5 consecutive steps  $T$

$= \min(cmp \cdot T, T$

$N$

)

$N_f$

$n+1$

$N$

$\max$

$AP_n$

with  $T$

$T$

$\max =$

initial

Its default value ( $cmp = 1.1$ ) guarantees stability and precision, but it can in general be increased (with more up to 1.3) to accelerate integration.

$COEF\_DIVI\_PAS = cdp$

**Coefficient of refinement of the step of time ( $>1$ ) when the error is higher than 1, that it iteration count maximum ( $NMAX\_ITER\_PAS$ ) is reached and only the step of times minimal is not reached:**

1

$T$

$T >$

,  $Niter < Niter$

$T > plr * T$

$T$

$N$

$N$

$=$

$N_f$

$\max$  and

$N$

*initial*

*N*

*APn*

*cdp*

*Its default value is 1.3334, that is to say a reduction of a factor 0,75.*

*PAS\_LIMI\_RELA = plr*

*Coefficient applied to the step of initial time to define the limit of refinement and thus the step of minimal time:*

*T*

*= plr T*

*min*

*\* initial*

*NB\_POIN\_PERIODE = NR*

*A number of points per apparent period. It is this parameter which fixes the precision of calculation. It must*

*to be at least equal to 20; its default value (50) guarantees a satisfactory precision (order of 1à 2%) in the majority of the cases.*

*NMAX\_ITER\_PAS*

*A maximum number of reductions of the step of time per step of calculation:*

*if  $err > 1$  and  $Niter < Niter\ max$ :  $tn = cdp * tn$*

*It is by defect equal to 16, which limits the coefficient of reduction of the step to  $(1/1,33)^{16} = 102$  by iteration. *NMAX\_ITER\_PAS* can be:*

*.*

*increased to allow the step time to fall in a more brutal way,*

*.*

*decreased if the step of time seems excessively refined.*

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#### **4.13 Operands**

##### **SENSIBLITE**

*SENSITIVITY =*

*Activate the calculation of derived from the field from displacement, speed and acceleration compared to*

*a significant parameter of the problem.*

*The document [U4.50.01] specifies the operation of the key word.*

#### **4.14 Key word**

##### **FILING**

*FILING =*

*Key word factor defining filing. In the absence of this key word factor, all steps of time are filed.*

*Whatever the option of filing chosen, one files the last step of time and all the fields associated to allow a possible continuation.*

##### **4.14.1 Operand LIST\_ARCH**

*/LIST\_ARCH = l\_arch*

*List entreties defining the moments of calculation for which the solution must be filed in the concept dyna\_tran result.*

##### **4.14.2 Operand PAS\_ARCH**

*/PAS\_ARCH = ipa*

*Entirety defining the periodicity of filing of the solution of transitory calculation in the concept dyna\_trans result.*

*If ipa = 5 one files all the 5 steps of calculation.*

*This operand is obligatory for the step of adaptive time, if the key word factor FILING is present. This entirety then makes it possible to calculate the interval between two moments of filing in the concept result, equal to PAS\_ARCH\*PAS. With this convention, the step of filing is always higher or equal to the maximum step used by calculation. For one moment of filing given, one seeks the moment of calculation nearest, which will be the actually filed moment.*

#### ***4.14.3 Operand CHAM\_EXCLU***

*CHAM\_EXCLU = (  
I "DEPL",*

*I "QUICKLY",*

*I "ACCE",*

*)*

*Allows to exclude filing from one or more fields among "DEPL", "QUICKLY" and "ACCE".*

*This exclusion is ignored for the last moment of calculation: the three fields are necessary for a CONTINUATION.*

## **4.15 Operand**

### **TITRATE**

*TITRATE = title*

*Titrate structure of data result [U4.03.01].*

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## **5 Concept product**

*dyn is a produced concept of dyna\_trans type which will contain from 1 to 3 fields with the nodes for each filed moment.*

*These cham\_no has as a reference symbol:*

*DEPL: displacement*

*QUICKLY: speed*

*ACCE: acceleration*

## **6 Phase of execution**

### **6.1 Classification**

*The operator checks that the assembled matrices are built on the same classification.*

## **6.2 Continuation**

*In the event of continuation, one checks:*

*the existence in the concept of the dyna\_trans type provided moment (or sequence number) who is used as initial conditions,*

*for this moment of the existence of fields “DEPL”, “QUICKLY” and “ACCE”.*

## **6.3 Production run for the diagrams of the centered differences and adaptive**

*The use of these diagrams imposes certain restrictions of use:*

*these two diagrams require the use of a matrix of diagonal mass. A test checks that the matrix of mass was created with option “MASS\_MECA\_DIAG” of CALC\_MATR\_ELEM. In addition, the matrix of mass must be stored in line of sky,*

*there should not be other boundary conditions only blocked ddls.*

*A test checks that there are no boundary conditions of the connections type between ddls.*

*It is not either possible to impose nonnull displacements via one assembled vector,*

*for the diagram of the centered differences, one makes sure that the step of selected time checks them stability conditions:*

*I*

*K*

*dt < 0 0*

*, 5/F*

*front F*

*II*

*= max*

*EC. and K and m*

*max*

*max*

*II*

*II*

*1 I*

***nddl 2***  
***diagonal terms of***  
***mii***  
***matrices of stiffness and mass.***

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***BATHE K.J. : Finite Element Procedures in Analysis engineering. Prentice-hall, 1982.***
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### ***1 Goal***

***To calculate the dynamic evolution of a structure whose material or geometry has a behavior nonlinear. They can be for example nonlinearities of material (plasticity or geometry (great displacements)) [R5.05.05]. The syntax of this order is very similar to that of operator STAT\_NON\_LINE [U4.51.03] and DYNA\_NON\_LINE [U4.53.01]. The essential difference with DYNA\_NON\_LINE is the resolution which is done by an explicit method on accelerations.***

***The dynamic evolution is studied starting from an initial state, configuration of reference, which can be produced by a quasi-static analysis (operator STAT\_NON\_LINE [U4.51.03]) or dynamics former (operators DYNA\_NON\_LINE and DYNA\_TRAN\_EXPLI).***

***The dynamic evolution can be studied in several successive work, by a continuation to be left from one moment already calculated, if a data base were defined in the profile of study of the user.***

***Product a concept of the evol\_noli type.***

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## 2 Syntax

*will dynatra [evol\_noli] = DYNA\_TRAN\_EXPLI*

(  
*reuse = will dynatra,*

*MODEL*  
*= Mo,*  
*[model]*

*CHAM\_MATER*  
*=*  
*chmat,*  
*[cham\_mater]*

*MODE\_STAT*  
*=*  
*modestat,*  
*[mode\_stat\_depl]*

*CARA\_ELEM*  
*=*  
*carac,*  
*[cara\_elem]*

*EXCIT =\_F (TYPE\_CHARGE*  
*=*  
*/"FIXE\_CSTE"*  
*, [DEFECT]*  
*/*

**“FIXE\_PILO”,**

/

**“SUIV”,**

/

**“DIDI”,**

**CHARGE**

=

**chi**

,

**[char\_meca]**

**/FONC\_MULT**

= **fi**

**, [function]**

/

**DEPL**

=

**depl,**

**[function]**

**QUICKLY**

=

**quickly,**

**[function]**

**ACCE**

=

**acce,**

**[function]**

***MULT\_APPUI =/"YES",***

***/***  
***"NOT",***  
***[DEFECT]***

***DIRECTION***  
***= (d1, d2, d3),***  
***[l\_R]***

***NODE***  
***=***  
***lno***  
***,***  
***[l\_noeud]***

***GROUP\_NO***  
***=***

*lgrno,*  
*[l\_gr\_noeud]*

),

*AMOR\_MODAL*  
*=\_F (*

*MODE\_MECA = mode,*  
*[mode\_meca]*

*AMOR\_REDUIT*  
*=*  
*l\_amor, [l\_R]*

*NB\_MODE =/nbmode, [I]*  
*/*  
*9999,*  
*[DEFECT]*

***REAC\_VITE***  
***=/“YES”,***  
***[DEFECT]***

***/“NOT”,***

***),***

***PROJ\_MODAL***  
***=\_F (***

***MODE\_MECA = mode,***  
***[mode\_meca]***

***NB\_MODE =/nbmode, [I]***

***/***

***9999,***

***[DEFECT]***

***),***

***/ COMP\_INCR =\_F (see [U4.51.11])***

***/***

***COMP\_ELAS =\_F (see (U4.51.11)),***

***ETAT\_INIT***

***=\_F***

***(***

***//***

***SIGM =***

***sig***

***,***

***[cham\_elem\_SIEF\_R]***

***[carte\_SIEF\_R]***

***/***

***VARI =***

***vain,***

***[cham\_elem\_VARI\_R]***

***/***

***DEPL =***

***depl,***

***[cham\_no\_DEPL\_R]***

***/***

***QUICKLY =***

***quickly,***

***[cham\_no\_DEPL\_R]***

***/***

*VARI\_NON\_LOCAL = vanolo*  
*, [cham\_no\_VANL\_R]*

*/*  
*EVOL\_NOLI*  
*=*  
*evol,*  
*[evol\_noli]*  
*/NUME\_ORDRE*  
*= nuini,*

*[I]*  
*/*  
*INST*  
*=*  
*instini,*  
*[R]*  
*PRECISION*  
*=/1.0E-3, [DEFECT]*

*/*  
*prec,*  
*[R]*  
*CRITERION =/"RELATIVE", [DEFECT]*  
*/*  
*"ABSOLUTE",*

*NUME\_DIDI*

*= nudidi,*  
*[I]*

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*INST\_ETAT\_INIT*

=

*istetaini, [R]*

),

*INCREMENT =\_F (*

*LIST\_INST*

=

*litps,*

*[listr8]*

*EVOLUTION*

*=/"CHRONOLOGICAL",*

*[DEFECT]*

/

*"RETROGRESSES",*

*/"WITHOUT",*

/

*NUME\_INST\_INIT*

=

*nuini,*

*[I]*

/

*INST\_INIT*

=

*instini,*



[R]  
/NUME\_INST\_FIN

= *nufin*,

[I]  
/  
INST\_FIN

= *instfin*, [R]

PRECISION

=  
/  
1.0E-3, [DEFECT]

/  
*prec*,  
[R]

SUBD\_PAS

=  
/  
1,  
[DEFECT]

/subpas  
, [I]

SUBD\_PAS\_MINI

=  
*submini*,  
[R]

COEF\_SUBD\_PAS\_1

= / 1.,  
[DEFECT]  
/  
*coefsub*,

[R]

*OPTI\_LIST\_INST: /"INCR\_MAXI",  
[DEFECT]*

*NOM\_CHAM*

:

*nomch,  
[KN]*

*NOM\_CMP:*

*nomcmp, [kN]*

*VALE*

:

*valley*

,

*[R]*

),

*RECH\_LINEAIRE*

*=\_F (*

*RESI\_LINE\_RELA =/1.E-1,*

*[DEFECT]*

*/*

*reslin*

,

*[R]*

*ITER\_LINE\_MAXI =/3,*

*[DEFECT]*

*/*

*itelin, [I]*

),

*PARAM\_THETA =/1. ,*

*[DEFECT]*

*/*

*theta,*

[R]

*PILOTING* = *\_F* (*STANDARD* = /“*DDL\_IMPO*”,

/  
“*LONG\_ARC*”,

/  
*NODE*  
= *No*,  
[*node*]

/  
*GROUP\_NO*  
=  
*grno*,  
[*gr\_noeud*]

*NOM\_CMP*: *nomcmp*, [kN]

/“*DEFORMATION*”,  
/“*PRED\_ELAS\_INCR*”,  
/“*PRED\_ELAS*”,  
/ALL =

“*YES*”,  
[*DEFECT*]

/  
*GROUP\_MA*  
=  
*lgrma*,  
[*l\_gr\_maille*]

/  
*NET*  
=  
*lma*,  
[*l\_maille*]

*COEF\_MULT*

=  
/  
1.,  
[DEFECT]  
/  
*cmult*,  
[R]  
*ETA\_PILO\_MAX* = *eta max*, [R]

*ETA\_PILO\_MIN* = *eta*  
*min*  
,  
[R]

)

*SOLVEUR* = *\_F* (see the document [U4.50.01]),  
*FILING*  
= *\_F*  
(

/  
*LIST\_INST*  
=  
*list\_r8*,  
[listr8]  
/  
*INST*  
=  
*l\_r8*,  
[R]  
/  
*PAS\_ARCH*  
=

*npas,*

*[I]*  
*PRECISION*

*=*  
*/*

*1.E-3,*  
*[DEFECT]*

*/*  
*prec*

*,*  
*[R]*  
*/ARCH\_ETAT\_INIT = "YES",*

*/*  
*NUME\_INIT*

*=*  
*nuinit, [I]*  
*DETR\_NUME\_SUIV = "YES",*  
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*CHAM\_EXCLU =*  
*/ "DEPL",*

*/ "QUICKLY",*

/ "ACCE",  
/ "SIEF\_ELGA",  
/ "VARI\_ELGA",  
/ "VARI\_NON\_LOCAL",  
/ "LANL\_ELGA",  
)

*OBSERVATION*

=\_F  
(

*NOM\_CHAM* = /  
"DEPL",

/  
"QUICKLY",

/  
“ACCE”,

/  
“DEPL\_ABSOLU”,

/  
“VITE\_ABSOLU”,

/  
“ACCE\_ABSOLU”,

/  
“SIEF\_ELGA”,

/  
“VARI\_ELGA”,

*NOM\_CMP =*  
*lnocmp,*

*[l\_Kn]*



*/LIST\_ARCH*

*= larch,*

*[listis]*

*/*

*LIST\_INST*

*=*

*linst*

*,*

*[listr8]*

*/*

*INST =*

*linst*

*,*

*[l\_R]*

*/*

*PAS\_OBSE*

*=*

*not*

*,*

*[I]*

*/| NODE*

*= lno*

*,*

*[l\_noeud]*

*| GROUP\_NO = lgmo,*

*[l\_gr\_noeud]*

```
/
NET
=
lma
,
[l_maille]
NOT
=
lpoint
,
[l_I]

),

LAGR_NON_LOCAL =_F
(
ITER_PRIM_MAXI =/10,
[DEFECT]
/iterprimmax,
[I]
RESI_PRIM_ABSO = resiprimab,

[R]
ITER_DUAL_MAXI =/50,
[DEFECT]
/
iterdmax,
[I]

RESI_DUAL_ABSO

=
residabso, [R]
R
```

=  
/  
1000.,  
[DEFECT]  
/rho  
,  
[R]  
)  
*SOLV\_NON\_LOCAL = \_F (see the document [U4.50.01])*  
)

*INFORMATION =*  
/ 1  
,  
[DEFECT]

/ 2  
,

*TITRATE*  
=  
*tx,*  
[KN]

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### **3 Operands**

#### **3.1 Operands**

**MODEL/CHAM\_MATER/CARA\_ELEM/MODE\_STAT**

*MODEL = Mo*

*Name of the model whose elements are the subject of mechanical calculation.*

*CHAM\_MATER = chmat*

*Name of the affected material field on the model Mo.*

*CARA\_ELEM = carac*

*Name of the characteristics of the elements of hull, beam, bars, discrete cable, and elements affected on the model Mo, if necessary.*

*MODE\_STAT = modestat*

*Name of the static mode necessary in the case of a seismic calculation with excitations multi-supports [R4.05.01].*

#### **3.2 Word**

**key**

**EXCIT**

*EXCIT = \_F*

*This key word factor makes it possible to describe with each occurrence a load (requests and conditions with the limits), and possibly a multiplying coefficient and/or a type of load.*

##### **3.2.1 Operands**

**CHARGE/FONC\_MULT**

*CHARGE = chi*

*CH is the mechanical loading (possibly comprising the evolution of a field of*

*I*  
temperature) specified with the *i*ème occurrence of *EXCIT*.

Only one load can comprise the evolution of a field of temperature, which will have previously be defined thanks to key word *TEMP\_CALCULEE* of the order *AFFE\_CHAR\_MECA*.

$$FONC\_MULT = f_i$$

*F* is the multiplying function of the time of the loading specified with the *i*ème occurrence of *I* *EXCIT*.

The loading and boundary conditions for *N* occurrences of the key word factor *EXCIT* are:

$$\begin{aligned} N \\ CH &= F CH \\ I \\ I \\ I \\ &= 1 \end{aligned}$$

For the conditions of *DIRICHLET*, of course, only the specified value is multiplied by *F*.

By defect: *F* = 1.

The field of temperature is not multiplied by *F*.

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### **3.2.2 Operand**

#### **TYPE\_CHARGE**

*TYPE\_CHARGE* = *tchi*

*By defect, tchi is worth "FIXE\_CSTE": that corresponds to a loading applied to initial geometry and not controlled. It can however be a function, and depend in particular time.*

*If tchi is worth "FIXE\_PILO", the loading is always fixed (independent of the geometry) but will be controlled thanks to the key word PILOTING [§3.11].*

*The loads controllable must result from AFFE\_CHAR\_MECA or AFFE\_CHAR\_MECA\_F and not to be affected key word FONC\_MULT. One cannot control the loadings of gravity, the centrifugal force, the forces of Laplace, them thermal loadings or of initial or anelastic deformations, and conditions of connection.*

*If tch is worth*

*I*

*"SUIV", the loading is known as "follower", i.e. it depends on the value unknown factors: for example, pressure, being a loading applying in the direction normal with a structure, depends on the geometry brought up to date of this one, and thus of displacements. A following loading is revalued with each iteration of the algorithm of resolution. A fixed loading is revalued only at each new moment, and only if chi depends on time (defined in AFFE\_CHAR\_MECA\_F and parameterized by the moment).*

Currently the loadings which can be qualified “SUIV” are the loading of gravity for the element of CABLE\_POULIE, the pressure for modelings 3D, 3D\_SI, D\_PLAN, D\_PLAN\_SI, AXIS, AXIS\_SI, C\_PLAN, C\_PLAN\_SI and for all them modelings THM (3D\_HHM, 3D\_HM, 3D\_JOINT\_CT, 3D\_THH, 3D\_THHM, 3D\_THM, AXIS\_HHM, AXIS\_HM, AXIS\_THH, AXIS\_THHM, AXIS\_THM, D\_PLAN\_HHM, D\_PLAN\_HM, D\_PLAN\_THH, D\_PLAN\_THHM, D\_PLAN\_THM) and the centrifugal force into large displacements (key word ROTATION in AFFE\_CHAR\_MECA).

If tchi is worth “DIDI then” the conditions of DIRICHLET (imposed displacements, conditions linear) will apply to the increment of displacement as from the moment given under ETAT\_INIT/NUME\_DIDI (by defect the moment of resumption of calculation) and not on displacement total. For example for an imposed displacement (key word DDL\_IMPO of AFFE\_CHAR\_MECA) the condition will be form:  $U - U = D$

0  
where  $u_0$  is the displacement defined by NUME\_DIDI and not:  $U = D$ .

### 3.2.3 Operands

**MULT\_APPUI /ACCE /VITE /DEPL /DIRECTION /NOEUD /GROUP\_NO**

In the case of an excitation multi-supports (MULT\_APPUI: “YES”), the other operands have exactly same significance as in the key word factor EXCIT of the operator DYNA\_TRAN\_MODAL [U4.53.21].

## 3.3 Description of the diagram of integration in time

Currently in DYNA\_TRAN\_EXPLI, only the diagram of the centered differences, one of the versions explicit of the diagram of Newmark, is available. For more detail to see the documentation of reference [R5.05.06].

## 3.4 Word

key  
**COMP\_INCR**

/ COMP\_INCR = \_F

This key word factor gathers the relations of behavior connecting of the rates of deformations to rates of constraints (incremental behavior). One can have in same calculation certain parts of the structure obeying with various incrémentaux behaviors (COMP\_INCR) and other parts obeying with various elastic behaviors (COMP\_ELAS). All the incremental relations of behavior supported by STAT\_NON\_LINE are available also in DYNA\_TRAN\_EXPLI, provided that the calculation of the matrix of mass elements concerned is envisaged. One will thus refer to the document [U4.51.11]

for a description of the relations of behavior available (operand RELATION) thus that other operands of key word COMP\_INCR.

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### 3.5 Word

key

**COMP\_ELAS**

/

**COMP\_ELAS = \_F**

*This key word factor gathers the relations of behavior connecting the deformations (taken by report/ratio in an initial state of reference) and the constraints (elastic behavior). All them incremental relations of behavior supported by STAT\_NON\_LINE are available also in DYNA\_TRAN\_EXPLI, provided that the calculation of the matrix of mass of elements concerned is envisaged. One will thus refer to the document [U4.51.11] for one description of the relations of behavior available (operand RELATION) as well as other operands of key word COMP\_ELAS.*

### 3.6 Word

key

**ETAT\_INIT**

**ETAT\_INIT = \_F**



*Under this key word the initial conditions of the problem are defined. If key words **EVOL\_NOLI**, **DEPL**, and **QUICKLY** miss, one supposes that the initial state is with displacements, speeds and constraints null, and one calculates accelerations corresponding to the loading at the moment instini defined by operand **INST**. The other operands of key word **ETAT\_INIT** have the same one significance that in the document [U4.51.03].*

### **3.7 Word**

**key**

#### **INCREMENT**

*INCREMENT =\_F*

*The list of the moments of calculation defines. The operands of the key word **INCREMENT** have the same one significance that in the document [U4.51.03].*

### **3.8 Operand**

#### **PARAM\_THETA**

*PARAM\_THETA*

*=*

*/*

*1.*

*[DEFECT]*

*/*

*theta*

*For modelings **THM**, the argument *theta* is the parameter of the *theta*-method used for to solve the evolutionary equations of thermics and hydraulics (cf [R5.03.60] for more details). Its value must lie between 0 (explicit method) and 1 (method completely implicit).*

*For certain laws of behaviors, the argument *theta* is used for integration. It can take them values 0.5 or 1.*

*To refer, for more details with [U4.53.01].*

### **3.9 Word**

**key**

#### **PILOTING**

*PILOTING =\_F*

*When the intensity of part of the loading is not known a priori (loading known as of reference defined in **AFFE\_CHAR\_MECA** or **AFFE\_CHAR\_MECA\_F** with load of the type **FIXE\_PILO**), the key word **PILOTING** makes it possible to control this loading via one*

*node (or node groups) on which one can impose various modes of piloting (key word TYPE). The operands of the key word PILOTING have the same significance as in the document [U4.51.03]. However, this option also activates with DYNA\_TRAN\_EXPLI is to be used there with reserve owing to the fact that time has a physical and nonvirtual significance: it is not useful primarily with indicer increments of load as with STAT\_NON\_LINE.*

**Caution:**

*With FIXE\_PILO, one cannot use for the loading of reference the key word FONCT\_MULT.*

**Caution:**

*When the loading of reference is defined by AFFE\_CHAR\_MECA\_F, this loading can be a function of the variables of space but not of time.*

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**3.10 Word**

**key**

**SOLVEUR**

*The syntax of this key word common to several orders is described in the document [U4.50.01].*

**3.11 Word**

**key**

**FILING**

*FILING = \_F*

*Allows to file or certain results with all or certain moments of calculation.*

*In the absence of this key word all the steps of time are filed, including the moments of calculations lately created by automatic recutting of the step of time. Operands of the key word FILING have the same significance as in the document [U4.51.03].*

**3.12 Word**

**key**

**AMOR\_MODAL**

*This key word makes it possible to take into account a damping equivalent to modal damping broken up on a basis of modes precalculated in the form of concept of the mode\_meca type. This damping is taken overall into account in the dynamic equilibrium equation like one correct force with the second member - CX&.*

**3.12.1 Operands MODE\_MECA/AMOR\_REDUIT/NB\_MODE**

*MODE\_MECA*

*= mode*

*AMOR\_REDUIT = l\_amor*

*NB\_MODE = nbmode*

*The concept mode of the mode\_meca type (entered by operand MODE\_MECA) represents the base of modes precalculated on which one breaks up modal damping. This base must imperatively to have the same profile of classification as that of the dynamic system defined by parameters of key word SOLVEUR [§3.12]. It be possible to truncate the modal base with one a number of modes defined by NB\_MODE. Failing this, one takes all the modes of the modal base.*

*Modal depreciation in reduced form is given in the form of a list of realities of which the number of terms is lower or equal to the number of modes taken into account. If the number of terms of the list is strictly lower, one extends this list with the value of its last term until its size reaches the number of calculated modes.*

**3.12.2 Operand REAC\_VITE**

*If its value is "YES", one modifies the correct force of modal damping to each iteration intern of NEWTON defined in the key word NEWTON [§3.8].*

*If its value is "NOT", one updates this term only to the beginning of each step of time.*

**Note:**

*In the case of DYNA\_TRAN\_EXPLI, there is only one internal iteration of NEWTON.*

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### **3.13 Word**

**key**

**PROJ\_MODAL**

*This key word makes it possible to make calculation on a beforehand calculated modal basis.*

*MODE\_MECA = mode,*

*[mode\_meca]*

*NB\_MODE =/nbmode, [I]*

*/*

*9999,*

*[DEFECT]*

*One specifies the modal base to use (MODE\_MECA) and numbers it modes (NB\_MODE).*

**Important remark:**

*The modal base must be based on a coherent classification with that of the evolution calculated (cf [§ 3.14]): even profile of classification.*

### **3.14 Word**

**key**

**OBSERVATION**

*This key word makes it possible post-to treat certain fields with the nodes or the elements on parts of model at moments of a list (known as of observation) generally more refined than the list of moments filed defined in the key word **FILING** [§3.14] (where one stores all the fields on all it model). It is used primarily for economies of storage.*

*This key word is répétable and allows the creation of a table of of the same observation name than the concept result of **DYNA\_TRAN\_EXPLI**.*

**3.14.1 Operands LIST\_ARCH/LIST\_INST/INST/PAS\_OBSE**

*These operands make it possible to define in the choices a list of moments of observation. They have the same one significance that of the same operands name being used to define a list of filing. **PAS\_OBSE** playing the same part as **NOT** in **FILING** [§3.14].*

**3.14.2 Operands NOM\_CHAM/NOM\_CMP**

*These operands make it possible to define the fields post-to be treated like their components given by their name (by **NOM\_CMP**).*

**3.14.3 Operands NODE/GROUP\_NO**

*These operands make it possible to define the nodes of postprocessing for fields in the nodes (“**DEPL**”, “**QUICKLY**”, “**ACCE**”, “**DEPL\_ABSOLU**”, “**VITE\_ABSOLU**”, “**ACCE\_ABSOLU**”).*

**3.14.4 Operands NETS/NOT**

*These operands which go hand in hand make it possible to define the meshes of postprocessing and their points of extraction for fields with the elements (“**SIEF\_ELGA**” or “**VARI\_ELGA**”).*

**3.15 Operand****SOLV\_NON\_LOCAL**

*The syntax of this key word is identical to key word **SOLVEUR** describes in the document [U4.50.01].  
With  
to use for a nonlocal model.*

**3.16 Operand****LAGR\_NON\_LOCAL**

*See Doc. [U4.51.03].*

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### **3.17 Operand INFORMATION**

*INFORMATION*

=

*inf*

*Allows to carry out in the file message various intermediate impressions in the presence of unilateral contact treaty by the method of the active constraints.*

*inf =*

*1 impression of the list of the nodes in contact after convergence with each iteration of Newton.*

= 2

*idem 1 plus impression of associations/dissociations of nodes enters iterations of the method of the active constraints.*

*Other impressions are made systematically during nonlinear calculation, independently value assigned to the key word INFORMATION: they are the impressions of the residues and the increments relative of displacement during iterations of Newton.*

### **3.18 Operand**

#### **TITRATE**

*TITRATE = tx*

*tx is the title of calculation. It will be printed at the head results. See [U4.03.01].*

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*Author (S):*

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## ***Operator DYNA\_LINE\_HARM***

### ***1 Goal***

***To calculate the dynamic response complexes of a system to a harmonic excitation. Direct calculation for a structure in physical space, calculation by harmonic under-structuring for several under structures defined by their modal base in modal co-ordinates.***

***Product a structure of data of the dyna\_harmo type or acou\_harmo or harmo\_gene.***

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### ***2 Syntax***

***harm [\*]***

***= DYNA\_LINE\_HARM***

***(***

***MODEL***

***=***

***Mo***

**[model]**

**CHAM\_MATER =**  
**chmat**  
**[cham\_mater]**

**CARA\_ELEM**  
**=**  
**carac**  
**[cara\_elem]**

**MATR\_MASS**  
**=**  
**m**  
**/**  
**[matr\_asse\_DEPL\_R]**  
**/**  
**[matr\_asse PRES\_C]**  
**/**  
**[matr\_asse\_GENE\_R]**

**MATR\_RIGI**  
**=**  
**K**  
**/**  
**[matr\_asse\_DEPL\_R]**  
**/**  
**[matr\_asse\_DEPL\_C]**  
**/**  
**[matr\_asse PRES\_C]**  
**/**  
**[matr\_asse\_GENE\_R]**

*/*  
*MATR\_AMOR*  
*=*  
*C*  
*/*  
*[matr\_asse\_DEPL\_R]*  
*/*  
*[matr\_asse\_PRES\_C]*  
*/*  
*[matr\_asse\_GENE\_R]*

*/AMOR\_REDUIT = L*  
*[l\_R]*

*/LIST\_AMOR*  
*= C*  
*[listr8]*

*MATR\_IMPE\_PHI*  
*=*  
*imp*  
*/*  
*[matr\_asse\_DEPL\_R]*

/

**[matr\_asse\_GENE\_R]**

/

**FREQ**

=

**lf**

**[l\_R]**

/

**LIST\_FREQ**

=

**cf**

**[listr8]**

/

**TOUT\_CHAM**

=

**“YES”**

**[DEFECT]**

/

**NOM\_CHAM**

= | **“DEPL”**

/“**QUICKLY**”

/“**ACCE**”

/  
**SENSITIVITY** = (  
... to see [U4.50.02]....

)

**EXCIT=\_F** (/   
**VECT\_ASSE** = *vecti*  
/[**cham\_no\_DEPL\_R**]  
/  
[**cham\_no\_PRES\_C**]  
/  
[**vect\_asse\_GENE**]

/

***CHARGE***

=

***chi [char\_meca]***

***TYPE\_CHARGE***

=

***“FIXES”***

***[DEFECT]***

***/FONC\_MULT\_C = hci***

***[fonction\_C]***

***/COEF\_MULT\_C = aci***

***[C]***

/

***FONC\_MULT***

=

***hi***

***[function, formula]***

**/**  
**COEF\_MULT**  
**=**  
**have**  
**[R]**

**PHAS\_DEG**  
**=**  
**/**  
**0.**  
**[DEFECT]**

**/I**  
**[R]**

**PUIS\_PULS**  
**=/0 [DEFECT]**  
**/**  
**nor**  
**[Is]**

)

**TITRATE**

=

**tx**

**[l\_Kn]**

);

**if MATR\_RIGI = [matr\_asse\_DEPL\_R]**

**then [\*]**

**dyna\_harmo**

**[matr\_asse\_DEPL\_C]**

**dyna\_harmo**

**[matr\_asse\_PRES\_C]**

**acou\_harmo**

**[matr\_asse\_GENE\_R]**

**harm\_gene**

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### **3 Recalls**

#### **3.1**

#### **Equation of dynamic behaviour under harmonic excitation**

**The damping of the structure can be viscous or hysteretic [U1.01.05] [R5.05.04].**

**This operator solves the equation:**

$$\begin{aligned}
 & ( \\
 & \begin{matrix} 3 \\ 2 \\ J \\ K \\ N \\ J \\ I \end{matrix} \\
 & - J \\
 & I - \\
 & M + J C + K \{Xe\} = H (F) I
 \end{aligned}$$

$$\begin{aligned}
 & 180 \\
 & E \\
 & G (P) \\
 & I \\
 & I
 \end{aligned}$$

$$I = 1$$

**where  $K$  represents a matrix of rigidity (real or complex),**

***M***

*represent a matrix of mass,*

***C***

*represent a matrix  
of damping,*

***I***

*represent a matrix  
of acoustic impedance resulting from a formulation in  
displacement-pressure-potential,*

*P is a current point of the structure.*

### ***3.2 Damping hysteretic***

*This operator also allows to calculate the harmonic response of a structure with  
damping hysteretic.*

(  
***K***  
***I***  
***K - M) X =***  
***N***  
***J***  
***I***  
***I ()***  
***.e***  
***2***  
***180***  
***H***  
***F***  
***.g (P)***  
***I***  
*with K stamps complex rigidity.*  
*i=1*

*For detailed examples, one will refer to the document [U1.05.01].*

*This operator is usable in imposed force and imposed (relative reference frame or absolute).*

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**4 Operands**

**4.1 Operand**

**MODEL**

**MODEL = Mo**

**Name of the concept defining the model whose elements are the subject of harmonic calculation.**

**4.2 Operand**

**CHAM\_MATER**

**CHAM\_MATER = chmat**

**Name of the concept defining the affected material field on the model Mo.**

**4.3 Operand**

**CARA\_ELEM**

**CARA\_ELEM = carac**

**Name of the concept defining the characteristics of the elements of beam, hulls, etc...**

#### **4.4 Operand** **MATR\_MASS**

**MATR\_MASS = m**

*Name of the concept stamps assembled corresponding to the matrix of mass of the system.*

#### **4.5 Operand** **MATR\_RIGI**

**MATR\_RIGI = K**

*Name of the concept stamps assembled corresponding to the matrix of rigidity of the system.*

#### **4.6 Operand** **MATR\_AMOR/AMOR\_REDUI/T/LIST\_AMOR**

**/MATR\_AMOR = C**

*Name of the concept stamps assembled corresponding to the matrix of viscous damping of system.*

**/AMOR\_REDUI/T = L**

*List of all reduced depreciation: (1, 2,..., N).*

**/LIST\_AMOR = C**

*Name of the concept of the listr8 type containing the list of reduced depreciation.*

#### **4.7 Operand** **MATR\_IMPE\_PHI**

**MATR\_IMPE\_PHI = imp**

*Name of the concept stamps assembled corresponding to the matrix of impedance for a system fluid-structure whose formulation is in displacement-pressure-potential (U, p,) [R4.02.02].*

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#### **4.8 Operands**

***FREQ/LIST\_FREQ***

/

*FREQ = lf*

List of all the frequencies of calculation:  $(f_1, f_2, \dots, f_n)$ .

/

*LIST\_FREQ = cf*

Name of the concept of the *listr8* type containing the list of the frequencies of calculation.

#### **4.9 Operands**

***TOUT\_CHAM/NOM\_CHAM***

/

*TOUT\_CHAM =*

“YES”

/

*NOM\_CHAM*

= | “DEPL”

/ “QUICKLY”

/ “ACCE”

*Choice of the fields to calculate to represent the answer: displacement, speed, acceleration or three.*

#### **4.10 Operands**

##### **SENSIBLITE**

/

**SENSITIVITY =**

*Activate the calculation of derived from the field from displacement, speed and acceleration compared to a significant parameter of the problem.*

*The document [U4.50.01] specifies the operation of the key word.*

#### **4.11 Word**

**key**

##### **EXCIT**

**EXCIT**

*Operand allowing to define several excitations. Maybe by indicating an assembled vector correspondent with a loading, is loads which will lead to the calculation and the assembly of one second member. For each occurrence of the key word factor, one defines a component of the excitation in the form  $(H(F)(G P), \text{phase})$ .*

##### **4.11.1 Operands VECT\_ASSE/CHARGE/TYPER\_CHARGE**

*Allow to define  $G(P)$  space discretization of the loading, in the form of a field with nodes corresponding to one or more loads of force or imposed movement.*

/

**VECT\_ASSE = vecti**

**Name of the concept produced by:**

**.  
operator ASSE\_VECTEUR in imposed force or imposed of  
displacement in an absolute reference frame. The amplitudes of the excitation can be  
defined in the concepts of the type charges corresponding,  
.**

**operator CALC\_CHAR\_SEISME moving imposed of displacement, speed  
or acceleration corresponding to the vector assembled in a relative reference frame: in  
this case the loads should contain only conditions kinematics (DDL\_IMPO  
of zero value).**

**/  
CHARGE = chi**

**chi name of the concept of loading specified by the ième event of EXCIT.**

**TYPE\_CHARGE = "FIXES"**

**Is there only to use the routines of the non-linear one.**

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#### **4.11.2 Operands FONC\_MULT\_C/COEF\_MULT\_C/FONC\_MULT/COEF\_MULT**

*Allow to define H (F) law of evolution, complex or real, frequency, applied to all components of the field to the node associated with this occurrence. Several possibilities are offered:*

/  
*FONC\_MULT\_C = hci*

*Name of the concept of the fonction\_C type defining a function H (F) complex of frequency F,*

/  
*COEF\_MULT\_C = aci*

*Coefficient complexes multiplying loading, independent of the loading,*

/  
*FONC\_MULT = hi*

*Concept of the function type defining a function H (F) real of the frequency F,*

/  
*COEF\_MULT = have*

*Multiplying real coefficient of the loading, independent of the loading.*

#### **4.11.3 Operand PUIS\_PULS**

*PUIS\_PULS = nor*

*Allows to define the power of the pulsation when the loading is a function of the frequency  $n_i = (2 F) \text{ nor}$ ; by defect  $n_i = 0$ .*

#### **4.11.4 Operand PHAS\_DEG**

*PHAS\_DEG = I*

*Allows to define the phase of each component of the excitation in degrees compared to one single reference of phase; by defect  $I = 0$ .*



#### **4.11.5 Notice**

*For a problem with imposed movement, one defines the blocked degrees of freedom (conditions kinematics preliminary to the construction of the cham\_no); one can then choose an excitation:*

- .  
in imposed displacement  $N = 0, = 0^\circ$*
- .  
in imposed speed  $N = 1, = 90^\circ$*
- .  
in imposed acceleration  $N = 2, = 180^\circ$*

#### **4.12 Operand**

**TITRATE**

**TITRATE = tx**

*Titrate attached to the concept produced by this operator [U4.03.01].*

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**5**

**Example of use in imposed force**

```

# -----
# REFERENCE: SFM/VPCS SDLD21 ORDERS
# -----
# SYSTEM MASSE-RESSORT A 8 DEGREES OF FREEDOM WITH DAMPING
# VISCOUS PROPORTIONAL (HARMONIC ANSWER)
# 9 SPRINGS 8 MASSES -- K =1.E+5 M =10 --
# -----
BEGINNING (CODE=_F (NOM=' SDLD21A '),);
# -----
MA = LIRE_MAILLAGE ();
MO =
AFFE_MODELE (MAILLAGE= MA,
AFFE= (_F (TOUT=' OUI', PHENOMENE=' MECANIQUE',
MODELISATION=' DIS_T'),

_F (GROUP_NO= MASSES, MODELISATION=' DIS_T'),,));

CARELEM = AFFE_CARA_ELEM (MODELE= MO,
DISCRET= (_F (GROUP_MA=
"SPRING", CARA=' K_T_D_L',
VALE= (1.E+5,1., 1.),),),);

_F (GROUP_NO= MASSES, CARA=' M_T_D_N', VALE= 10. ,),

_F (GROUP_MA=
DEADENED, CARA=' A_T_D_L',
VALE= (50. , 1. , 1.),),,);
#
CH =AFFE_CHAR_MECA (MODELE= MO,
DDL_IMPO=
(_F (GROUP_NO=
"A_ET_B",

DX=0., DY=0., DZ=0.,),

_F (GROUP_NO=
"MASS",

```

*DY=0., DZ=0.,),),*  
*FORCE\_NODALE=\_F (*  
*NOEUD=*  
*“P4”,*  
*FX=*  
*I.,),);*

*MELR = CALC\_MATR\_ELEM (MODELE= MO, CHARGE= CH, OPTION=' RIGI\_MECA',*  
*CARA\_ELEM=*  
*CARELEM,*

)

;

*MELM = CALC\_MATR\_ELEM (MODELE= MO, CHARGE= CH, OPTION=' MASS\_MECA',*  
*CARA\_ELEM=*  
*CARELEM,*

)

;

*MELC = CALC\_MATR\_ELEM (MODELE= MO, CHARGE= CH, OPTION=' AMOR\_MECA',*  
*CARA\_ELEM=*  
*CARELEM,*

)

;

*VECT = CALC\_VECT\_ELEM (CHARGE= CH,*

*OPTION=' CHAR\_MECA');*

*# -----*

*NUM = NUME\_DDL (MATR\_RIGI= MELR,);*

*MATASSR = ASSE\_MATRICE (MATR\_ELEM= MELR, NUME\_DDL= NUM,);*

*MATASSM = ASSE\_MATRICE (MATR\_ELEM= MELM, NUME\_DDL= NUM,);*

*MATASSC = ASSE\_MATRICE (MATR\_ELEM= MELC, NUME\_DDL= NUM,);*

*VECTASS = ASSE\_VECTEUR (VECT\_ELEM= VECT, NUME\_DDL= NUM,);*

*# -----*

**# EXCITATION BY a FORCE SINUSOIDALE Of CRETE AMPLITUDE FX = 1.N**  
**# AT the P4 POINT**  
**# (AMPLITUDE INDEPENDENT OF THE FREQUENCY)**  
**LIFREQ = DEFI\_LIST\_REEL (DEBUT=5.,**  
**INTERVALLE=\_F (JUSQU\_A=40., NOMBRE=70,));**

**DYNAHARM = DYNA\_LINE\_HARM**

**(MATR\_MASSE= MATASSM, MATR\_RIGI= MATASSR, MATR\_AMOR= MATASSC,**

**LIST\_FREQ = LIFREQ, EXCIT=\_F (VECT\_ASSE= VECTASS, COEF\_MULT= 1. ,));**

**IMPR\_RESU (MODELE=MO, RESU=\_F (RESULTAT= DYNAHARM,));**

**END ();**

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***Operator DYNA\_TRAN\_MODAL***

***1 Goal***

*To calculate the transitory dynamic response of a system deadened or not in generalized co-ordinates. Calculation is carried out by modal superposition or under-structuring.*

*Not-null initial conditions can be introduced making it possible amongst other things to use the results of a former calculation.*

*The loading is given in the form of a linear combination of vectors generalized and of functions of time describing the temporal evolution of these vectors.*

*Three explicit methods of integration: "EULER", "DEVOGE", "ADAPT" (method of integration with step adaptive time), an integral method "ITMI" and a method of integration implicit: "NEWMARK" are available. The explicit algorithms and "ITMI" support calculation with taking into account of non-linearities located with the nodes of the shocks type and friction. Methods "EULER" and "ADAPT" support the taking into account of non-linearities of the fluid blade type and antiseismic device type.*

*The structure of data result contains for various moments of calculation, the results generalized and calculated forces of shock.*

*The conversion of the results generalized in physical space is possible by the operators REST\_BASE\_PHYS [U4.63.21] or for a component by RECU\_FONCTION [U4.32.03].*

*Product a concept of the tran\_gene type.*

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## 2 Syntax

**tranmo [tran\_gene] = DYNA\_TRAN\_MODAL (**

**reuse**

**= tranmo,**

**MASS\_GENE**

**=**

**my**

**,**

**[matr\_asse\_gene\_R]**

**RIGI\_GENE**

**=**

**laughed**

**,**

**[matr\_asse\_gene\_R]**

**/AMOR\_GENE = amndt**

**,**

**[matr\_asse\_gene\_R]**

**/**

**AMOR\_REDUIT**

**=**

**,**

**[l\_R]**

**/**

**LIST\_AMOR**

=  
*l\_amor*  
,  
*[listr8]*

**METHOD**

=  
/  
“EULER”,  
*[DEFECT]*  
/  
“DEVOGE”,  
/  
“NEWMARK”,  
/  
“ADAPT”,  
/  
“ITMI”,

*INCREMENT = \_F (*  
*INST\_INIT =*  
*to,*  
*[R]*

*INST\_FIN = tf,*  
*[R]*

**NOT**

=  
*dt*,  
*[R]*

*VERI\_PAS* =/  
“*YES*”,  
*[DEFECT]*  
/  
“*NOT*”,

*# Operands specific to an integration by step of adaptive times*

*VITE\_MIN* =/  
“*STANDARD*”, *[DEFECT]*  
/  
“*MAXIMUM*”,

*COEF\_MULT\_PAS* =/*1.1*,  
*[DEFECT]*  
/  
*cmp*  
,  
*[R]*

*COEF\_DIVI\_PAS =/1.33333334, [DEFECT]*

*/*

*cdp*

*, [R]*

*PAS\_LIMI\_RELA =/1.E-6,*

*[DEFECT]*

*/*

*per*

*, [R]*

*NB\_POIN\_PERIODE =*

*/ 50,*

*[DEFECT]*

*/*

*NR,*

*[I]*

*NMAX\_ITER\_PAS =/16,*

*[DEFECT]*

*/*

*NR,*

*[I]*

*# End of the operands specific to an integration by step of adaptive times*

*),*

*ETAT\_INIT = \_F (/RESU\_GENE =  
LMBO,  
[tran\_gene]*

*/  
/ DEPL\_INIT\_GENE = C, [vect\_asse\_gene]*

*/ VITE\_INIT\_GENE = vo, [vect\_asse\_gene]*

*INST\_INIT =  
to,*

[R]

*CRITERION* =  
/“*RELATIVE*”, [*DEFECT*]  
/  
“*ABSOLU*”,

*PRECISION* =/1.E-3,  
[*DEFECT*]  
/  
*prec*, [R]

),

*EXCIT*  
= *\_F* (  
*VECT\_GENE*  
=  
*v*,  
[*vect\_asse\_gene*]

*NUME\_MODE*

=

*nmod,*

*[I]*

/

*FONC\_MULT*

=

*F,*

*[function]*

/

*COEF\_MULT*

=

*has,*

*[R]*

/

*ACCE*

=

*ac,*

*[function]*



*QUICKLY*

=

*VI,*

*[function]*

*DEPL*

=

*dp,*

*[function]*

*# Operands and key words specific to the seismic analysis*

*[\$3.5]*

*MULT\_APPUI =/"NOT",*

*[DEFECT]*

*/*

*"YES",*

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*DIRECTION*

= (*dx, Dy, dz, drx, dry, drz*), [*l\_R*]

*/NODE*

= *lno*,

[*l\_noeud*]

/

*GROUP\_NO*

=

*lgrno,*

*[l\_groupe\_no]*

*CORR\_STAT*

=

/

*“NOT”*

*[DEFECT]*

/

*“YES”*

*D\_FONC\_DT*

=

*dfdt,*

*[function]*

*D\_FONC\_DT2*

=

*dfdt2,*

*[function]*

)

*/MODE\_STAT*

=

*psi,*

*[mode\_stat]*

/

*MODE\_CORR*

=

*modcor, [mult\_elas]*

),

*# End of the operands and key words specific to the seismic analysis*

*SHOCK*

=

*\_F (*

*[\$3.6.1]*

*ENTITLE =*

*int*

,

*[l\_Kn]*

*/NOEUD\_1*

=

*no1,*

*[node]*

*/GROUP\_NO\_1*

=

*grno1,*

*[group\_no]*

*/NOEUD\_2*

=

*no2,*

*[node]*

*/GROUP\_NO\_2*

=

*grno2,*

*[group\_no]*

*OBSTACLE*

= *obs*,

[*obstacle*]

*NORM\_OBST*

=

*NOR*,

[*listr8*]

*ORIG\_OBST*

=

*ori*,

[*listr8*]

*PLAY*

=

/

*1.*,

[*DEFECT*]

/

*play*,

[*R*]

*ANGL\_VRIL*

=

*gamma,*  
*[R]*

*DIST\_1*

=

*dist1,*  
*[R]*

*DIST\_2*

=

*dist2,*  
*[R]*

*SOUS\_STRUC\_1*

= *ss1,*

*[K8]*

*SOUS\_STRUC\_2 = ss2, [K8]*

*LOCATE*

=

/

“TOTAL”,  
[DEFECT]

/

*nom\_sst*, [K8]

*RIGI\_NOR* = *kN*,

[R]

*AMOR\_NOR* =/

0.,

[DEFECT]

/

*Cn*,

[R]

*RIGI\_TAN* =/

0.,

[DEFECT]

/

*kt*,

[R]



*AMOR\_TAN =/  
0.,  
[DEFECT]  
/  
ct,  
[R]*

*COULOMB  
=  
/  
0.,  
[DEFECT]  
/  
driven,  
[R]*

*# Operands and key words specific to the taking into account of a fluid blade  
[§3.6.2]*

*LAME\_FLUIDE  
=  
“NOT”,  
[DEFECT]  
/  
“YES”,*

*ALPHA*

= /

0.,

[DEFECT]

/

*alpha,*

[R]

*BETA*

=

/

0.,

[DEFECT]

/

*beta, [R]*

*CHI*

=

/

0.,

[DEFECT]

/

*chi,*

[R]

*DELTA*

= /

0.,

[DEFECT]

/

*delta,*

*[R]*

*NMAX\_ITER*

=

/

*20,*

*[DEFECT]*

/

*niter,*

*[I]*

*RESI\_RELA*

=

/

*1.E-3,*

*[DEFECT]*

/

*residue, [R]*

*LAMBDA*

=

/

*10.,*

*[DEFECT]*

/

*lambda, [R]*

),

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*# End of the operands and key words specific to the taking into account of a fluid blade*

*VERI\_CHOC = \_F (*

*[\$3.7]*

*STOP\_CRITERE*

*= /*

*“YES”,*

*[DEFECT]*

*/*

*“NOT”,*

*THRESHOLD =*  
*/ 0.5*  
*,*  
*[DEFECT]*  
*/*  
*S,*  
*[R]*

*),*

*ANTI\_SISM = \_F (*

*[\$3.8]*

*/NOEUD\_1*

*=*

*no1,*

*[node]*

*/GROUP\_NO\_1*

=

*grno1,*  
*[group\_no]*

*/NOEUD\_2*

=

*no2,*  
*[node]*

*/GROUP\_NO\_2*

=

*grno2,*  
*[group\_no]*

*RIGI\_K1*

=

*/*  
*0.,*  
*[DEFECT]*

*/*

*kN,*

*[R]*

*RIGI\_K2*

=

/  
0.,  
[DEFECT]  
/  
kN,  
  
[R]

SEUIL\_FX =/  
0.,  
[DEFECT]  
/  
Py,  
  
[R]

C  
=  
/  
0.,  
[DEFECT]  
/  
C,  
  
[R]

PUIS\_ALPHA  
=  
/  
0.,  
[DEFECT]  
/

*alpha,*

*[R]*

*DX\_MAX*

*=*

*/*

*1.,*

*[DEFECT]*

*/*

*dx,*

*[R]*

*),*

*BUCKLING*

*= \_F (*

*[\$3.9]*

*/NOEUD\_1*



=

*no1,*

*[node]*

*/GROUP\_NO\_1*

=

*grno1,*

*[group\_no]*

*/NOEUD\_2*

=

*no2,*

*[node]*

*/GROUP\_NO\_2*

=

*grno2,*

*[group\_no]*

*OBSTACLE*

=

*obs,*

*[obstacle]*

*ORIG\_OBST*

=

*ori,*

*[listr8]*

*NORM\_OBST*

=

*NOR,*

*[listr8]*

*ANGL\_VRIL*

=

/

*0,*

*[DEFECT]*

/

*gamma,*

*[R]*

*PLAY*

=

/

*1.,*

*[DEFECT]*

*/jeu,*

*[R]*

*DIST\_1*

=

*dist1,*

[R]

*DIST\_2*

=

*dist2,*

[R]

*LOCATE*

=

/"TOTAL", [DEFECT]

/

*nom\_sst*

,

[K8]

*RIGI\_NOR = kN, [R]*

*FNOR\_CRIT*

=

*flim, [R]*

*FNOR\_POST\_FL*

=

*fseuil,*

[R]

*RIGI\_NOR\_POST\_FL*

=

*k2,*

*[R]*

),

*RELA\_EFFO\_DEPL = \_F (*

*[\$3.10]*

*NODE*

= *Noah,*

*[node]*

*SOUS\_STRUC*

=

*ss,*

*[K8]*

*NOM\_CMP*  
=  
*nomcmp, [K8]*

*RELATION*  
= *F*,  
*[function]*

),

*RELA\_TRANSIS = \_F (*

*[§3.11]*

*NODE*  
= *Noah*,  
*[node]*

*SOUS\_STRUC*  
=  
*ss*,  
*[K8]*

*NOM\_CMP*  
=  
*nomcmp*, *[K8]*

*RELATION*  
= *F*,  
*[function]*

),  
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*RELA\_EFFO\_VITE = \_F (*

*[\$3.12]*

*NODE*

= *Noah*,

*[node]*

*SOUS\_STRUC*

=

*ss,*

*[K8]*

*NOM\_CMP=*

*nomcmp, [K8]*

*RELATION*

= *F,*

*[function]*

),

*# key Words only associated with method "ITMI"*

*[\$3.13]*

*BASE\_ELAS\_FLUI =*

*mix, [melasflu]*

*NUME\_VITE\_FLUI =*

*Nvitf, [I]*



*ETAT\_STAT*

=

/

“NOT”,

[DEFECT]

/

“YES”,

*PREC\_DUREE =/1.E-2,*

[DEFECT]

/

*prec,*

[R]

*CHOC\_FLUI*

=

/

“NOT”,

[DEFECT]

/

“YES”,

*NB\_MODE = Nmode,*

[I]

*NB\_MODE\_FLUI*

=

*Nmodef, [I]*

*TS\_REG\_ETAB = tsimu,*

[R]

*# End of the key words only associated with method “ITMI”*

*FILING*

=

*\_F (/LIST\_ARCH*

=

*l\_arch, [l\_I]*  
*[\$3.14]*

*/PAS\_ARCH = ipa,*

*[I]*

*),*

*INFORMATION =/1,*  
*[DEFECT]*

*/2,*

*IMPRESSION*  
*=*  
*\_F (*

*/ALL = "YES", [DEFECT]*  
*/*

*LEVEL*

=

/

“*DEPL\_LOC*”,

/

“*VITE\_LOC*”,

/

“*FORC\_LOC*”,

/

“*TAUX\_CHOC*”,

*INST\_INIT*

=

*Ti*,

[*R*]

*INST\_FIN*

=

*tj*,

[*R*]

),

*TITRATE*

=

*titrate*,

[*l\_Kn*]

)

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### **3 Operands**

#### **3.1 Matrices**

##### **generalized**

***In the case of a calculation by modal recombination, the generalized matrices must be established by operator PROJ\_MATR\_BASE [U4.63.12] or by macro-order MACRO\_PROJ\_BASE [U4.63.11], starting from the same modal base.***

***In the case of a calculation by dynamic under-structuring, the generalized matrices must be established by operator ASSE\_MATR\_GENE [U4.65.04], starting from same generalized classification.***

***MASS\_GENE = my***

***Stamp of mass of the generalized system.***

***Concept of the matr\_asse\_gene\_R type.***

***RIGI\_GENE = laughed***

***Stamp rigidity of the generalized system.***

***Concept of the matr\_asse\_gene\_R type.***

***/AMOR\_GENE = amndt***

***Stamp damping of the generalized system.***

***Concept of the matr\_asse\_gene\_R type.***

*This option is not available with method “DEVOGE”.*

*/AMOR\_REDUIT = lam*

*List reduced depreciation (percentage of damping criticizes) corresponding to each mode of the system in the form of list of realities.*

*This option is not available in dynamic under-structuring because depreciation reduced must be defined for each substructure separately (operator MACR\_ELEM\_DYNA [U4.65.01]).*

*Note:*

*If the number of reduced depreciation given is lower than the number of vectors of base used in the modal base, depreciation of the additional vectors are taken equal to the last damping of the list.*

*/LIST\_AMOR = l\_amor*

*List the depreciation reduced in the form of concept listr8.*

## **3.2 Algorithms of integration**

### **3.2.1 Operand METHOD**

#### **METHOD**

=

*Choice of the numerical method of resolution.*

*In the case of a traditional calculation by modal recombination, the user has three methods of the explicit type, an integral method and method of an implicit type.*

*In the case of a calculation by dynamic under-structuring [R4.06.04], method of calculation transient on modal basis calculated by under-structuring supports all the diagrams of integration evoked except the integral method. On the other hand, method of calculation transitory on the “bases” of the substructures supports only the diagram of Euler and the diagram with step of time adaptive.*

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### **3.2.1.1 METHOD = “EULER”:** diagram clarifies order 1

*This diagram supports calculation with taking into account of the whole of localised non-linearities available.*

### **3.2.1.2 METHOD = “DEVOGE”:** diagram clarifies order 4

*The diagram of DEVOGELAERE supports calculation with taking into account of the whole of not localised linearities available.*

### **3.2.1.3 METHOD = “NEWMARK”:** implicit scheme

*This diagram allows only the integration of linear problems.*

### **3.2.1.4 METHOD = “ADAPT”:** diagram clarifies order 2

*This diagram supports calculation with taking into account of the whole of localised non-linearities available. This method uses the diagram of the centered differences, the algorithm of adaptation of no time is based on the calculation of a “apparent frequency”:*

**1**

**X**

**& - x&**

**F**

**T**

**T-1**

**APt =**

**2**

***X - X***

***T***

***T-1***

***One specifies Ci after the operands specific to the method of integration per step of adaptive times. They are the operands following of the key word factor INCREMENT:***

***NB\_POIN\_PERIODE = NR***

***A number of points per apparent period. It is this parameter which fixes the precision of calculation. It must to be at least equal to 20; its default value (50) guarantees a satisfactory precision (order from 1%) in the majority of the cases.***

***VITE\_MIN***

***=***

***Method of calculation the speed of reference used to evaluate the apparent frequency. When the denominator of the frequency connects (X - X***

***N***

***n-1) becomes weak, this one can***

***to become very high, which leads to an unjustified refinement of the step of time. To cure it, the algorithm uses the following criterion:***

***X - X***

***N***

***n-1***

***1***

***(x& - X***

***N***

***& N***

***& -1)***

***V***

***F***

***=***

***T***

***min***

***AP N***

***2***

***V***

***T***

***min***

*Vmin can be calculated in two ways different according to the value from VITE\_MIN:*

*V tn*

*“NORM” = min (N)*

*( )*

*V*

*T*

*=*

*for all the degrees of freedom.*

*100*

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*Can be used:*

*.*

*if the system has several degrees of freedom,*

*.*

*if the order of magnitude of displacement is not too different according to degrees' from freedom.*

*Max (V I (tp))*

*I*

*<*

*0 T < t*

*p*



*N*  
*“MAXIMUM” = Vmin (tn) =*  
*for the degrees of freedom I.*  
*100*

*Can be used:*

*·*  
*if the system has a small number of degrees of freedom (from 1 to 3),*

*·*  
*for a system with several degrees of freedom, if the order of magnitude of displacement is very different according to degrees' of freedom (for example involved of ddl of Lagrange in under-structuring),*

*·*  
*if the order of magnitude speed does not vary too much in the course of time.*

*NMAX\_ITER\_PAS = NR*

*A maximum number of reductions of the step of time per step of calculation. It is by defect equal to 16, it who limits the coefficient of reduction of the step to 0 7516*  
*10 2*

*·*  
*=*  
*- by iteration (when the step of time is too high, one takes again calculation with a weaker step:  $T = 0 7$*

*. 5t*

*N*  
*N).*

*NMAX\_ITER\_PAS can be:*

*·*  
*increased to allow the step time to fall in a more brutal way,*

*·*  
*decreased if the step of time seems excessively refined, for example in presence discontinuities (solid friction, discontinuous excitation,...).*

*COEF\_MULT\_PAS = cmp*

*Coefficient of increase in the step when the error is sufficiently weak:*

*0 7*

*. 5*

*T <*

***T***  
***= cmp T***  
***N***  
***.***  
***Nf***  
***n+1***  
***N***  
***APn***

***Its default value (cmp = 1.1) guarantees stability and precision, but it can in general be increased (with more up to 1.3) to accelerate integration.***

***COEF\_DIVI\_PAS = cdp***

***Coefficient of refinement of the step of time (>1) when the error is higher than 1, that the number maximum iterations (N\_MAX\_ITER\_PAS) is not reached and that the step of minimal time is not reached:***

***1.***  
***T <***  
***, NR***  
***< NR***  
***and T > plr.t***  
***N***  
***Nf***  
***iter***  
***iter\_max***  
***N***  
***initial***  
***AP N***  
***T***

***T***  
***N***  
***=***  
***N***  
***cdp***

***The default value is 1.33333334, that is to say a reduction of a factor 0.75.***

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***PAS\_LIMI\_RELA = plr***

***Coefficient applied to the step of initial time to define the limit of refinement and thus the step of minimal time:***

***The default value is 1.33333334, that is to say a reduction of a factor 0.75.***

***T***

***= plr T***

***min***

***. initial***

### ***3.2.2 Word***

***key***

***INCREMENT***

#### ***3.2.2.1 Operands***

***INST\_INIT/INST\_FIN***

***INST\_INIT = to***

***.***

***Methods “EULER”, “DEVOGE”, “NEWMARK”, “ADAPT”:***

***Moment of beginning of transitory calculation. In the event of recovery, one uses key word ETAT\_INIT***

***cf [§3.3]: under this key word, the initial moment is recovered with operand INST\_INIT or taken equal to the last moment of filed preceding calculation. Operand INST\_INIT must thus be used only if there is no resumption of a preceding calculation.***

•  
**Method “ITMI”:**

**Indicate the moment of beginning of simulation. When calculation in a step of time of the phase transient is required, simulation begins with  $INS\_INIT$  + “computing time from transient”**

$$INST\_FIN = tf$$

**Moment of simulation.**

**3.2.2.2 Operands**

**NOT/VERI\_PAS**

$$NOT = dt$$

•  
**Methods “EULER”, “DEVOGE”, “NEWMARK”:**

**No the time of transitory calculation.**

•  
**Method “ADAPT”:**

**Indicate at the same time the step of initial time and the step of maximum times used by the algorithm.**

**This parameter must be sufficiently weak:**

**- to allow the calculation of the static phases (which always uses the step of time maximum),**

**-  
to start the algorithm correctly.**

**It must however be sufficiently high not to penalize the whole of calculation.**

•  
**Method “ITMI”:**

**Indicate the step of time appointed for the first step of calculation (after possible passage of transient). Thereafter, the algorithm automatically manages the step of calculation according to rigidity of the structure and the zones of transition flight/shock.**

$$VERI\_PAS = \text{reference mark}$$

**Checking of the step of computing time relative to the step of time limits given in function the highest frequency of the modes of the modal base considered or bases of**

*substructures (cf [§4.2]).*

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*3.3 Word*

*key*

*ETAT\_INIT*

*Key word factor which allows a continuation of a transitory calculation, while taking as initial state:*

*.*

*that is to say a result resulting from a calculation by modal synthesis preceding EXCIT (RESU\_GENE);*

*.*

*maybe displacements and speeds expressed in the form of generalized assembled vectors EXCIT (DEPL\_INIT\_GENE and VITE\_INIT\_GENE)*

*Note:*

- This functionality is not available for a calculation by transitory under-structuring without double projection nor for method ITMI.*
- At the time of a continuation, the state of adherence or shock is not safeguarded.*
- Displacements and speeds generalized must be establish by the operator PROJ\_VECT\_BASE [U4.63.13] starting from the modal base used for the matrices of rigidity generalized or by operator RECU\_GENE [U4.71.03] steady to a calculation precedent.*

### 3.3.1 Operands

**RESU\_GENE/DEPL\_INIT\_GENE/VITE\_INIT\_GENE**

**/RESU\_GENE = tran**

*Concept of the tran\_gene type resulting from a preceding calculation with DYNA\_TRAN\_MODAL.*

**/I**

**DEPL\_INIT\_GENE = C**

*Concept of the vect\_asse\_gene type, generalized displacements initial.*

**I VITE\_INIT\_GENE = vo**

*Concept of the vect\_asse\_gene type, initial generalized speeds.*

### 3.3.2 Operand

**INST\_INIT**

**INST\_INIT = to**

*Moment of preceding calculation to in the case of extract and take as initial state a recovery. In the absence of this operand, the moment of recovery is taken equal to the last moment of preceding calculation filed.*

### 3.3.3 Operand

**CRITERION**

**CRITERION**

*Indicate with which precision the research of the moment must be done:*

*“RELATIVE”: interval of research [(1-prec) .instant, (1+prec) .instant]*

*“ABSOLUTE”: interval of research [moment-prec, instant+prec]*

*The criterion is “RELATIVE” by defect.*

### 3.3.4 Operand

**PRECISION**

**PRECISION**

**=/1.E-03**

**[DEFECT]**

**/**

***prec***  
***[R8]***

***Indicate with which precision the research of the moment must be done.***

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***Description of the loading: key word EXCIT***

***EXCIT***

***Key word defining the loading. This key word must be repeated time as many as there are vectors loading generalized fi. The total loading is the sum of these vectors loading.***

***3.4.1 Operands***

***VECT\_GENE/NUME\_MODE***

***The loading is taken into account in the form of vector projected on the modal basis***

***EXCIT =\_F (VECT\_GENE) or in the form of modal component EXCIT =\_F (NUME\_MODE) or both***

***at the same time.***

***/VECT\_GENE = v***

***Generalized vector allowing to describe the space distribution of the loading.***

***Concept of the vect\_asse\_gene type.***

***The generalized vectors must be establish by operator PROJ\_VECT\_BASE [U4.63.13] with to leave the modal base used for the generalized matrices. In the case of a calculation by dynamic under-structuring, the generalized vectors must be establish by the operator ASSE\_VECT\_GENE [U4.65.05] starting from the generalized classification used for generalized matrices.***

***/NUME\_MODE = nmod***

***Number of the mode of excitation of the structure.***

### ***3.4.2 Operand***

***FONC\_MULT/COEF\_MULT***

***/FONC\_MULT = F***

***Function of time (function) allowing to describe the temporal evolution of the vector loading.***

***/COEF\_MULT = has***

***Multiplying coefficient of the generalized vector (constant actual value compared to time).***

## ***3.5***

***Particular case of the seismic analysis***

***3.5.1 Taking into account of the modes neglected by static correction: key words MODE\_CORR, CORR\_STAT and D\_FONC\_\****

***During the seismic analysis of an excited mono structure, it is possible to take into account, has posteriori, the static effect of the neglected modes. In this case, at the time of the return on the physical base, them calculated relative displacements (respectively relative speeds and accelerations) are corrected by a pseudo-mode.***

***One will find the details of this type of correction in [R4.05.01].***

***Key words MODE\_CORR and EXCIT (CORR\_STAT, D\_FONC\_DT and D\_FONC\_DT2) specific to static correction a posteriori must be simultaneously present.***

***MODE\_CORR = modcor***

***Concept of the mult\_elas type produces by the macro-order MACRO\_ELAS\_MULT [U4.51.02] which corresponds to the linear static response of the structure to a unit loading of type forces imposed (constant acceleration) in the direction of the seism considered.***



*It is noted that there is as many loading case of direction of seism.*

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*EXCIT*

*=\_F (CORR\_STAT)*

*If MODE\_CORR is present, CORR\_STAT = "YES" makes it possible to take into account the contribution*

*modal correction a posteriori for each occurrence of key word EXCIT.*

*EXCIT =\_F (D\_FONC\_DT and D\_FONC\_DT2)*

*D\_FONC\_DT and D\_FONC\_DT2 are respectively the derivative first and derived seconds of time of the definite accélérogramme, in each seismic direction considered, by the operand FONC\_MULT. They balance the contribution of the modal correction a posteriori for each occurrence of key word EXCIT in order to obtain the corrections speed respectively and of acceleration on the physical basis.*

*Note:*

- The taking into account of the static correction excludes that from the multi-supports.*
- The concept mult\_elas must be based on a coherent classification of the equations (even profile and even option of renumerotation) with that of the system solved in operator DYNA\_TRAN\_MODAL.*
- With the ième occurrence of key word EXCIT corresponds the ième elastic solution of MODCOR.*

### **3.5.2 Taking into account of the multi-supports: key words *MODE\_STAT*, *MULTI\_APPUI* and *ACCE*, *QUICKLY*, *DEPL***

*In the case of a multimedia structure, in order to restore the sizes calculated in the reference mark absolute or to take into account nonlocated linearities, it is necessary to calculate the answer generalized in*

*taking into account the component of drive.*

*For more details, one will refer to the reference [R4.05.01].*

*Key words *MODE\_STAT* and *EXCIT* (*MULT\_APPUI*; *ACCE*, *QUICKLY*, and *DEPL*; *DIRECTION* and *NODE* or*

*GROUP\_NO*) specific to the taking into account of the multimedia character must be simultaneously present.

*MODE\_STAT = psi*

*Concept of the mode\_stat type produces by the order *MODE\_STATIQUE* [U4.52.14] which corresponds to (3 or 6) the .nb\_supports static modes (where nb\_supports is the number of supports who undergo a different acceleration).*

*EXCIT*

*=\_F (MULT\_APPUI)*

*If one calculates the seismic response of a multimedia structure, *MULT\_APPUI* = “YES”, one compare at every moment, the vector of absolute displacements of each point of shock considered, in order to determine if there is shock and to calculate the corresponding forces of shock. If not, *MULT\_APPUI* = “NOT”, one compares at every moment, the vector of relative displacements of each node likely to shock.*

*/ACCE*

*=  
ac,*

*QUICKLY*

*=  
VI,*

*DEPL*

*=  
dp*

*Names of the functions acceleration (*ACCE*), speed (*QUICKLY*) and displacement (*DEPL*) imposed at the time of*

*calculation of the seismic response of multimedia structures.*

*Note:*

*If the structure is mono-excited, the accélérogramme is defined by key word FONC\_MULT.*

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*DIRECTION = (dx, Dy, dz, drx, dry, drz)*

*Components of the vector giving the direction of the seism in the total reference mark.*

*/*

*NODE*

*=*

*lno*

*/*

*GROUP\_NO =*

*lgrno*

*List names of nodes (or group of nodes) corresponding to the supports concerned where seism is imposed.*

*3.6 Taking into account of nonlocalised linearities of shock type,*

## ***friction and fluid blade***

### ***3.6.1 Not localised linearities of shock type and friction: key word SHOCK***

#### ***SHOCK***

***This key word factor is used for the study of the response of structures (generally slim) whose displacements are limited in one (or several) (S) - not specified a priori by the user by the presence of an obstacle (the various types of obstacles available are described in documentation [U4.44.21] of operator DEFI\_OBSTACLE), another antagonistic structure or of an effect of blade fluid.***

#### ***3.6.1.1 Operand***

##### ***ENTITLE***

***ENTITLE = int***

***Heading (eight characters to the maximum) allowing to name non-linearity. If nothing is specified by the user, the heading is the name of the NOEUD\_1.***

#### ***3.6.1.2 Operands***

***NOEUD\_1/NOEUD\_2/GROUP\_NO\_1/GROUP\_NO\_2***

***NOEUD\_1 or GROUP\_NO\_1***

***Node or name of the group of node of the structure to which the condition of non-linearity relates. In the case of a non-linear calculation by dynamic under-structuring, one indicates under this key word***

***the node of shock pertaining to the first substructure (various substructures do not belong to the same grid).***

***NOEUD\_2 or GROUP\_NO\_2***

***Node or name of the group of node of the second structure to which the condition relates of non-linearity. This operand is specific to the definition of a contact between two structures mobiles.***

***In the case of a non-linear calculation by dynamic under-structuring, one specifies the node of shock coinciding with the node indicated in NOEUD\_1 (or GROUP\_NO\_1), but pertaining to second substructure.***

***Note:***

***It is checked that the groups of nodes contain well one and only one node.***

#### ***3.6.1.3 Operand***

## **OBSTACLE**

**OBSTACLE = obs**

*Name of the concept of the obstacle type defining the geometry of an indeformable obstacle or form envelope of the play between two antagonistic structures. It is produced by the operator **DEFI\_OBSTACLE** [U4.44.21].*

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### **3.6.1.4 Operand**

**NORM\_OBST**

**NORM\_OBST = NOR**

*List of 3 realities defining the normal in the plan of cut of the obstacle, i.e. the vector **xloc**. One advises that **xloc** is the direction of neutral fibre or a generator of the structure studied.*

### **3.6.1.5 Operand**

**ORIG\_OBST**

**ORIG\_OBST = ori**

*List of 3 realities defining the position of the origin of the obstacle in the total reference mark (key word obligatory in the case of shocks between a mobile structure and a fixed wall). In the case of*

*shocks between two mobile structures, the code considers by defect that the origin is located at medium of the two nodes of shock NOEUD\_1 (or node of the GROUP\_NO\_1) and NOEUD\_2 (or node of GROUP\_NO\_2).*

### **3.6.1.6 Operand PLAY**

*PLAY = play*

*In the case of a shock enters a mobile structure and an indeformable obstacle, the operand PLAY represent:*

*·  
the half-distance inter-plans for obstacles of the type PLAN\_Y and PLAN\_Z*

*·  
the radius of the circular obstacle for an obstacle of the type RINGS*

*This key word is unutilised in the case of obstacles discretized by segments of the DISCRETE type.*

*Note:*

*The obstacle of the type PLAN\_Y or PLAN\_Z comprises in fact two plane obstacles. Thus in case where the user wishes to model the shock on a single level, not to be obstructed by the rebound of the structure studied on the symmetrical level, one advises with the user of to push back very far (cf [3.6.1.6 Figure - has]), J represents the real play between the studied structure and the obstacle.*

*Yloc*

*Y*

*play*

*J*

*Zloc*

*K*

*X*

*orig\_obs*

*m*

*no1*

*Appear 3.6.1.6 - has: System mass-arises impacting a fixed wall*

*Note:*

*The key word PLAY is not used in the case of shock between mobile structures.*

*The various cases of plays are represented in the documentation of DEFI\_OBSTACLE [U4.44.21].*

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### **3.6.1.7 Operand**

**ANGL\_VRIL**

*ANGL\_VRIL = gamma*

, angle in degrees defining the angular position of the local reference mark of the obstacle in its plan.

By convention, normal **N** in the plan of cut of the obstacle, *NORM\_OBST* defines the axis **xloc** locate local. One passes from the total reference mark **X Y Z** to the reference mark of the plan of obstacle **N y Z**

**2 2** by one

product of two rotations of angles around **Z** then around transformed **y1** of **Y**.

The position of the obstacle in this plan is obtained by a rotation of angle around the direction normal **xloc** (cf [3.6.1.7 Figure - has]).

**Z2**

**Zloc**

**Z=Z1**

**Y**

**Y2 = Y1**

**Yloc**

Obstacle of the type *PLAN\_Z*

**Xloc = N = X2**



*X1*

*X*

*Y*

*X1*

*Z2*

*Y1*

*X2*

*Zloc*

*X1*

*Z2*

*Yloc*

*X*

*Z1*

*Y2*

*Z=Z1*

*Y1=Y2*

*X2=Xloc*

***Appear 3.6.1.7 - has: Rotations allowing to pass from the total reference mark to the local reference mark of the obstacle.***

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*The angles and are automatically given starting from the normal with obstacle N.*

*locate local X*

*, Y*

*, Z*

*loc*

*loc*

*loc*

*results then from the reference mark N, y*

*, Z*

2  
 2 per rotation of an angle  
 of gimlet ANGL\_VRIL around N.

**Note:**

- *If the user does not specify anything, the angle of gimlet is calculated by the code in the case of shocks between mobile structures with obstacles of the type BI\_PLAN.*
- *With regard to the other types of obstacles, the default value of gamma is zero.*

**3.6.1.8 Operands**

***DIST\_1/DIST\_2***

*DIST\_1 = dist1*

*Outdistance characteristic of matter surrounding NOEUD\_1: no1 (or GROUP\_NO\_1).  
 Operand specific to the contact between two mobile structures.*

*DIST\_2 = dist2*

*Outdistance characteristic of matter surrounding NOEUD\_2: no2 (or GROUP\_NO\_2).  
 Operand specific to the contact between two mobile structures.*

**Note:**

- *DIST\_1 and DIST\_2 is defined within the meaning of the outgoing normals of the two solids in opposite (DIST\_1 and DIST\_2 they are > 0 bus represent the thickness of the structures studied).*
- *Because of the calculation of the normal distance from shock, the sum of DIST\_1 and DIST\_2 must to be sufficiently large compared to the supposed amplitude of the relative displacement of*

*nodes of shocks (cf [R5.06.03]).*

### **3.6.1.9 Operands**

#### **SOUS\_STRUC\_1/SOUS\_STRUC\_2**

*SOUS\_STRUC\_1 = ss1*

*Name of the substructure which contains the node of shock informing key word NOEUD\_1 (or GROUP\_NO\_1).*

*SOUS\_STRUC\_2*

*= ss2*

*Name of the substructure which contains the node of shock informing key word NOEUD\_2 (or GROUP\_NO\_2).*

### **3.6.1.10 Opérande LOCATES**

**LOCATE = reference mark**

*Specify the reference mark in which the position of the obstacle is defined.*

/

**“TOTAL”**

*The absolute position of the obstacle is defined independently of rotations and translations which the various substructures are subjected.*

/

**nom\_sst**

*Name of a substructure.*

*The position and the normal of the obstacle are given in the reference mark used to define them co-ordinates of the nodes of the substructure nom\_sst, the position and the normal finales of the obstacle being the result of rotation and the translation to which is subjected substructure.*

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### *3.6.1.11 Operand RIGI\_NOR*

*RIGI\_NOR = kN*

*Value of the normal rigidity of shock (N/m unit in USI).*

### *3.6.1.12 Operand AMOR\_NOR*

*AMOR\_NOR = Cn*

*Value of the normal damping of shock (unit NR m/s in USI).*

### *3.6.1.13 Operand RIGI\_TAN*

*RIGI\_TAN = kt*

*Value of the tangential rigidity of shock (N/m unit in USI).*

### *3.6.1.14 Operand AMOR\_TAN*

*AMOR\_TAN = ct*

*Value of the tangential damping of shock (unit NR m/s in USI).*

*Note:*

*If a stiffness kt is specified and that key word AMOR\_TAN misses, the code calculates one damping optimized in order to minimize the residual oscillations in adherence according to the formula:*

$$C = 2 (K + K) m - 2 K m$$

*T*

*I*

*T*

*I*  
*I*  
*I*  
*I*

*where I is the index of the dominating mode in the response of the structure.*

### **3.6.1.15 COULOMB Operand**

*COULOMB = driven*

*Value of the coefficient of friction of COULOMB.*

### **3.6.2 Not localised linearities of fluid blade type**

*The operands following are specific to transitory calculation with localised non-linearity of blade type fluid.*

#### **3.6.2.1 Operands**

*NMAX\_ITER/RESI\_RELA/LAMBDA*

*In this case, the projected system takes the form:*

*T. M.& + T.*

*C. & + T. K. = T. F (T) + T. F*

*(. . &.*

*T*

*T*

*T*

*E*

*fluid*

*T*

*T*

*& T)*

*&t is thus not given explicitly according to,*

*T*

*T*

*&. To obtain accelerations*

*generalized, one uses the algorithm of point fixes according to:*

*&0 = &*

*T*

*T1*

*-, ,*

*T*

***T***  
**& are given. One repeats until convergence:**

-  
&  
*i+1*  
*I*  
= [*T*. (*M* +.  
*T*  
*T*  
*I*  
*T*  
*T*  
*I*  
*T*  
*I*  
*My*).]. (. *F*  
+. *Mr.*  
*fluid*  
*has*  
&  
+. *F* -.  
*C.*  
*T*  
*E*  
& -. *K.*  
*T*  
*T*  
*T*)

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**where:**

**My the diagonal contribution of the matrix of added mass represents resulting from fluid blade,**

**is a parameter (higher than 1) used to guarantee the character contracting of the iterations of fixed point. By defect = 10.**

**Convergence is tested by  $\&i+1 - \&i < . I$**

**T**

**&**

**T**

**T where is the relative residue.**

**NMAX\_ITER = niter**

**Numbers maximum iterations of the algorithm. By defect, niter = 20.**

**RESI\_RELA = residue**

**Relative residue, noted above. By defect, = 103.**

**LAMBDA: lambda**

**Parameter of convergence, noted above. By defect, = 10.**

### **3.6.2.2 Operands**

**LAME\_FLUIDE/ALPHA/BETA/CHI/DELTA of the key word factor SHOCK**

**LAME\_FLUIDE = reference mark**

**Specify if the interaction enters the node and the obstacle or between the two nodes has involved place of a fluid blade. By defect, the connection is supposed of dry contact type.**

**The force of reaction of the fluid blade [R5.06.05] takes the following general form:**

**X**

**X 2**

**X**

**X X**

*Ffluid* =.

&

.

&

.

&

+. &. &

*X + H +*

*X + H + (X +h) 3 (X +h) 2*

*where H is the thickness of the fluid blade at rest.*

*ALPHA, BETA, CHI, DELTA*

*Parameters of the fluid force of blade.*

*3.7 Word*

*key*

*VERI\_CHOC*

*Key word which makes it possible to evaluate a posteriori, the aptitude of the modal base to represent them correctly impacts.*

*If VERI\_CHOC is present, one calculates in each node of shock and for each mode, the rate of*  
*2*

*N (T I. im*

*F Po)*

*reconstitution of the static solution: T = K*

*S*

*statics*

*and, for information, the rate of*

*K*

*i=1*

*I*

*N T I. im*

*F Po*

*reconstitution of the shearing action: T*

*T*



**NR =**

**. (im**

**F Po. K.i). One calculates then them**

**K**

**i=1**

**I**

**values cumulated on the whole of the modes which constitute the modal base used.**

**It is checked that the report/ratio of the neglected flexibility (static flexibility minus static flexibility reconstituted) on the flexibility of shock remains lower than the value given by the operand**

**THRESHOLD (THRESHOLD**

**0.5 per defect are worth) if not:**

**.**

**if STOP\_CRITERE = "YES" one stops the execution of the program (it is the case by defect);**

**.**

**if STOP\_CRITERE = "NOT" one continues the execution of the program with emission of one alarm.**

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**Note:**

- This functionality is available only for obstacles of the plane type or bi\_plan.**
- If the rate of reconstitution of the static solution is lower than the value of the threshold, one advises with the user to supplement the modal base by the local modes at the points of shock which have**

*an important local flexibility.*

*· The formula is not applicable in the event of static modes (noninvertible matrix of rigidity). Calculation continues then without checking of the criteria of shock and the user is informed by it.*

### **3.8 Word**

*key*

**ANTI\_SISM**

*Key word ANTI\_SISM is incompatible with a calculation by dynamic under-structuring. It allows to calculate the nonlinear force which exists if an antiseismic device is placed between the two nodes antagonists whose names are specified by the key words (NOEUD\_1 or GROUP\_NO\_1 and*

*NOEUD\_2*

*or GROUP\_NO\_2):*

*(K - K*

*1*

*2) X*

*X*

*F*

*K X*

*+ C sign (X*

*2*

*&) X*

*D =*

*+*

*&*

*2*

*X*

*K X*

*max*

*1 + 1*

*Py*

**RIGI\_K1, RIGI\_K2, SEUIL\_FX, C, PUIS\_ALPHA and DX\_MAX**

*Parameters of the force due to the presence of an antiseismic device.*

*As example, values of the parameters for an antiseismic device of BULGE type are:*

*K1 = 6. E+06 N/m, K2 = 0.53 E+06 N/m, Py = 1200. , C = 0.07 E+05 Nm/s, alpha = 0.2 and xmax = 0.03 m (if the problem is posed in USI).*

### **3.9 Word**

**key**

**BUCKLING**

*This key word is used for the detection of possible buckling and the evaluation of the deformation residual of an element at the time of a shock between two mobile structures or a mobile structure and a fixed wall. The force of reaction at the time of a shock with taking into account of buckling can be summarized by the following diagram:*

***F***

***Flim***

***kN***

***Fseuil***

***k2***

***compression***

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*It is considered that there is buckling if the force of reaction  $F$  reaches the value limits  $F_{lim}$  defined by the user. The normal rigidity of shock after buckling  $k_2$  is then different from front rigidity buckling  $kN$ .*

*Only the operands specific to the key word BUCKLING are detailed. The other key words allow to define the places of shock and are identical to the operands of the key word SHOCK.*

***FNOR\_CRIT = flim***

***Force normal limit which involves the buckling of the structure.***

***FNOR\_POST\_FL = fseuil***

***Force normal limit after buckling which causes a residual deformation of the structure.***

***RIGI\_NOR\_POST\_FL = k2***

***Value of normal rigidity after buckling.***

***Note:***

***The calculation of shock with buckling does not allow the taking into account of the fluid blade and of the damping of shock.***

### ***3.10 Word***

***key***

***RELA\_EFFO\_DEPL***

***RELA\_EFFO\_DEPL***

***Key word factor allowing to define a relation force-displacement or moment-rotation on one degree of freedom given in the shape of a nonlinear curve.***

#### ***3.10.1 Operand NODE***

***NODE = No***

***Name of the node of the structure to which the relation relates.***

#### ***3.10.2 Operand SOUS\_STRUC***

***SOUS\_STRUC = ss***

***Name of the substructure containing the node informing the operand NODE.***

#### ***3.10.3 Operand NOM\_CMP***

***NOM\_CMP = nomcmp***

***Name of the component of the node of the structure to which the relation relates.***

#### ***3.10.4 Operand RELATION***

## **RELATION = F**

*Name of the nonlinear function.*

*The nonlinear relation is defined starting from the linear limit of behavior.*

*Note:*

*Contrary to key word RELA\_TRANSIS, there is not linear limit, the definite function under the key word RELATION is thus defined on] -, + [.*

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*The equilibrium equation, for the modelled structure, subjected to a horizontal acceleration of ground ax in direction X, and having terms of correction coming from non-linearities is written:*

$$Mx\ddot{x} + Cx\dot{x} + Kx = -My + F$$

*X*

*C*

*where FC is the corrective force due to nonthe linearity of the ground. It can, for example, be defined by the following relation (cf case test SDND103):*

*F (X*

*)*

*X*

$F(X)$   
*threshold*  
 $F(X)$   
 $C$   
 $=$   
 $-$   
 $)$  with, if  $X > X$   
 $() = K 1 -$   
 $. X.$   
 $X$   
*threshold, F X*  
 $0$   
*threshold*  
 $x0$

*In example Ci above, one thus imposes, under the operand RELATION the function:*

$K$   
 $F(X) = 0 X. [X - X$   
 $C$   
*threshold].*  
 $x0$

### 3.11 Word

key  
**RELA\_TRANSIS**

**RELA\_TRANSIS**

*This key word factor was introduced in order to ensure a compatibility with the preceding versions. It corresponds in fact to key word RELA\_EFFO\_DEPL of version 4. It thus allows, just like current key word RELA\_EFFO\_DEPL to impose a relation force-displacement on a degree of freedom of a node given in the form of a nonlinear function. The nonlinear relation being defined starting from the linear limit of behavior.*

*The operands NODE, SOUS\_STRUC, NOM\_CMP and RELATION have the same direction for key words RELA\_EFFO\_DEPL, RELA\_TRANSIS and RELA\_EFFO\_VITE. They are thus not detailed in this paragraph.*

### 3.12 Word

key  
**RELA\_EFFO\_VITE**

**RELA\_EFFO\_VITE**

***Key word factor allowing to define a relation force-speed on a degree of freedom of a node given in the form of a nonlinear function.***

***The operands NODE, SOUS\_STRUC, NOM\_CMP and RELATION have the same direction for key words RELA\_EFFO\_DEPL, RELA\_TRANSIS and RELA\_EFFO\_VITE. They are thus not detailed in this paragraph.***

### ***3.13 Response of mechanical systems very slightly deadened with couplings fluidelastic***

***One describes  $C_i$  below the key words specific to the calculation of the response of mechanical systems***

***linear very slightly deadened with couplings fluidelastic possibly associated with non-linearities located with the nodes of the shocks type and frictions.***

***METHOD = "ITMI"***

***This diagram of integration by integral method allows, for the slightly deadened systems, to obtain an exact response by taking account of the variations of fluidelastic forces obtained in the presence of shocks.***

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***Note:***

***This diagram of integration is not usable in continuation and does not allow calculation by***

*dynamic under-structuring.*

*The presence of the key word SHOCK is imperative even for simulations of phases without shocks known as “phases of flight”.*

*The taking into account of non-linearities of the fluid blade type was not introduced to date into diagram of integration*

*BASE\_ELAS\_FLUI = mix*

*Modal base used for calculation.*

*Concept of the melasflu type produces by the operator CALC\_FLUI\_STRU [U4.66.02] who contains the whole of the modal bases calculated for different the rate of flow definite. It key word is obligatory for method “ITMI”.*

*NUME\_VITE\_FLUI = Nvitf*

*Rate of flow retained for calculation (sequence number).*

*Allows to extract in the concept melasflu the modal base corresponding at the speed of flow retained (cf [U4.66.02]). This key word is obligatory for method “ITMI”.*

*ETAT\_STAT*

*=*

*For the systems very slightly deadened, this option makes it possible to avoid an expensive calculation of linear phase preceding the first shock. This phase, called thereafter “transitional stage” precede the establishment by a mode made up of a succession of nonlinear phases of shocks and/or of linear phases called of “flight” according to functions' of excitation of the mechanical system applied. The time of transient corresponds to a displacement equal to the play of a thrust. It can to be relatively important (50 to 100 seconds).*

*ETAT\_STAT = “YES”:* the passage in only one step of computing time of the phase allows transient.

*The passage of the transitional stage is carried out by supposing the mechanical system in “flight”. time necessary to the passage of the transient is estimated by the algorithm according to mechanical characteristics of the system in `flight '. This estimate is based on a criterion where intervene parameter PREC\_DUREE and the durations of excitations due to the turbulent efforts.*

*Note:*

*If one asks for a simulation with calculation in a step of time of the transitional stage, it will be necessary to take care to introduce one duration of sufficiently long excitation. This duration*



***must***

***to correspond to the duration necessary to the passage of the transient increased by the duration of simulation in established mode wished. This total duration of simulation will be indicated via two operands INST\_INIT and INST\_FIN under the key word factor INCREMENT.***

***ETAT\_STAT = "NOT": Simulation does not distinguish the transitory state from the established mode.***

***PREC\_DUREE = prec***

***Allows to define the precision chosen to determine the duration of the transitional stage according to formulate:***

***-***

***(***

***Ln prec)***

***T =***

***where***

***and***

***tr***

***reduced damping and the pulsation indicate respectively***

***2***

***0***

***0***

***0***

***0***

***of each mode considered. The default value of this parameter is 1%.***

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**CHOC\_FLUI**

=

*Determine the treatment carried out by the algorithm during the phases of shock with respect to the forces fluidelastic.*

*By defect, variation of the fluidelastic forces in phase of shock related to the modification of rigidity and of the damping of the mechanical system (impact on the thrust) is not taken in count.*

**NB\_MODE = Nmode**

*A number of modes of the modal base retained for dynamic calculation.*

*The preserved modes correspond to increasing frequencies (first modes). If*

*NB\_MODE is not specified, one takes all the modes of the modal base of the concept of the type melasflu.*

**NB\_MODE\_FLUI = Nmodef**

*A number of modes of the modal base disturbed by the fluidelastic phenomena of coupling in phase of shock (lower than the number of modes retained for dynamic calculation).*

*The preserved modes correspond to Nmodef first increasing frequencies (first modes). If NB\_MODE\_FLUI is not specified, one takes the number of modes retained for dynamic calculation.*

**TS\_REG\_ETAB = tsimu**

*Duration of desired simulation.*

*In the case of a simulation without preliminary calculation and in a step of time of the transitional stage*

*(ETAT\_STAT = "NOT"), this duration corresponds to the duration of simulation whatever the state of*

*system enters the moments of beginning and end of simulation. Consequently one will have to ensure oneself*

*that: TS\_REG\_ETAB INST\_FIN - INST\_INIT*

*By defect, one will have TS\_REG\_ETAB = INST\_FIN - INST\_INIT*

*In the case of a simulation with calculation of the transitional stage (ETAT\_STAT = "YES"), this duration corresponds to the duration of really desired simulation when the phase of shocks is established from the numerical point of view. Consequently one will have to make sure that:*

***TS\_REG\_ETAB INST\_FIN - INST\_INIT - “time considered transitory”***

***If this last condition is not observed, the user is informed with precision of the minimum time of excitation necessary for its calculation INST\_FIN - INST\_INIT. By defect, one a: TS\_REG\_ETAB = INST\_FIN - INST\_INIT - “time considered transitory”***

### ***3.14 Word***

***key***

***FILING***

***FILING***

***Key word factor defining filing.***

#### ***3.14.1 Operand LIST\_ARCH***

***Methods “EULER”, “DEVOGE”, “NEWMARK”:***

***/LIST\_ARCH = l\_arch***

***List entirities defining the moments of calculation for which the solution must be filed in the concept tran\_gene result.***

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#### ***3.14.2 Operand PAS\_ARCH***

**PAS\_ARCH = ipa**

· **Méthodes “EULER”, “DEVOGE”, “NEWMARK”, “ITMI”:**

**Entirety defining the periodicity of filing of the solution of transitory calculation in the concept tran\_gene result.**

**If ipa = 5 one files all the 5 steps of calculation.**

**Whatever the option of filing chosen, one files the last step of time and all the fields associated to allow a possible recovery.**

**By defect one files all the steps of calculation.**

·  
**Method “ADAPT”:**

**Entirety which makes it possible to calculate the interval between two moments of filing in the concept**

**result, equal to PAS\_ARCH\*PAS. With this convention, the step of filing is always superior or equal to the maximum step used by calculation.**

**With a variable step, the moments of filing do not correspond exactly to steps of calculation. The algorithm thus files the sizes with the steps of calculation closest to the moments of filing indicated by the user (in Tn on this diagram):**

**No calculation**

**T**

**Tn+1**

**N**

**No filing**

**Moments of filing**

### **3.15 Operand**

#### **INFORMATION**

**INFORMATION = imp**

**Entirety allowing to specify the level of impression in the file MESSAGE.**

**If INFORMATION: 1, one prints following information in the file MESSAGE:**

**<I> <nom of the routine where information suivantes> is written**

**If <I> <MDTR74>, one recalls that it is a transitory calculation on modal basis “traditional”, if not <I> <SSDT74> it is a transitory calculation on modal basis by under-structuring dynamics.**

**<----->**

#### **CALCULATION BY MODAL SUPERPOSITION**

**! The BASE OF PROJECTION EAST a >type of the base of projection<**

***! NB Of EQUATIONS EAST: Nb***  
***! METHOD UTILISEE EAST: >nom of the method of integration <***  
***! BASE UTILISEE EAST: >nom of the modal base <***  
***! NB OF BASIC VECTORS EAST: nbv***  
***! THE INITIAL TIME NO EAST: step value of initial time***  
***(only if method ADAPT requested)***  
***! THE TIME NO OF CALCULATION EAST: step value of computing time***  
***! NB OF CALCULATION EAST NO: nbc***  
***! NB OF FILE EAST NO: nba***  
***! THE NUMBER OF PLACE (X) OF SHOCK EAST: nbchoc***  
***! THE NUMBER OF RELA\_EFFO\_DEPL EAST: nbrelaed***  
***(only if the number of relations is nonnull)***  
***! THE NUMBER OF RELA\_EFFO\_VITE EAST: nbrelaev***  
***(only if the number of relations is nonnull)***

-----  
***If INFORMATION: 2, one prints, in addition to written information if INFORMATION is worth 1, them***

***following information in the file MESSAGE:***

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*For each obstacle:*

- *The number and type of the obstacle;*
- *The name and co-ordinates in the total reference mark of the node of shock (of the nodes of shock in the case of a shock between mobile structures);*
- *Orientation, in the total reference mark, of the normal to the obstacle;*
- *The value of the angle of gimlet;*
- *The value of the initial play;*

*And for each node of shock and each mode, the number of the mode, values of local stiffnesses of shock and the rate of local flexibility and the local flexibility. One also prints at the end, for each node of shock:*

*RATE OF RESTIT FLEXIBILITY: 9.9539E-01 is 99.53% of local flexibility;  
RATE OF RESTIT SHARP EFFORT: 1.8979E-02 is 1.89% of the sharp effort.*

*One prints these quantity overall for the whole of the modes and each mode.*

*One prints moreover:*

·  
*for each node of shock, local the flexibility reports/ratios on flexibility of shock and static flexibility minus local flexibility on flexibility of shock,*

·  
*for each mode, its participation on the deformations statics in the nodes of shock. It is worth the report/ratio of the number of conditioning of the matrix closed by the modal vector and them static deformations on the number of conditioning of the matrix of the deformations statics.*

### **3.16 Operand IMPRESSION**

#### **IMPRESSION**

*Key word factor which makes it possible to print in the file RESULT of the sizes, nonprintable by an operator of impression, such as local displacement, local speed, the forces of contact with the nodes of shock and the value cumulated on all the modes of the modal base of projection of the rate of reconstitution of the static solution.*

#### **3.16.1 Operands ALL/LEVEL**

*The key word LEVEL makes it possible to print one or more table (X) among “DEPL\_LOC”, “VITE\_LOC”, “FORC\_LOC” and “TAUX\_CHOC”. With ALL = “YES” (default value), one prints the four tables.*

#### **3.16.2 Operands INST\_INIT/INST\_FIN**

*These two key words make it possible the user to filter the impressions in each loop on the steps time.*

### **3.17 Operand TITRATE**

**TITRATE = title**

*Titrate structure of data result [U4.03.01].*

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## **4 Phase of execution**

### **4.1 Checking on the matrices**

***In the case of a calculation by modal recombination, one checks that the generalized matrices are well exits of a projection on a common basis and with the same number of basic vectors. In case of a calculation per dynamic under-structuring, one checks that the generalized matrices are well exits of the same generalized classification.***

### **4.2 Checking and council on the choice of the step of time for diagrams EULER, DEVOGE and NEWMARK:**

***One makes sure that the step of selected time checks the stability conditions of the numerical diagram (criterion CFL):***

- in the case of NEWMARK, stability is always assured but the going beyond of the criterion can to induce a lack of precision on the result and is announced by a message; calculation continues (with the risk to produce a not very precise or false result).***
- in the case of diagrams of EULER and DEVOGE, if operand VERI\_PAS is worth "YES" (value by defect), the execution is stopped, a step of minimum time is proposed. If the operand VERI\_PAS is worth "NOT" or if it is about diagram ADAPT, a message of alarm is transmitted and it calculation continues (with the risk to produce a not very precise or false result).***

***In a transitory analysis without non-linearity, it should be taken care that the step of time is such as:***

***$dt < 0,1/fn$  for NEWMARK and DEVOGE***

***$dt < 0,05/fn$  for EULER***

***fn being the highest frequency of the modes of the modal base considered.***

**Note:**

***It is mentioned that with nonlocalised linearities the step of selected time must be sometimes very lower than this advised value.***



## 4.3

### ***Production run for method “ADAPT”:***

***The execution is stopped when the step of time reaches a minimal step equal to NOT X PAS\_LIMI\_RELA.***

#### ***Note:***

***The diagram of the centered differences does not restore in an exact way the own pulsations of one system, which leads to important miscalculations in the two following cases:***

- ***Calculation of a very great number of free periods of oscillations;***
- ***Calculation of the oscillations of a system very slightly deadened (< 10%) excited on one frequency of resonance.***

***In these two cases, it is often necessary to increase parameter NB\_POIN\_PERIODE.***

***Method “ADAPT” can be used in under-structuring.***

***The step of time can be recovered by operator RECU\_FONCTION, with following syntax:***

```
not = RECU_FONCTION (  
RESU_GENE = dynamoda  
NOM_CHAM = PTEM  
....)
```

***For more clearness, it is in fact the decimal logarithm of the step of time which is stored in concept result of RECU\_FONCTION.***

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**Production run for method "ITMI"**

**The execution is stopped:**

**.**

**when the duration of excitation chosen by the user is incompatible with the time of simulation wished (mode established + simulation after obtaining the established mode). In it case, the user is informed with precision of the minimum time of excitation necessary for sound calculation,**

**.**

**when the algorithm does not succeed in finding a solution converged at the time of the diagonalisation matrix of stiffness,**

**.**

**when the phases of transition flight/shock cannot be given with a precision sufficient.**

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## 5 Examples of use

### 5.1 Calculation of the linear response of a system

One presents an example partial of use of a linear calculation of response with static correction.

#### # Description of the loading

```
condlim = AFFE_CHAR_MECA (MODEL = model,
DDL_IMPO=_F (GROUP_NO=' A2',
DX=0., DY=0., DZ=0., DRX=0., DRY=0., DRZ: 0.)
)
```

```
charge = AFFE_CHAR_MECA (model MODELE=,
FORCE_NODALE=_F (GROUP_NO=' B2', FX=1.0D6)
)
```

```
v_elem = CALC_VECT_ELEM (OPTION=' CHAR_MECA', CHARGE= charges)
```

```
v_asse = ASSE_VECTEUR (VECT_ELEM = v_elem, NUME_DDL=NUM)
```

#### # # Calculation of the static loading

```
modcor = MACRO_ELAS_MULT (model MODELE=, NUME_DDL= NUM,
CARA_ELEM = champcar,
CHAM_MATER= champmat,
CHAR_MECA_GLOBAL= condlim,
CAS_CHARGE= _F (NOM_CAS= "CASI",
CHAR_MECA= charges)
)
```

#### # # Calculation dynamic by modal superposition

# One projects on the first 9 modes of the base

```
MACRO_PROJ_BASE (BASE = MODES, NB_VECT = 9,
MATR_ASSE_GENE = _F (MATRIX = mass_gen, MATR_ASSE = m_asse),
MATR_ASSE_GENE = _F (MATRIX = rigi_gen, MATR_ASSE = k_asse),
VECT_ASSE_GENE = _F (VECTOR = vect_gen, VECT_ASSE = v_asse)
)
```

#### # # Response with static correction

#

```
tran_gen = DYNA_TRAN_MODAL (  
MASS_GENE = mass_gen,  
RIGI_GENE = rigi_gen,  
METHOD = "DEVOGE",  
MODE_CORR = modcor,  
EXCIT = _F (VECT_GENE = vect_gen,  
CORR_STAT = "YES",  
FONC_MULT = depl,  
D_FONC_DT = quickly, D_FONC_DT2 = gamma  
),  
INCREMENT = _F (INST_INIT= 0. ,  
INST_FIN: 0.1,  
NOT = 0.00001),  
FILING = _F (PAS_ARCH = 100)  
)
```

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*5.2*

*Calculation of the nonlinear response of a system*

*One presents the file of execution for the dynamic calculation of a steam generator with thrusts side and frontal tilted with 22° limiting its displacements (see [Figure 5.2-a]).*

*PUMP*

**Y**

**PRIMARY EDUCATION**

**Connect out of U**

**Cold branch**

**Frontal thrust**

**Side thrust**

**dimensioned PP**

**GENERATOR**

**D E VAPOR**

**Connect Chaud E**

**Side thrust**

**FERMENT**

**dimensioned opposite PP**

**22°**

**X**

*Appear 5.2-a: Diagram of a primary education branch of circuit*

**5.2.1 Modeling of the side thrust**

*The side thrust with the Steam generator is parallel to the axis of the hot branch. One selected one obstacle of the type BI\_PLAN\_Z, the normal direction of shock is thus Zloc (cf [Figure 5.2.1-a])*

**BI\_PLAN\_Z**

**Zloc**

**Y**

**Yloc**

**Steam Generator**

**22°**

**Center hot branch**

**Side thrust**

**X**

*Appear 5.2.1-a: Description of the side thrust of Steam Generator*

*One chooses that the normal direction in the plan of Xloc cut is axis Z of the total reference mark:*

**NORM\_OBST = (0. , 0. , 1.).**

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***Titrant:******Operator DYNA\_TRAN\_MODAL******Date:******18/02/05******Author (S):******E. BOYERE, Fe. Key WAECKEL******:******U4.53.21-G Page******: 32/34******.******Calculation of Yloc and Zloc in the total reference mark******According to the figure [3.6.1.7 Figure - has],***

***$$X_{loc} = \cos \cos X + \cos \sin Y - \sin Z$$***

***$$Y_{loc} = (- \sin \cos + \sin \cos \sin) X + (\cos \cos + \sin \sin \sin) Y + \cos \sin Z$$***

***$$Z_{loc} =$$***

***$$(\sin \sin + \sin \cos \cos) X + (- \cos \sin + \sin \sin \cos) Y + \cos \cos Z$$***

 ***$X_{loc} = Z$  thus  $= 90^\circ$  (2) and is unspecified, one takes  $= 0$*** 

***$$X_{loc} = Z$$***

***$$Y_{loc} = - \sin X + \cos Y$$***

***$$Z_{loc} = - \cos X - \sin Y$$***

***In the example [Figure 5.2.1-a], the side thrust with the Steam generator is parallel to the axis of the hot branch, it even tilted of  $22^\circ$  compared to axis X:  $Y_{loc} = \cos 22 X + \sin 22 Y$ . One has then:  $ANGL\_VRIL = -$*** ***•******68 .******.******Command file******#******# Calculation of the clean modes******#-----***

#

*modejeu = MODE\_ITER\_INV (MATR\_A = mkassjeu,  
 MATR\_B = mmassjeu,  
 CALC\_FREQ = \_F (OPTION = "ADJUSTS",  
 FREQ = (0.1, 40.),  
 NMAX\_FREQ = 150,*

)

)

#

# *Definition of the excitation*

#-----

#

*INCLUDE (UNIT = 38)*

#

*accelx = CALC\_FONCTION (COMB = \_F (FUNCTION = accdirx,  
 COEF = 3.)*

)

*dirxj = CALC\_CHAR\_SEISME (MATR\_MASS = mmassjeu,  
 DIRECTION = (1. , 0. , 0. ),  
 MONO\_APPUI = "YES")*

#

*# Calculation of the matrices of generalized mass and stiffness  
 # of a generalized effort*

#-----

#

*numgenej = NUME\_DDL\_GENE (BASE = modejeu,  
 STORAGE = "FULL")*

)

*rigigenj = PROJ\_MATR\_BASE (BASE = modejeu,  
 NUME\_DDL\_GENE = numgenej,  
 MATR\_ASSE = mkassjeu*

)

*massgenj = PROJ\_MATR\_BASE (BASE = modejeu,  
 NUME\_DDL\_GENE = numgenej,  
 MATR\_ASSE = mmassjeu*

)

*seismexj = PROJ\_VECT\_BASE (BASE = modejeu,  
 NUME\_DDL\_GENE = numgenej,  
 VECT\_ASSE = dirxj)*

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**#**

**# definition of an obstacle of the type BI\_PLAN\_Z**

**#-----**

**#**

**biplanz = DEFI\_OBSTACLE (STANDARD = "BI\_PLAN\_Z")**

**#**

**# calculation transitory generalized with presence of an obstacle to node NO10**

**#-----**

**#**

**Zloc**

**GV2INFL2**

**BUT11**

**DIST\_1**

**J**

**abtg122**

**Yloc**

**DIST\_2**

**Y**

**Steam Generator**

**Center hot branch**

**X**

**repbasnl = DYNA\_TRAN\_MODAL (METHOD = "ADAPT",**

**MASS\_GENE = massgenj,**

**RIGI\_GENE = rigigenj,**

**LIST\_AMOR = lamorjeu,**

**INCREMENT = \_F (INST\_INIT = t0,**



**NOT = not,**  
**INST\_FIN = tf**  
)  
**FILING = \_F (PAS\_ARCH = 10),**  
**EXCIT = \_F (VECT\_GENE = seismexj,**  
**FONC\_MULT = accelx,**  
**DIRECTION = (1. , 0. , 0. , 0. , 0. , 0.),**  
**GROUP\_NO = "SOL1"**  
)  
**SHOCK = \_F (ENTITLES = "GV2INFL2",**  
**GROUP\_NO\_1 = "BUT11",**  
**GROUP\_NO\_2 = "abtgvl22",**  
**OBSTACLE = biplanz,**  
**NORM\_OBST = (0. , 0. , 1.),**  
**ANGL\_VRIL = -68. ,**  
**DIST\_1 = 1.7749,**  
**DIST\_2 = 1.7749,**  
**RIGI\_NOR = 14.3E8,**  
**AMOR\_NOR = 7.E5,**  
)  
)

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**#**

**# statistical Post treatment of the shocks**

**#-----**

```

tabchoc = POST_DYNA_MODAL (RESU_GENE = repbasnl,
SHOCK = _F (NB_BLOC = 10,
OPTION = "IMPACT",
),
TITRATE = "RESULTS SHOCKS STEAM GENERATOR",
)
#
# Restitution on physical basis
#-----
#
repl = REST_BASE_PHYS (RESU_GENE = repbasnl,
TOUT_CHAM = "YES",
)
#
# Extraction of the curves
#-----
#
n2175axn = RECU_FONCTION (RESULT = repl,
NOM_CHAM = "ACCE",
NODE = "N2175",
NOM_CMP = "DX",
TITRATE = "AX NULL PLAY LCUVV"
)
#
# Impression of the curves
#-----
#
IMPR_COURBE (FILE = "GNU PLOT",
FORMAT = "AGRAF",
TITRATE = "ACCELERATIONS NONLINEAR CASE X IN LCUVV",
LABEL_X = "TIME (S)",
LABEL_Y = "ACCELERATION (m/s2)",
CURVE = _F (COLOR = "RED",
FUNCTION = n2175axn
),
)
#
END ()

```

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**Organization (S): EDF-R & D /AMA**

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**Operator DYNA\_ALEA\_MODAL**

## ***1 Goal***

***To calculate the spectral response of a linear structure under an excitation known by its DSP.***

***The operator provides the modal response in the form of interspectre of power.***

***The produced concept is of `tabl_intsp` type.***

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## ***2 Syntax***

***int***

***[`tabl_intsp`] = `DYNA_ALEA_MODAL`***

***(***

***`BASE_MODALE` = `_F`***

***(***

**MODE\_MECA**

=

**modemec [mode\_meca]**

**/NUME\_ORDRE = order**

**[l\_I]**

**AMOR\_REDUIT**

=

**lamor**

**[l\_R]**

/

**BANDAGE**

=

**(f1, f2) [l\_R]**

**AMOR\_UNIF**

=

**amor**

**[R]**

)

***MODE\_STAT***

=

***mosta***

***[mode\_stat]***

***EXCIT***

= ***\_F***

(

***# Order of derivation of the excitation***

***DERIVATION***

=

/

***0***

***[DEFECT]***

**/ 1**

**/ 2**

**SIZE =**

**/**

**“DEPL\_R”**

**[DEFECT]**

**/**

**“EFFO”**

**/**

**“SOUR\_DEBI\_VOLU”**

**/**

**“SOUR\_DEBI\_MASS”**

**/**

**“SOUR\_PRESS”**

**/**

**“SOUR\_FORCE”**

**#**

***interspectre***

***excitation***

***INTE\_SPEC***

=  
***interexc***  
***[tabl\_intsp]***  
***NUME\_VITE\_FLUI = list\_ind***  
***[l\_I]***  
***OPTION***  
=  
/  
***“ALL”***  
***[DEFECT]***  
***/“DIAG”***

#  
***place***  
***of application***  
***of***  
***the excitation***

***/NUME\_ORDRE\_I***

=  
***noi***  
***[l\_I]***

***NUME\_ORDRE\_J***

=  
***noj***  
***[l\_I]***

***/NODE***

=  
***list\_noe [l\_noeud]***



***NOM\_CMP =  
list\_comp [l\_cmp]***

***MODAL  
=  
“NOT” [DEFECT]***

***/CHAM\_NO =  
list\_vass [l\_cham\_no\_\*]***

***MODAL  
=  
“NOT” [DEFECT]***

/  
**MODAL**  
= "YES"

/  
**NOEUD\_I**  
=

**noeudi**  
[l\_noeud]

**NOEUD\_J**  
=

**noeudj**  
[l\_noeud]

**NOM\_CMP\_I** =

**cmpi**  
[l\_cmp]

**NOM\_CMP\_J** =

**cmpj**  
[l\_cmp]

**NODE** =

**list\_noe** [l\_noeud]

***NOM\_CMP***

=

***list\_comp***

***[l\_cmp]***

***MODAL =***

***“NOT” [DEFECT]***

)

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*ANSWER =\_F (*

*# order of derivation of the answer*

*DERIVATION =*

*/*

*0*

*[DEFECT]*

/ 1

/ 2

*# possible limitation of calculation to the diagonal*

*OPTION*

=

/

*“ALL”*

*[DEFECT]*

/

*“DIAG”*

*# frequential dicretisation for the answer*

*FREQ\_MIN*  
= *fmin*  
[R]

*FREQ\_MAX*  
= *fmax*  
[R]

*NOT*  
=

*not*

[R]

*FREQ\_EXCIT* =  
/  
“WITH”  
[DEFECT]  
/  
“WITHOUT”

*NB\_POIN\_MODE*

=

/

50

[DEFECT]

/N

[I]

)

*TITRATE*

=

*titrate*

[I\_Kn]

*INFORMATION =/1 [DEFECT]*

/ 2

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### ***3 Functionalities***

***Operator DYNA\_ALEA\_MODAL allows to calculate the response in the frequential field, on basis modal, of a structure subjected to an excitation represented by a matrix interspectrale (cf DEFI\_INTE\_SPEC [U4.36.02]).***

***The size excitation can be of imposed ddl type or effort associated with a ddl. It also can to correspond to sources of fluid excitation [R4.05.02].***

***The excitation can be given in form derived of a nature equal to 0, 1 or 2 (displacement, speed or acceleration).***



*L`operator REST\_SPEC\_PHYS [U4.63.22] makes it possible to restore the response in displacement or effort with the ddl “of observation” (couple node, component).*

*The matrix interspectrale modal answer thus calculated can be reintroduced in a new calculation.*

## **4 Operands**

### **4.1 Word**

*key*

**BASE\_MODAL**

**BASE\_MODAL = \_F (**

*Key word factor for the definition of the parameters of selection of the modal base of calculation.*

#### **4.1.1 Operand**

**MODE\_MECA**

**MODE\_MECA**

*= modemec*

*modemec is the concept of the mode\_meca type containing the dynamic modes.*

#### **4.1.2 Operands**

**NUME\_ORDRE/AMOR\_REDUIT**

**/NUME\_ORDRE = lordre**

*lordre is the list of the sequence numbers of the modes of the concept modemec actually taken in account in calculation. Example: (2 3 4).*

**AMOR\_REDUIT = lamor**

*lamor is the list of reduced modal depreciation corresponding to the modes selected. a many elements of the list are equal to the number of elements of lordre. Example: (0.05 0.05 0.02). This key word is usable only with NUME\_ORDRE.*

#### **4.1.3 Operands**

**BANDAGE/AMOR\_UNIF**

/  
**BANDAGE = (f1 f2)**

*The dynamic modes taken into account will be those of modemec whose frequency is in the band (f1 f2)*

**AMOR\_UNIF = amor**

*For each mode selected, damping is equal to amor. This key word is not usable that with BAND.*

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**4.2 Operand**

**MODE\_STAT**

**MODE\_STAT = mosta**

*Concept of the mode\_stat type containing the static modes necessary to calculation.*

*This key word is necessary only in the case of a seismic calculation multi-supports where the excitation*

*fact on ddl (I. E. when the key word SIZE under the key word factor EXCIT is worth "DEPL\_R").*

### **4.3 Word**

**key**

**EXCIT**

**EXCIT = \_F (**

*Key word factor defining all the parameters relating to the excitation.*

*The key words DERIVATION, SIZE and MODAL define the type of excitation.*

*Key words INTE\_SPEC, NUME\_VITE\_FLUI, NUME\_ORDRE\_I, NUME\_ORDRE\_J, NOEUD\_I, NOEUD\_J, NOM\_CMP\_I and NOM\_CMP\_J define the interspectre excitation.*

#### **4.3.1 Operand**

**DERIVATION**

**DERIVATION**

**=**

*When the size of the excitation is of imposed ddl type (“DEPL\_R”), this key word allows to describe if the interspectre excitation must be regarded as a displacement, a speed or an acceleration imposed. The user then specifies 0, 1 or 2.*

*This key word is optional. By defect, it is equal to 0.*

**Note:**

*In the case of a seismic calculation, the excitation is often an acceleration. This key word must then be equal to 2.*

#### **4.3.2 Operand**

**SIZE**

**SIZE**

**=**

*This key word makes it possible to say if the excitation is of imposed ddl type (“DEPL\_R”), imposed effort (“EFFO”), source of flow-volume (“SOUR\_DEBI\_VOLU”), source of flow-mass (“SOUR\_DEBI\_MASS”), source of pressure (“SOUR\_PRESS”) or fluid source of force (“SOUR\_FORCE”).*

*This key word is optional. By defect, it is equal to “DEPL\_R” and the excitation is of ddl type of displacement imposed in all the cases except in the case of supports represented by*

*assembled vectors (key word CHAM\_NO).*

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*4.3.3 Operands*

*INTE\_SPEC and NUME\_VITE\_FLUI*

*These key words define L (be) interspectre (S) of excitation.*

*INTE\_SPEC = interexc*

*interexc is the concept of the tabl\_intsp type containing the whole of the matrices interspectrales (spectral concentration of power) of excitation. It is taken into account such as it is defined in the function associated with the concept, i.e. in particular which one does not interpret a possible folding up of spectrum.*

*For a function defined by:*

*F [F, F*

*1*

*2 ]*

*S (F) given*

*One will interpret:*

*F < F*

**S**  
**1**  
**(F) = 0**  
**F [F, F**  
**1**  
**2 ]**  
**S (F) given**  
**F F**  
**S**  
**2**  
**(F) = 0**

**If the loop of frequency [F, F**  
**1**  
**2] must be reproduced for the negative frequencies, it is necessary:**

**.**  
**that is to say to give the whole of the spectrum on the axis of realities,**  
**.**  
**that is to say to apply a coefficient 2 to the value of the DSP, possible skirting,**  
**since all calculation is linear in order DYNA\_ALEA\_MODAL.**

**NUME\_VITE\_FLUI = nk**

**nk is the sequence number if the concept tabl\_intsp contains several tables of interspectres**  
**(indexed by this parameter).**

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### **4.3.4 Operands NUME\_ORDRE\_I, NUME\_ORDRE\_J, NODE, NOM\_CMP, CHAM\_NO and MODAL**

*These key words bind the terms of ( ) the interspectre (S) of excitation and the points of excitation for one modal excitation or when the parameters of the table were subscripted by sequence numbers.*

*/NUME\_ORDRE\_I = noi1, noi2.*

*NUME\_ORDRE\_J =noj1, noj2,...*

*These lists of sequence number are appairées two by two in order to determine it term of the matrix interspectrale given.*

*/NODE = list\_noe*

*This key word makes it possible to specify the nodes where the multispectral excitation will be applied. Example (N1 N5 N7).*

*For all the types of sizes of excitation, except for the sources of pressure and the sources of force, list\_noe contains as many terms as it y has couples of indices defining of the interspectres of excitation.*

*In the case of sources of pressure or sources of force, with each source is associated a dipole, i.e. two points of application.*

*list\_noe then has twice more terms than there are couples of indices defining interspectres.*

*NOM\_CMP = list\_cmp*

*This key word makes it possible to specify the components on which the excitation multispectral will be applied. Example ("CLOSE" "DRZ" "PHI").*

*These components must of course correspond to degrees of freedom of the nodes of supports.*

*In all the cases, list\_cmp has the same number of elements as list\_noe.*

*For the fluid sources, it is the ddl "CLOSE" which is excited.*

*MODAL = " NON' [DEFECT]*

*The excitation is not modal in this case.*

/  
**CHAM\_NO = list\_vass**

*When this key word is present, each support of excitation is a vector assembled definite before in the command file. list\_vass the list of the assembled vectors contains holding place of supports. Size associated exciter is "EFFO". It is recommended that the associated intensity to the effort which one imposes by this skew is given by the interspectre: assembled vector is primarily used to define a function of form support of a spectrum of power in effort. It is thus standardized.*

*This option makes it possible to affect a spectrum of power of effort on one function of form.*

*In all the cases, list\_vass contains as many terms as there is couples of indices defining of the interspectres.*

**MODAL = "NON" [DEFECT]**

*The excitation is not modal in this case.*

/  
**MODAL = "YES"**

*The presence of "YES" under this key word implies that the interspectre of excitation is regarded as a modal excitation.*

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#### **4.3.5 Operands**

**NOEUD\_I, NOEUD\_J, NOM\_CMP\_I and NOM\_CMP\_J**

*These key words bind the terms of ( ) the interspectre (S) of excitation and the points of excitation when them parameters of the table were subscripted by physical data made up of the couple (Node-CMP).*

*/NOEUD\_I = ndi1,  
ndi2,...  
NOM\_CMP\_I = cmpi1, cmpi2.*

*NOEUD\_J = ndj1,  
ndj2,...  
NOM\_CMP\_J = cmpj1, cmpj2,...*

*These lists of sequence number are appairées two by two in order to determine it term of the matrix interspectrale given. The length of the preceding lists must to correspond to the number of excitations imposed on the structure.*

**NODE**  
=

*list\_noe [l\_noeud]*

**NOM\_CMP = list\_comp**

*[l\_comp]*

*These two key words have the same significance as in [§4.3.4].*

**MODAL**  
=

**“NOT” [DEFECT]**



*The excitation is not modal in this case.*

#### **4.4 Word**

*key*

**ANSWER**

**ANSWER = \_F (**

*Key word factor for the definition of all the parameters concerning the answer.*

*The three following key words describe the type of the answer.*

##### **4.4.1 Operand**

**DERIVATION**

**DERIVATION**

=

*This key word has the same direction as for the key word factor EXCIT [§4.3.1].*

##### **4.4.2 Operand**

**OPTION**

**OPTION**

=

*If this key word is specified with “DIAG”, then all the nondiagonal functions of the interspectre answer are initialized to zero without being calculated. Only the autospectres are calculated. In the contrary case (“ALL”), all the functions of the interspectre answer are calculated.*

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#### **4.4.3 Operands**

**FREQ\_MIN/FREQ\_MAX/NOT/FREQ\_EXCIT/NB\_POIN\_MODE**

*These key words are used to describe the frequential discretization in which the answer will be given.*

**FREQ\_MIN = fmin**

**FREQ\_MAX = fmax**

*fmin and fmax are the two terminals of the interval of frequency. not is the minimum step of discretization.*

**NOT = not**

**fmax - fmin**

*If the values of fmin and fmax are given, not is then worth by defect*

**.**  
**100**

*If not one takes fmax the greatest Eigen frequency of the dynamic modes retained for calculation.*

**2\*fmax**

*Then the discretization covers the field [0; 2\*fmax], not =*

**.**  
**100**

*On the other hand, if not is present, one makes sure that the step of discretization of the answer is everywhere lower than step.*

**FREQ\_EXCIT =**

**/**

**“WITH”**

/

**“WITHOUT”**

*If the user gives the argument “WITH” under key word **FREQ\_EXCIT**, then the frequencies excitation are integrated into the discretization of the answer (default option). If it gives the argument “WITHOUT”, they will be ignored. This key word is put at “WITHOUT” in the event of presence key word **FREQ\_MIN**.*

**NB\_POIN\_MODE = N [defect = 50]**

*The response is refined to the place of the Eigen frequencies in order to ensure good description of the response to the place of the peaks.*

*Key word **NB\_POIN\_MODE** makes it possible to define the number of steps of frequency per frequency proper taking into account. By defect, there are 50 steps per Eigen frequency. This key word is not taken into account if **FREQ\_MIN** is given.*

*Each function of the interspectre will have by defect a mode of interpolation of the type “LINEAR” and a mode of prolongation out of the field of discretization of the type “EXCLUDED”.*

#### **4.5 Operand**

**TITRATE**

**TITRATE = title**

*title is the title of calculation. It will be printed at the head results. See [U4.03.01].*

#### **4.6 Operand**

**INFORMATION**

**INFORMATION**

=

*Specify the options of impression on the file **MESSAGE**.*

**1**  
*no impression*

**2**  
*point out the selected options of calculation.*

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**5 Remarks**

**of use**

**·**  
**Need for a static and standard mode of dynamic modes:**

***In the case of excitation in imposed displacement, the dynamic modes are calculated in supports blocked and the presence of the static mode is obligatory.***

***In the other cases, the dynamic modes are calculated in free supports, and the presence of one static mode is not justified any more.***

***dimension of the matrix interspectrale = a number of static modes + a number of modes dynamic taken into account.***

***Thus, for a structure with five dynamic modes, excited in displacement by two supports, dimension of the matrix interspectrale of modal answer is 7.***

***If the excitation is given in imposed force, there are not static modes and the dimension of stamp interspectrale is 5.***

**·**  
**Use of the MODAL key word under the key word factor EXCIT:**

*In the case of use of the MODAL key word under the key word factor EXCIT to introduce directly the matrix of modal response like excitation, it is necessary to give again under the key words EXCIT BASE\_MODAL and MODE\_STAT all the arguments which had been used to create the matrix interspectrale modal (nodes and ddls supports).*

## **6** *Phase of checking*

*The coherence of the data is checked:*

*.  
a number of modal depreciation = a number of modes selected.*

*.  
a number of nodes of supports equal to the component count (for the excitation).*

*.  
a number of couples of indices retained in the interspectre excitation = a number of supports or a number of points of excitation.*

*.  
in the case of sources of pressure: a number of nodes supports equal to twice the number couples of indices retained in the interspectre of excitation.*

*.  
the presence of a mode\_stat is checked in the cases of excitation by a size of the type DEPL\_R.*

*.  
fmax fmin.*

## **7 Example**

```
DYNALEA1=DYNA_ALEA_MODAL (  
BASE_MODAL=_F (  
MODE_MECA = FREQ1,  
NUME_ORDRE = 1,  
AMOR_REDUIT = 0.05),  
MODE_STAT=MODESTA1,  
EXCIT=_F (  
DERIVATION = 2,  
INTE_SPEC = INTEREXC,  
NUME_ORDRE_I = 1,  
NUME_ORDRE_J = 1,  
NODE = "PI",  
NOM_CMP = "DX"),
```

**REPNSE=\_F (**  
**DERIVATION = 2)**  
**)**

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***Operator DYNA\_SPEC\_MODAL***

***Date:***  
***27/01/05***  
***Author (S):***  
***A. Key ADOBES***  
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***Organization (S): EDF-R & D /MFTT***

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## ***Operator DYNA\_SPEC\_MODAL***

### ***1 Goal***

***To calculate the response by modal recombination of a linear structure to a random excitation. This excitation is defined in the form of interspectres of power of modal efforts. The answer is established in the form of interspectres of power of generalized displacements.***

***Each matrix interspectrale is associated a modal base for which the answer is calculated. The produced result is a concept of the tabl\_intsp type.***

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***2***

***Syntax***

***tinsp [tabl\_intsp] = DYNA\_SPEC\_MODAL***

***(***

***BASE\_ELAS\_FLUI***

***=***

***bef***

***,***

**[melasflu]**

**EXCIT = \_F**

(

**INTE\_SPEC\_GENE = exc**

,  
**[tabl\_intsp]**

)

**OPTION**

=

/

**“ALL”**

**[DEFECT]**

/

**“DIAG”**

,

**TITRATE**

=

**titrate**

, **[TXM]**

);

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Operator *DYNA\_SPEC\_MODAL*

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**3**

**Operands**

**3.1 Operand**

**BASE\_ELAS\_FLUI**

*BASE\_ELAS\_FLUI = bef*

*Concept of the melasflu type, defines a whole of modal bases associated different rates of flow of the fluid.*

**3.2 Key word**

**EXCIT**

*EXCIT*

*Key word factor which defines the excitation.*

*INTE\_SPEC\_GENE = exc*

*Concept of the tabl\_intsp type, defines the interspectres excitation (modal efforts).*

**3.3 Operand**

**OPTION**

*OPTION = "ALL" or "DIAG"*

*Argument of the text type which indicates if one wants to calculate all the interspectres “ALL” or them autospectres only “DIAG”. By defect one calculates all the interspectres.*

### **3.4 Operand**

#### **TITRATE**

*TITRATE = title*

*Argument of the text type defining the title attached to the concept tabl\_intsp at exit.*

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*Titrate:*

*Operator* ***THER\_LINEAIRE***

*Date:*

*23/06/05*

*Author (S):*

***C. Key DURAND***

*:*

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*Organization (S): EDF-R & D /AMA*

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***Operator THER\_LINEAIRE***

### ***1 Goal***

***To solve a linear problem of thermics in stationary regime or evolutionary.***

***The thermal loading is defined by the key word CHARGES.***

***The temporal discretization of an evolutionary calculation is provided by the list of moments defined under the key word***

***LIST\_INST. This calculation can be initialized, at the first moment, in three different ways (key word TEMP\_INIT):***

- by a constant temperature,***
- by a field of temperature, definite, or extracted as a preliminary from a preceding calculation,***
- by a preliminary stationary calculation.***

***The concept produced by this operator is of evol\_ther type.***

***When a calculation of sensitivity of the result compared to a parameter is required, there is production of as many structures of data of the evol\_ther type of necessary parameters.***

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***Titrate:  
Operator THER\_LINEAIRE***

**Date:**  
**23/06/05**  
**Author (S):**  
**C. Key DURAND**  
**:**  
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## **2 Syntax**

**temper**  
**[evol\_ther]**  
**=**  
**THER\_LINEAIRE**

**(reuse**  
**=**  
**temper,**

**MODEL**  
**=**  
**Mo,**

**[model]**

**CHAM\_MATER**  
**=**  
**chmat,**  
**[cham\_mater]**

**CARA\_ELEM**  
**=**  
**carac,**

***[cara\_elem]***

***EXCIT***

***= \_F (***

***CHARGE***

***=***

***tank,***

***[load]***

***FONC\_MULT***

***=***

***fonc,***

***[function]***

***),***

***TEMP\_INIT =\_F (***

***/STATIONARY =***

**“YES”, [DEFECT]**

/  
**VALE**

= *tinit*,  
**[R]**  
/  
**CHAM\_NO =**  
*tinit*,  
**[cham\_no\_TEMP\_R]**

/  
**EVOL\_THER = temp**,  
**[evol\_ther]**

**NUME\_INIT = nuini\_evol, [I]**