
Operator POST_RCCM

1 Drank

To check criteria of the RCC-M. It acts in particular:

- criteria of level 0 and certain criteria of level A of B3200 in postprocessing of computations on structures 2D or 3D;
- criteria of fatigue of the §B3600 in postprocessing of computations of pipework.

The criteria of level 0 aim at securing the material against the damages of excessive strain, plastic instability and elastic and elastoplastic instability. These criteria require the computation of the equivalent stresses of membrane P_m , local membrane Pl and membrane plus bending $P_m + Pb$.

The criteria of level A aim at securing the material against the damages of progressive strain and fatigue. Except fatigue, they require the computation of the amplitude of variation of stress linearized, noted Sn , and possibly of the quantity Sn^* and the thermal ratchet. For fatigue, they require in more computation of the amplitude of variation of stress, noted Sp .

As starter of the command `POST_RCCM`, it is necessary to specify:

- maybe of the arrays of stresses on a segment of analysis built afterwards of thermomechanical computations 2D or 3D (`TYPE_RESU_MECA=' EVOLUTION'`);
- maybe of the arrays of stresses on a segment of analysis corresponding to unit loadings and the associated torsors of loading (`TYPE_RESU_MECA=' UNITAIRE'`);
- that is to say computation result thermomechanical on line of pipework (`TYPE_RESU_MECA=' TUYAUTERIE'`).

Product a data structure of the type `counts`.

Before a first use, it is strongly advised to refer to the reference documents [R7.04.03] and of advice [U2.09.03].

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2 Syntax

```

TABL_POST_RCCM = POST_RCCM (

    ◊TYPE_RESU      =      "VALE_MAX",                      [DEFAULT]
                      /      "DETAILS",

    ◊INFO           /1 ,                      [DEFAULT]
                      /2 ,

    ◊TITER          =titer ,                      [kN]

    ◆ TYPE_RESU_MECA = "EVOLUTION",                      [DEFAULT]
                      /"UNITAIRE",
                      /"PIPEWORK",

# if TYPE_RESU_MECA = "EVOLUTION"
    ◆ OPTION        =      "PM_PB",
                      /      "SN",
                      /      "FATIGUE_ZH210",
                      /      "AMORCAGE",

    ◆MATER          =mat ,                      [to subdue]

    ◊ SY_MAX        =symax ,                      [R]

    ◆ TRANSITOIRE=_F (
        ◊ TABL_RESU_MECA=tabmeca ,                      [array]
        ◊ TABL_SIGM_THER=tabth ,                      [array]
        ◊ TABL_RESU_PRES=tabpres ,                      [array]
        ◊ TABL_SIGM_THETA=tabsigt ,                      [array]

        ◊ NB_OCCUR=/nocc ,                      [I]
                      /1 ,                      [DEFAULT]

                      ◊/TOUT_ORDRE=' OUI',

        /INST              =linst ,                      [1_R]
        /LIST_INST         =linst ,                      [listr8]
    ◊CRITERE = "RELATIF",                      [DEFAULT]
                ◊ accuracy = prec, [R]
                /1.E-6, [DEFAULT]
                /"ABSOLU",
                ◆ accuracy =prec , [R]
                )

```

```
# if TYPE_RESU_MECA = "UNITAIRE"
  ◆ OPTION = "PM_PB",
            / "SN",
            / "FATIGUE",
  ◆ MATER =mat , [to subdue]
  ◇ SY_MAX =symax , [R]
  ◆ TYPE_KE=/ "KE_MECA", [DEFAULT]
            /"KE_MIXTE"
  ◆ CHAR_MECA=_F (
    ◆ NUME_CHAR=numchar , [I]
    ◇NOM_CHAR=nomchar , [kN]
    / ◆ MX=mx , [R]
        ◆ MY=my , [R]
        ◆ MZ=mz , [R]
        ◇ FX=fx , [R]
        ◇ FY=fy , [R]
        ◇ FZ=fz , [R]

    / ◆ MX_CORP=mx , [R]
        ◆ MY_CORP=my , [R]
        ◆MZ_CORPS=mz , [R]
        ◇FX_CORPS=fx , [R]
        ◇ FY_CORP=fy , [R]
        ◇FZ_CORPS=fz , [R]
        ◆ MX_TUBU=mx , [R]
        ◆ MY_TUBU=my , [R]
        ◆ MZ_TUBU=mz , [R]
        ◇ FX_TUBU=fx , [R]
        ◇ FY_TUBU=fy , [R]
        ◇ FZ_TUBU=fz , [R]
        ) ,

  ◆ RESU_MECA_UNIT=_F (
    / ◆ TABL_MX=tabsigmx , [array]
        ◆ TABL_MY=tabsigmy , [array]
        ◆ TABL_MZ=tabsigmz , [array]
        ◇ TABL_FX=tabsigfx , [array]
        ◇ TABL_FY=tabsigfy , [array]
        ◇ TABL_FZ=tabsigfz , [array]
        ◆ TABL_PRES=tabsigpr , [array]

    / ◆ TABL_MX_CORP=tabsigmx , [array]
        ◆ TABL_MY_CORP=tabsigmy , [array]
        ◆ TABL_MZ_CORP=tabsigmz , [array]
        ◇ TABL_FX_CORP=tabsigfx , [array]
        ◇ TABL_FY_CORP=tabsigfy , [array]
        ◇ TABL_FZ_CORP=tabsigfz , [array]
        ◆ TABL_MX_TUBU=tabsigmx , [array]
        ◆ TABL_MY_TUBU=tabsigmy , [array]
        ◆ TABL_MZ_TUBU=tabsigmz , [array]
        ◇ TABL_FX_TUBU=tabsigfx , [array]
        ◇ TABL_FY_TUBU=tabsigfy , [array]
        ◇ TABL_FZ_TUBU=tabsigfz , [array]
        ◆TABL_PRES=tabsigpr , [array]
        ) ,

  ◇ RESU_THER=_F (
    ◆ NUME_RESU_THER=numtran , [I]
    ◆ TABL_RESU_THER=table , [array]
    ) ,
```

```
◇ SEISME=_F (
  ◆ NUME_SITU=numsitu           ,           [I]
  ◇NOM_SITU=nomsitu            ,           [kN]
  ◆ NB_OCCUR=nbocc             ,           [I]
  ◆ NB_CYCL_SEISME=nbsss       ,           [I]
  ◆ NUME_GROUPE=numgroup       ,           [I]
  ◆ CHAR_ETAT=                 (list_num_char_meca), [L_I]
  ),

◆ SITUATION=_F (
  ◆ NUME_SITU=numsitu           ,           [I]
  ◇NOM_SITU=nomsitu            ,           [kN]
  ◆ NB_OCCUR=nbocc             ,           [I]
  ◆ NUME_GROUPE=numgroup       ,           [I]
  ◇ NUME_PASSAGE=              (num1, num2)   [L_I]
  ◇ COMBINABLE=/               "OUI",         [DEFAULT]
  /"NON",                       [kN]
  ◆PRES_A=pressa               ,           [R]
  ◆ PRES_B=pressb              ,           [R]
  ◇ TEMP_REF_A=tempa           ,           [R]
  ◇ TEMP_REF_B=tempb           ,           [R]
  ◆ CHAR_ETAT_A=              (list_num_char_meca), [L_I]
  ◆ CHAR_ETAT_B=              (list_num_char_meca), [L_I]
  ◇ NUME_RESU_THER=liste_num_tran ,           [L_I]
  ),
```

```

# if TYPE_RESU_MECA= "PIPEWORK"
  ◆OPTION= "TIRES",
  ◆ MODELE=modelle , [model]

  ◆ZONE_ANALYZE=_F (
    ◇/ TOUT=' OUI', [DEFAULT]
    /GROUP_MA=gma1 , [groupma]
    /MAILLE=ma1 , [mesh]
    will ◆CARA_ELEM=cara ,
    [cara_elem]
  ◆TYPE_QUE=/ "KE_MECA", [DEFAULT]
    /"KE_MIXTE"
  ◆CHAM_MATER=chmat , [cham_mater]
  ◆RESU_MECA=_F (
    ◆ NUME_CHAR=numchar , [I]
    ◇NOM_CHAR=nomchar , [kN]
    ◆/RESULTAT=resu , / [evol_elas]
    / [evol_noli]
    ◆ /TOUT_ORDRE = ' OUI',
    /NUME_ORDRE =lordre , [l_I]
    /INST =linst , [l_R]
    /NOEUD_CMP =lnoecmp , [l_K16]
    # If INST:
    ◇ CRITERE = "RELATIF", [DEFAULT]
    ◇ accuracy = prec, [R]
    /1.E-6, [DEFAULT]
    /"ABSOLU",
    ◆ accuracy =prec , [R]
    ◆NOM_CHAM=/ "EFGE_ELNO",
    / "SIEF_ELNO",
    /CHAM_GD =cham_effo , [cham_elem]
  )
  ◆INDI_SIGM=_F (
    ◇C1=/ 1. , [DEFAULT]
    /c1, [R]
    ◇C2=/ 1. , [DEFAULT]
    /c2, [R]
    ◇C3=/ 0.5, [DEFAULT]
    /c3, [R]
    ◇ K1=/ 1. , [DEFAULT]
    /k1, [R]
    ◇ K2=/ 1. , [DEFAULT]
    /k2, [R]
    ◇ K3=/ 1. , [DEFAULT]
    /k3, [R]
    ◆/ TOUT = ' OUI', [DEFAULT]
    /GROUP_MA=gma1 , [groupma]
    /MAILLE=ma1 , [mesh]
    ◇ /GROUP_NO=gno1 , [groupno]
    /NOEUD=no1 , [node]
    ◇ TYPE_ELEM_STANDARD=/ "DRO",
    /"NECK",
    /"TRN",
    /"TEE",
  )

```

```

    ◇ RESU_THER=_F (
      ◆ NUME_RESU_THER=numtran , [I]
      ◆ TABL_RESU_THER=table ,
[tabl_post_releve]
      ◆TABL_MOYE_THER=table ,
[tabl_post_releve]
      ◆/ TOUT = ' OUI', [DEFAULT]
        /GROUP_MA=gma1 , [groupma]
        /MAILLE=ma1 , [mesh]
      ◇ /GROUP_NO=gno1 , [groupno]
        /NOEUD=no1 , [node]
    )

    ◇SEISME=_F (
      ◆ NUME_SITU=numsitu , [I]
      ◇NOM_SITU=nomsitu , [kN]
      ◆ NB_OCCUR=nbocc , [I]
      ◆ NB_CYCL_SEISME=nbsss , [I]
      ◆ NUME_GROUPE=numgroup , [I]
      ◆ CHAR_ETAT= (list_num_char_meca), [L_I]
      ◇ TEMP_REF= tref, [R]
    )

    ◆ SITUATION=_F (
      ◆ NUME_SITU=numsitu , [I]
      ◇NOM_SITU=nomsitu , [kN]
      ◆ NB_OCCUR=nbocc , [I]
      ◆ NUME_GROUPE=numgroup , [I]
      ◇ NUME_PASSAGE= (num1, num2) , [I]
      ◇ COMBINABLE=/ "OUI", [DEFAULT]
        /"NON", [kN]
      ◆PRES_A=pressa , [R]
      ◆ PRES_B=pressb , [R]
      ◇ TEMP_REF_A=tempa , [R]
      ◇ TEMP_REF_B=tempb , [R]
      ◆ CHAR_ETAT_A= (list_num_char_meca), [L_I]
      ◆CHAR_ETAT_B= (list_num_char_meca), [L_I]
      ◇ NUME_RESU_THER=liste_num_tran , [L_I]
    )

```

3 Operands common runs with all the options

3.1 Operand TYPE_RESU

```
TYPE_RESU =      "VALE_MAX",  
                /  "DETAILS",
```

Type of values contained in the array produced as a result:

- VALE_MAX : only the maximum values are given;
- DETAILS : the computed values at every moment are provided.

3.2 Operand TITER

♦TITER=titer

Character string describing the title of the array of values created, which appears with the printing of this array by IMPR_TABLE [U4.91.03].

3.3 Operand INFO

```
♦INFO=/1  
      /2
```

Allows a display more or less detailed in the message file.

3.4 Types of results: key word TYPE_RESU_MECA

Three types of results are manageable by POST_RCCM :

Results of type evolution of transient: "EVOLUTION"

This kind of result is dedicated to the postprocessing of one or more thermomechanical computations (MECA_STATIQUE, STAT_NON_LINE) on a modelization 2D or 3D. The results are transmitted via arrays of stresses, extracted on the segments from analysis. The accessible criteria are:

- for the current zones (except geometrical singularity): criteria of level 0 (option PM_PB), of level A except fatigue (option SN) and of fatigue (option FATIGUE_ZH210) on segments;
- for the geometrical singularities: computation of the factor of starting (option AMORCAGE) on a circular cut line around the singularity.

This option is well adapted to the cases where there are few situations to study.

Results of the unit type: "UNITAIRE"

This kind of result requires the preliminary computation of the stresses for loadings unit (forces and unit total moments applied to the limits of the model; for example for a tube: FX FY FZ MX MY , MZ and pressure), and of the stresses related to the thermal transients considered. These forces can result either calculated with Code_Aster, or from data base OAR.

Each situation is then defined from its two stabilized mechanical states (described by the value of the load vector force) and of a thermal transient. The accessible criteria are the criteria of level 0 (option PM_PB), level A except fatigue (option SN) and of fatigue (option TIRES) on segments.

This option is well adapted to the computations on a component subjected to many situations, possibly distributed in several groups. Situations of seisme can be taken into account.

Results of type pipework: "PIPEWORK"

This kind of result is dedicated to the postprocessing of mechanical computations (`MECA_STATIQUE` , `STAT_NON_LINE` , `COMB_SISM_MODAL`) on line of pipework. The computation with fatigue is done according to the rules of the B3600 paragraph.

Several situations can be defined, but in only one group. Situations of seisme can be taken into account.

3.5 Count produced

command `POST_RCCM` generates a concept of the type `counts`. Command `IMPR_TABLE` [U4.91.03] makes it possible to print the contents of the array. For more information, one will be able to refer to the document [U2.09.03].

4 Operands specific to the results of the type EVOLUTION

For a precise description of the computations carried out by these options, one can consult the document [R7.04.03], the note of use [U2.09.03] and notes it [bib2].

The characteristics of the materials necessary to the computation of the criteria are to be defined `DEFI_MATERIAU` [U4.43.01] by the command. The computed values and the limiting values are stored in the array `tabl_post_rccm`, which one prints using command `IMPR_TABLE` [U4.91.03].

Notice on the use of characteristic of material according to the temperature :

For postprocessing, rules RCC-M B require the use of the characteristics of material, like SM, with the maximum temperature of the transients.

Operator `DEFI_MATERIAU` [U4.43.01] however authorizes the definition of the characteristics of material according to temperature (factor key word `RCCM_FO`). Actually, this possibility is reserved for the use of the option "UNITAIRE" in which one indicates the temperature of the transients.

With option "EVOLUTION", the user must define the characteristics of material, for postprocessing, only by the key word factor `RCCM` of the command `DEFI_MATERIAU`. Indeed, to use this option "EVOLUTION", the user has to provide in data input only stresses, the thermal evolution being ignored even if it exists in the preceding stages of computation.

With option "EVOLUTION", the use of the characteristics according to the temperature thus involves an error of execution.

The analysis is made in postprocessing one or more thermomechanical computations (`MECA_STATIQUE`, `STAT_NON_LINE`) on a modelization 2D or 3D. The results are transmitted via arrays of stresses, extracted on the segments from analysis. These arrays of stresses can be created by commands `POST_RELEVE_T` or `MACR_LIGN_COUPE`. The possible computation options are:

- 1) criteria of level 0 by option `PM_PB` ;
- 2) criteria of level A (except fatigue) by the option `SN` ;
- 3) criteria of fatigue (also of level A) by option `FATIGUE_ZH210` ;
- 4) criteria of starting in singular zones by option `AMORCAGE`.

The first three options can be called only or simultaneously. The last option can be called only: it indeed requires a statement of the stresses on a circular cut line around the geometrical singularity, whereas the other options are dedicated to segments crossing structure.

This option is well adapted to the cases where there are few situations to study. It is not possible to take into account situations of seisme.

4.1.1 Operand MATER

◆MATER=mat

It is the material containing the characteristics useful to `POST_RCCM` and definite under key word `RCCM` of `DEFI_MATERIAU` [U4.43.01].

Notice on the curves of fatigue:

For the small amplitudes of stresses, the difficulty of the prolongation of the curve of fatigue can arise: for example, for the curves of fatigue of the RCCM beyond 10^6 cycles, the corresponding stress, 180 MPa is regarded as limit of endurance, i.e. that very forced

lower than 180 MPa must produce a factor of null use, or an infinite number of cycles acceptable.

It is pointed out that the curve of fatigue is defined in the properties material (key word *TIRES/WOHLER*) as being the number of cycle to the fracture according to the half-amplitude of the stress *Salt*. The small amplitudes of stresses thus correspond to the prolongation on the left of the curve. Several situations can arise, according to the type of prolongation retained in *DEFI_FONCTION* :

- if *PROL_GAUCHE* = "EXCLUDED" or "CONSTANT", computation is made by supposing that the first value of the curve of Wohler provided is the limit of endurance of the material. In other words, very forced alternate smaller than the first value indicated in the *DEFI_FONCTION* will correspond to a factor of null use. The method adopted here thus corresponds well to the notion of limit of endurance;
- if *PROL_GAUCHE* = "LINEAIRE", the curve is prolonged in a linear way. Attention, the prolongation is not done in coordinates logarithmic curve, therefore one can have considerable factors of use even for the low values of *Salt*. To return to the notion of limit of endurance, it is then recommended to add in the definition of the curve the number of acceptable cycles for a very low value of *Salt* (calculated with the hand for example by interpolation with a model power).

4.1.2 Operand *SY_MAX*

◇ *SY_MAX*=symax ,

Limiting conventional of elasticity for the maximum temperature reached during the cycle. This operand is used only for the computation of the thermal ratchet (cf § 4.1.4.2). If elastic limit *SY_MAX* is not defined, one *SY_02* takes the value defined under the operand of key word *RCCM* in *DEFI_MATERIAU* [U4.43.01]; if this operand is not either defined, the computation of the thermal ratchet is impossible.

4.1.3 Option *PM_PB*

Option allowing to calculate the criteria of level 0 which aim at securing the material against the damages of excessive strain, plastic instability and elastic and elastoplastic instability. These criteria require the computation of the equivalent stresses of membrane *Pm*, local membrane *Pl*, bending *Pb* and membrane plus bending *Pm+Pb*.

The operands necessary are *MATER*, the array of stresses *TABL_RESU_MECA* (built by *POST_RELEVE_T* or *MACR_LIGN_COUPE* after mechanical computation on the place of post - processing) and possibly the array of stresses *TABL_SIGM_THER* built from a computation with the thermal loading only.

The points of computation are the two ends of the segment of analysis. If several segments of extraction were used to define the same array of stresses, computation is done successively for each one of them.

The limiting values are *Sm* and $1.5Sm$, *Sm* being working stress function of the material and the temperature, data by the key word *SM* of key word *RCCM* in *DEFI_MATERIAU* [U4.43.01].

Note:

- 1) *The computation of *PM* and *PMPB* is only done starting from the primary stresses, therefore except stresses of thermal origin. If *TABL_SIGM_THER* is indicated, it is supposed that result indicated in *TABL_RESU_MECA* corresponds to a thermomechanical computation and the thermal stresses are thus withdrawn to him. If only *TABL_RESU_MECA* is indicated, computation is done directly starting from the stresses indicated in the array.*

4.1.4 Option `SN`

Option allowing to calculate the criteria of level A (except fatigue) which aim at securing the material against the damages of progressive strain. They require the computation of the amplitude of variation of stress linearized in a point, noted S_n .

If the user asks it (presence of operand `TABL_SIGM_THER`) one carries out also the computation of S_n^* .

If the user asks it (presence of operands `TABL_SIGM_THER` and `TABL_RESU_PRES`) one carries out also the computation of the thermal ratchet.

The operands necessary are `MATER` and the array of stresses `TABL_RESU_MECA` (built by `POST_RELEVE_T` or `MACR_LIGN_COUPE` after mechanical computation on the place of post-processing) to informing in key word `TRANSITOIRE`.

The points of computation are the two ends of the segment of analysis. If several segments of extraction were used to define the same array of stresses, computation is done successively for each one of them.

The value limits of S_n is $3S_m$, S_m being working stress function of the material and the temperature, data by the key word `SM` of factor key word `the RCCM` in `DEFI_MATERIAU` [U4.43.01].

Note:

Key word `TABL_RESU_MECA` can be repeated several times under only one key word `TRANSITOIRE`. For the computation of S_n and S_n^* , there will be however no combination between the situations thus defined: each array of stresses will be treated successively.

4.1.4.1 Computation of S_n^*

If operand `TABL_SIGM_THER` of the key word factor `TRANSITOIRE` is present, one carries out also the computation of S_n^* .

It is necessary, so that computation is coherent and in conformity with the RCC-M, that the stresses provided in `TABL_SIGM_THER` were obtained with a thermal loading only, knowing that result given by `TABL_RESU_MECA` can be due to a combination of this thermal loading with other loadings. It is necessary thus that times of array `TABL_SIGM_THER` correspond to those of array `TABL_RESU_MECA`.

4.1.4.2 Computation of the thermal ratchet

If operands `TABL_SIGM_THER` and `TABL_RESU_PRES` of the key word factor `TRANSITOIRE` are present, one carries out also the computation of the thermal ratchet. For that, it is also necessary beforehand to have defined the conventional limit of elasticity for the maximum temperature reached during the cycle is by operand `SY_MAX` of `POST_RCCM`; maybe by the operand `SY_02` of key word `RCCM` in `DEFI_MATERIAU` [U4.43.01]. If no elastic limit is defined, the computation of the thermal ratchet is impossible.

It is necessary, so that computation is coherent and in conformity with the RCC-M, that the stresses provided in `TABL_RESU_PRES` were obtained with a direct loading of compression.

In the table result appear, for each end of each segment of analysis, the elastic limit `SY`, the amplitude of variation of the stress of origin thermal `SP_THER`, the maximum of general membrane stress due to pressure `SIGM_M_PRES` and two acceptable values maximum of the amplitude of variation of the thermal stress calculated either by supposing a linear variation in temperature in wall (`VALE_MAXI_LINE`), or by supposing a parabolic variation in temperature in wall (`VALE_MAXI_PARAB`).

4.1.5 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 stress in each end of the segment of analysis is calculated starting from the arrays of stresses `TABL_RESU_MECA`, for each combination of times belonging to (X) transitory (S) definite (S) by the user. Then one applies a method of combination and office plurality to obtain the factor of total use, cf [R7.04.03].

Times corresponding to the extreme states must be specified by the user by operands `NUME_ORDRE`, `INST` or `LIST_INST`.

Note:

Key word `TABL_RESU_MECA` can be repeated several times under only one key word `TRANSITOIRE`. For the fatigue analysis, the results contained in each array of stresses will be combined between them.

*For operands `NUME_ORDRE`, `INST` or `LIST_INST`, a possible confusion is the use of the list of times of thermomechanical computations (`MECA_STATIQUE`, `STAT_NON_LINE`) instead of the list of times corresponding to **states extreme** expected by the operator `POST_RCCM`. In the first case, all times of computations are then regarded as extrema of stresses and lead to computing times which can be important.*

4.1.6 Option AMORCAGE

Option allowing singular. to calculate the factor of starting on the level of a zone For this option, the stresses are with being provided in entry in array `TABL_SIGM_THETA` and must correspond to the extraction of the stresses, in local coordinate system, on a circular cut line of diameter `D_AMORC` (material parameter defined in the RCC-M) around the geometrical singularity. The tables of stresses can be created by means of operator `MACR_LIGN_COUPE` (`TYPE=' ARC'`).

For this option, it is also compulsory to define in materials properties (key word `RCCM`) the coefficients of the model of starting (`A_AMORC` and `B_AMORC`), the diameter of the circle on which the stresses are extracted (`D_AMORC`) and the coefficient between stress and effective stress (`R_AMORC`).

4.2 Key word TRANSITOIRE

This key word factor makes it possible to define it (or them) transitory (S) to study.

4.2.1 Operand INTITULE

Makes it possible to give a name to the transient. This name will be displayed in the produced array.

4.2.2 Operand TABL_RESU_MECA

◇ `TABL_RESU_MECA=tabmeca`

Counts of the stresses on the segment of analysis, built for example by `POST_RELEVE_T` or `MACR_LIGN_COUPE` from mechanical results of `evol_elas` type and `evol_noli`.

4.2.3 Operand TABL_SIGM_THER

◇ `TABL_SIGM_THER = tabth`

Array of the stresses on the segment of analysis, built for example by `POST_RELEVE_T` or `MACR_LIGN_COUPE` on one result obtained with a thermal loading only. This key word allows in particular the computation of S_n^* [§4.1.4.1].

4.2.4 Operand TABL_SIGM_THETA

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

◇TABL_SIGM_THETA = sigt

This operand is to be used only in the case of option AMORCAGE [§4.1.64.1.6]. It corresponds to the array of the stresses, in local coordinate system, on a circular cut line around the geometrical singularity. The table must obligatorily comprise columns ANGLE, ABSC_CURV, INST and SIZZ, where SIZZ corresponds to the stress $\sigma_{\theta\theta}$ in the local coordinate system of the cut line. The diameter of the circle on which the stresses are extracted is a material parameter (operand D_AMORC of DEFI_MATERIAU/RCCM)

Such a table can be built using operator MACR_LIGN_COUPE (TYPE=' ARC', REPERE=' CYLINDRIQUE').

4.2.5 Operand TABL_RESU_PRES

◇TABL_RESU_PRES = tabpres

Array of the stresses on the segment of analysis, built for example by POST_RELEVE_T or MACR_LIGN_COUPE on one result obtained with the direct loading of compression. This key word allows the computation of the thermal ratchet [§4.1.4.2].

4.2.6 Operand NB_OCCUR

◇NB_OCCUR=/nocc
/1 , [DEFAULT]

Many occurrences for the computation of the factor of use.

4.2.7 Operands TOUT_ORDRE / INSTS / LIST_INST / PRECISE DETAILS / CRITERE

◇TOUT_ORDRE , INST, LIST_INST

These keys key allow the selection of times corresponding to the fields gathered in the arrays of stresses tabmeca, tabth and /ou sigp under symbolic names previously specified.

◇PRECISION , CRITERE

key Keys (optional) defining the accuracy (1.E-6 by default into relative) and the search criterion (RELATIF by default) of a sequence number from a value of time.

4.3 Stage of execution

One checks that times of computation of the array tabth are identical to those of the array tabmeca. On the other hand, one cannot check only the thermal transients which contributed to the mechanical results tabth and tabmeca is identical. It is to the user to ensure coherence (including on the data materials).

Note:

If the various provided arrays as starter comprise the coordinates of the points, of the checks of coherences are carried out: alignment of the points (for options PM_PB, SN and FATIGUE_ZH210) or diameter of the circular cut line (option AMORCAGE); checking of coherence enters the various situations.

It is thus strongly recommended not to remove the coordinates of the points in the arrays of statements of stresses.

4.4 Example of use

an example of use of operator POST_RCCM with results of the type EVOLUTION can be found in the case test RCCM01.

A computation of the criteria of the RCCM proceeds in the following way:

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

- 1) definition of the parameters of the material and the curve of fatigue,
- 2) definitions of the mechanical and thermal loadings,
- 3) linear thermomechanical computation or not linear,
- 4) (if computation of S_n^*) mechanical computation with thermal loading only,
- 5) (if computation of the thermal ratchet) mechanical computation with direct compression,
- 6) definition of the segment of analysis and extraction of the results with
POST_RELEVE_T or MACR_LIGN_COUPE,

then (possibly in poursuite):

```
SN1=POST_RCCM (MATER=MAT,  
              TYPE_RESU=' VALE_MAX',  
              TYPE_RESU_MECA=' EVOLUTION',  
              OPTION=' SN',  
              TITER=' SN, RESULTAT: RESU2b AVEC RESUTH',  
              TRANSITOIRE=_F ( TABL_RESU_MECA = T_RESU2b,  
                              TABL_SIGM_THER = T_RESUTHb, )  
              )  
  
IMPR_TABLE (ARRAY = sn1)
```

an example of use of operator POST_RCCM with results of the type EVOLUTION for the option AMORCAGE can be found in the case test RCCM09.

For more information, one will be able to refer to the documents [U2.09.03] and [R7.04.03].

5 Operands specific to the results of the type PIPEWORK

5.1 Opening remarks concerning the stages preliminary to this postprocessing

From several results of mechanical computations (MECA_STATIQUE, STAT_NON_LINE, COMB_SISM_MODAL) on line of pipework, one calculates criteria of fatigue by the option TIRES.

The data necessary to postprocessing are summarized here (and detailed in the following paragraph):

- Geometry of line of pipework.
- The material field: it is the card of the materials assigned to the mesh groups of the mesh by AFFE_MATERIAU for which it is necessary to add the curve of fatigue, E_REFE, M_KE and N_KE (key words RCCM).
- AFFE_CARA_ELEM makes it possible to affect the elementary characteristics.
- Stress indexes (in each node of the mesh).
- The scenario of operation containing the list of the situations:
 - For each situation:
 - 1) Many occurrences of each situation (thus of each stabilized state).
 - 2) Pressure and average temperature of each stabilized state.
 - 3) List mechanical loadings of each stabilized state.
 - 4) The group of membership of the situation.
 - 5) The associated thermal transient.
- Results of computations for each mechanical loading (including the seisme), located by its number, with for information the name of the loading case: field by elements with the nodes of generalized forces, for each loading (EFGE_ELNO, or SIEF_ELNO).
- For each node, a reference to result thermal definite below.
- Results of thermal computations: computations finite elements 2D or 3D which give information depend at the same time on the geometry and the transient. There is thus a thermal computation by type of junction, and type of transient. In practice one carries out two POST_RELEVE_T per transient and different type of thickness or geometry: a POST_RELEVE_T with option EXTRACTION, and a second with the AVERAGE option

preliminary computations to carry out are thus:

- Computations of type beam (elastic design) for each loading (one makes use only of the moments, expressed in a local coordinate system with each element, locates presumedly identical for all the results) composing each of the two stabilized states of each situation.
- A seismic computation (inertial response and displacements of anchorage) (only one type of seisme taken into account).
- The computation of each thermal transient, in as many meshes 2D or 3D that there are different thickness or components.

The operands and key keys of the option FATIGUE were selected in order to allow a later use in restrain with tools OAR. They are thus inspired by the specifications of data base OAR [bib3].

5.2 Operand CHAM_MATER

◆CHAM_MATER=chmat

It is the material field containing, for all meshes model, the characteristics material useful to FATIGUE and definite under key word ELAS_FO, FATIGUE and RCCM of DEFI_MATERIAU [U4.43.01] (E, NU, ALPHA, WOHLER, E_REFE, M_KE, N_KE, SM).

Notice on the curves of fatigue:

For the small amplitudes of stresses, the difficulty of the prolongation of the curve of fatigue can arise: for example, for the curves of fatigue of the RCCM beyond 10^6 cycles, the corresponding stress, 180 MPa is regarded as limit of endurance, i.e. that very forced lower than 180 MPa must produce a factor of null use, or an infinite number of cycles acceptable.

The method adopted here corresponds to this notion of limit of endurance: if the amplitude of stress is lower than the first X-coordinate of the curve of fatigue, then one takes a factor of null use.

5.3 Operand CARA_ELEM

will ♦CARA_ELEM=cara

It is the field of characteristics of the beam elements (external radius and thickness, angle and radius of curvature of the elbows) defined by AFFE_CARA_ELEM.

5.4 Operand MODELS

♦ MODELE=model

It is the model (finite element of beam) on which were carried out computations of the mechanical loadings.

5.5 Operand TYPE_KE

♦ TYPE_KE=/ "KE_MECA", [DEFAULT]
/ "KE_MIXTE"

the elastoplastic factor of correction Ke can be calculated in two ways [R7.04.03]:

- KE_MECA : it is the original method, only available in the previous versions to version 7.2;
- KE_MIXTE : this method breaks up the amplitude of variation of the alternating loads into a thermal part and a mechanical part. It is authorized since the modifying 1997 of the RCCM.

5.6 Key word ZONE_ANALYSE

This key word makes it possible to limit the fatigue analysis to meshes or groups of mesh of line of pipework.

5.6.1 Operands TOUT/GROUP_MA/MESH

```
♦/TOUT=' OUI' ,  
/GROUP_MA =gma1 , [groupma]  
/MAILLE =ma1 , [mesh]
```

By default factor of use is calculated for all the nodes of the model.

These key word make it possible to restrict the analysis with meshes or mesh groups, which makes it possible to save computing time.

5.7 Key word RESU_MECA

This key word factor makes it possible to define the results of mechanical computations. It is répétable as many times as there are mechanical loadings different as a whole from the situations.

5.7.1 Operand NUME_CHAR

Number of the mechanical loading. This number is used to define the loadings associated with each situation (see key word SITUATION).

5.7.2 Operand NOM_CHAR

Name (optional) of the mechanical loading.

5.7.3 Operand RESULTAT/CHAM_GD

```

/♦      CHAM_GD=cham_effo      ,      cham_elem]
/♦RESULTAT=resu      ,      / [evol_elas]
      / [evol_noli]

      /TOUT_ORDRE      = ' OUI ' ,
      /NUME_ORDRE      =lordre      ,      [l_I]
      /LIST_ORDRE      =lordre      ,      [listIs]
      /INST      =linst      ,      [l_R]
      /NOEUD_CMP      =lnoecmp      ,      [l_K16]
      /LIST_INST      =linst      ,      [listr8]
♦NOM_CHAR=/      "EFGE_ELNO",
      / "SIEF_ELNO",
      )
    
```

the results of computations for each loading (fields by elements with the nodes of generalized forces) can be defined:

- that is to say a field by element: `cham_effo` which is of type `EFGE_ELNO`, or `SIEF_ELNO`,
- is a data structure `result` (resulting from `MECA_STATIQUE` or `STAT_NON_LINE`) with parameters of extraction: time, `NOM_CHAR=' EFGE_ELNO'`, or `"SIEF_ELNO"...` or resulting from `COMB_SISM_MODAL` or `MODE_STATIQUE` with the additional parameter of extraction `NOEUD_CMP`.

For the latter, the fields of forces relating to the seisme are the moments for each component of each seisme, resulting from a quadratic combination `NOEUD_CMP= ("COMBI", "QUAD")` for the inertial response; and of the nodes and the directions (for example `NOEUD_CMP= ("N1", "DX")`) for displacements of anchorages.

5.8 Operand INDI_SIGM

```

♦INDI_SIGM=_F (
  ♦C1=/      1. ,      [DEFAULT]
      = c1 ,      [R]
  ♦C2=/      1. ,      [DEFAULT]
      = c2 ,      [R]
  ♦C3=/      0.5 ,      [DEFAULT]
      = c3 ,      [R]
  ♦ K1=/      1. ,      [DEFAULT]
      = k1 ,      [R]
  ♦ K2=/      1. ,      [DEFAULT]
      = k2 ,      [R]
  ♦ K3=/      1. ,      [DEFAULT]
      = k3 ,      [R]
  ♦/      TOUT=' OUI ',
    
```

```
        /GROUP_MA=gma1                ,                [groupma]
        /MAILLE=ma1                    ,                [mesh]
    ◇ /GROUP_NO=gno1                    ,                [groupno]
        /NOEUD=no1                      ,                [node]
    ◇ TYPE_ELEM_STANDARD=/              "DRO",          [kN]
                                          / "NECK",        [kN]
                                          / "TRN",          [kN]
                                          / "TEE",          [kN]
    )
```

Values of the stress indexes to be used in the analysis of fatigue (values codified in the RCC - M B3683, variable according to the type of junction). The user provides for each mesh group, or each node of each mesh, the values of C1, C2, C3, K1, K2, K3, knowing that the default values are those which correspond to the right parts of the pipework, which facilitates the introduction of the data. One will be able to have for example:

```
        INDI_SIGM=_F ( GROUP_MA=' GMA1' ),
(assignment of the values by default for all the nodes of all meshes of GMA1 )
        _F ( MAILLE=' MA2', NOEUD=' NO2', C1=1.2, C2=1.4 ),
(assignment of particular indices for node NO2 of the mesh MA2 )
```

TYPE_ELEM_STANDARD is an optional key word, purely informative, making it possible to clearly show more in the array the results according to the type of elements and junctions. One will be able to give, as in OAR, [bib3] a description of the type:

- DRO : to some extent right,
- NECK : for an elbow,
- TRN : for a transition from thickness,
- TEE : for a t-piece.

5.9 Key word RESU_THER

This key word factor makes it possible to define the results of thermal computations. It is répétable as many times as there are different thermal computations and geometrical discontinuities or materials. As an indication, there can be: (many discontinuities) * (many thermal transients).

5.9.1 Operand NUME_RESU_THER

◆ NUME_RESU_THER=numtran [I]

Number of the thermal transients. This number is used to identify the thermal transient associated with each situation (see key word SITUATION).

5.9.2 Operand TABL_RESU_THER

◆ TABL_RESU_THER=table [array]

Counts resulting for example from POST_RELEVE_T, containing for each transitory thermal computation, the statement of the temperatures on a section (chosen by the user) of the mesh 2D or 3D of a junction or a right part at various times of the transient. The origin of the section must be the internal skin.

◆ TABL_MOYE_THER=table [array]

Counts resulting for example from POST_RELEVE_T (OPERATION=' MOYENNE'), containing for each transitory thermal computation, the averages of order 0 and 1 of the temperatures on the selected section (in coherence with TABL_RESU_THER) at various times of the transient.

These quantities are used to compute: the values of ΔT_1 , ΔT_2 , T_a and T_b [R7.04.03].

5.9.3 Operands TOUT / GROUP_MA/MESH/GROUP_NO/NOEUD

```

    ◇/TOUT=' OUI' ,
    /GROUP_MA      =gma1      ,          [groupma]
    /MAILLE        =ma1       ,          [mesh]
    ◇ /GROUP_NO    =gno1      ,          [groupno]
    /NOEUD         =no1       ,          [node]
    
```

the array and the transient are associated is with a mesh group, (in general this group contains all the right parts which see the same thermal transient), that is to say with a mesh, and a node of this mesh (what corresponds in general to a junction). One will be able to have for example:

```

    RESU_THER=_F (NUME_RESU_THER=1 ,
                TABL_RESU_THER=tabl1 ,
                TABL_MOYE_THER=tabl11 ,
                GROUP_MA=' gma1'),
                _F (NUME_RESU_THER=1 ,
                TABL_RESU_THER=tabl2 ,
                TABL_MOYE_THER=tabl22 ,
                MAILLE=' ma1' ,
                NOEUD=' no2' )
    
```

5.10 Key word SEISME

This key word factor makes it possible to define the situations of seisme. There can be one seisme by group of situations.

5.10.1 Operands NUME_SITU/NOM_SITU/NB_OCCUR/NB_CYCL_SEISME/NUME_GROUPE/TEMP_REF

```

    ◆ NUME_SITU=numsitu      ,          [I]
    ◇NOM_SITU=nomsitu       ,          [kN]
    ◆ NB_OCCUR=nbocc        ,          [I]
    ◆ NB_CYCL_SEISME=nbsss  ,          [I]
    ◇ NUME_GROUPE=numgroup  ,          [I]
    ◇TEMP_REF=temp         ,          [R]
    
```

Number of the situation, and name (indicative). NB_OCCUR corresponds to the key word OCCURRENCE of file OAR and indicates the number of occurrences of the situation. NB_CYCL_SEISME provides the number of under-cycles for each occurrence of the seisme, regarded as under-cycles in the computation of the factor of use.

NUME_GROUPE makes it possible to define the number of group to which the situation belongs. There can be one seisme by group of situations.

Reference temperature TEMP_REF of the situation of seisme is useful only if materials properties depend on the temperature (operand RCCM_FO of DEFI_MATERIAU).

5.10.2 Operand CHAR_ETAT

```

    ◆CHAR_ETAT=            (list_num_char_meca),          [L_I]
    
```

CHAR_ETAT makes it possible to define the list of the mechanical numbers of loadings associated with the situation of seisme. These numbers correspond to key word NUME_CHAR of the key word factor CHAR_MECA. They must correspond to the results of inertial computation using COMB_SISM_MODAL, and each displacement of anchorage under seisme, obtained either using MODE_STATIQUE, or on a case-by-case basis.

5.11 Key word SITUATION

This key word factor makes it possible to define the definitions of the situations. It is répétable as many times as there are situations.

5.11.1 Operands NUME_SITU/NOM_SITU/NB_OCCUR

◆ NUME_SITU=numsitu , [I]
◇ NOM_SITU=nomsitu , [kN]
◆ NB_OCCUR=nbocc , [I]

Number of the situation, and name (indicative). NB_OCCUR corresponds to the key word OCCURRENCE of file OAR and indicates the number of occurrences of the situation.

NUME_GROUPE makes it possible to define the number of group to which the situation belongs. For the results of the PIPEWORK type , it is not for the moment not possible to combine situations of groups different connected by a situation from transition.

5.11.2 Operand NUME_GROUPE/NUME_PASSAGE

◆ NUME_GROUPE=numgroup , [I]
◇ NUME_PASSAGE=(num1, num2), [L_I]

Number of group of situation for each situation. The situations of two different groups cannot be combined between them, except if there exists a situation of transition.

For the situations of transition, num1 and num2 indicate the two numbers of groups connected by this situation.

5.11.3 Operands PRES_A/PRES_B/TEMP_REF_A/TEMP_REF_B

◆ PRES_A=pressa , [R]
◆ PRES_B=pressb , [R]
◇ TEMP_REF_A=tempa , [R]
◇ TEMP_REF_B=tempb , [R]

Temperatures (stabilized) and pressures associated with each of the two stabilized states of the situation. The temperatures are used for the computation of materials properties with the two stabilized states; operands TEMP_REF_A and TEMP_REF_B are thus useful only if materials properties depend on the temperature (operand RCCM_FO of DEFI_MATERIAU).

5.11.4 Operands CHAR_ETAT_A/CHAR_ETAT_B

◆ CHAR_ETAT_A=(list_num_char_meca), [L_I]
◆ CHAR_ETAT_B=(list_num_char_meca), [L_I]

List of the mechanical numbers of loadings associated in each stabilized state. These numbers correspond to key word NUME_CHAR of the key word factor CHAR_MECA.

In the general case, only one mechanical loading is associated in each stabilized state.

5.11.5 Operand NUME_RESU_THER

◇ NUME_RESU_THER=liste_num_tran [L_I]

Lists numbers of arrays resulting from thermal computations associated with the situation. A each situation is associated a thermal transient (or several in the case of various sections of lines). If for a given situation, there are physically two transients, like the heating - cooling for example, it is of use in B3600 to combine these two transients in only one.

For each situation, one provides n arrays which represent the computation of the same thermal transient in various places from line (for each thickness or each discontinuity). These numbers must belong to the list of the numbers provided under key word NUME_RESU_THER of the key word factor RESU_THER.

5.11.6 COMBINABLE operand

```
◆COMBINABLE=/ "OUI" , [DEFAULT]  
               /"NON" , [kN]
```

This key word indicates if a situation is combinable with the others inside its group (general case).

If COMBINABLE= ' NON ', that means that the situation is a under-cycle.

5.12 Example of use

test RCCM02 provides a complete example of use. For more information, one will be able to refer to the document [U2.09.03].

6 Operands specific to the results of the type UNITAIRE

6.1 Preliminaries

One supposes here that the computation of the component was carried out in *Code_Aster* (operating of a statement of the stresses on a segment chosen by the user), or comes from one request to data base OAR [bib1], in whom can be stored profiles of stresses. One uses here a common specification of the form of the results resulting from these two paths.

Computations 2D or 3D of the component are to be made only for unit loadings (forces and unit total moments applied to the limits of the model, by connections 3D beam for example). It are combined then linearly according to the values of the forces and moments resulting from computation beam of the pipework, for all the loadings intervening in the situations of computation. Attention, **the reference used for computation 2D or 3D must be coherent with that in which are expressed the total forces resulting from computation beam.**

Preliminary computations to carry out in *Code_Aster* or to extract from data base OAR (so available):

- Computation of the stresses for each unit loading, by a model 2D or 3D elastic.
- Computation of each thermal transient, on the same mesh 2D or 3D.

The data necessary to postprocessing are summarized here (and detailed in the following paragraph):

- The material (presumably single initially) that the segment of study crosses: isotropic elastic material for which it is necessary to add the curve of fatigue, E_REFE , M_KE and N_KE .
- The scenario of operation (available in OAR) containing the list of the situations:
 - For each situation:
 - Many occurrences of each situation.
 - Pressure and average temperature of each stabilized state.
 - List mechanical loadings of each stabilized state.
 - The group of membership of the situation.
 - The associated thermal transient.
- The definition of each mechanical loading (including the seisme), located by its number, with for information the name of the loading case, and the load vector force generalized corresponding with this loading, to apply to the limits of the model.
- Results of computations for each unit mechanical loading (extraction of the values of the stresses on a segment chosen by the user of the model 2D or 3D).
- Results of thermal computations: extraction of the stresses on a segment of the model finite elements 2D or 3D. There is thus a thermal computation by transient.

Note:

Method UNITAIRE of operator POST_RCCM considers the mechanical and thermal stresses separately contrary to the method "EVOLUTION" which considers the total stresses. What results in maximizing the maximum amplitudes of variation of stresses considered and, consequently, the elastoplastic concentration factor Ke used in the computation of the factor of use.

Conservatism, desired, of method "UNITAIRE" can thus prove to be excessive. It is advisable to be vigilant on its use when the amplitudes of variation of the calculated stresses are too important.

6.1.1 Option PM_PB

Option allowing to calculate the criteria of level 0 which aim at securing the material against the damages of excessive strain, plastic instability and elastic and elastoplastic instability. These criteria

require the computation of the equivalent stresses of membrane P_m , local membrane P_l , bending P_b and membrane plus bending $P_m + P_b$.

6.1.2 Option SN

Option allowing to calculate the criteria of level A (except fatigue) which aim at securing the material against the damages of progressive strain. They require the computation of the amplitude of variation of stress linearized in a point, noted S_n . Under certain conditions, this option also allows the computation of S_n^* (if presence of the key word factor RESU_THER) and the thermal ratchet (if presence of the key word factor RESU_THER and of a pressure PRES_A/PRES_B under the key word factor SITUATION).

Note:

With the option "SN", computation is done without combination between the definite situations: each situation will be treated successively. To have the quantities with combination between each situation, the option should be used "TIRES".

6.1.3 Option TIRES

the fatigue analyzes (option "TIRES") are carried out within the meaning of the RCCM B3200 on the segment of analysis. Two fictitious transients are thus identified to combine two situations between them [R7.03.03].

The parameters of table result product are described in paragraph 6.10.1.

6.2 Operand MATER

◆MATER=mat

Name of the material containing, for the analyzed segment, the characteristics defined under key word ELAS and RCCM of DEFINI_MATERIAU [U4.43.01] (E, NU, ALPHA, WOHLER, E_REFE, M_KE, N_KE, SM)

Remark on the curves of fatigue:

Question of the prolongation of the curve of fatigue and the notion of limit of endurance are discussed in the § 4.1.1.

6.3 Operand SY_MAX

◇SY_MAX=symax

conventional Limit of elasticity for the maximum temperature reached during the cycle. This operand is used only for the computation of the thermal ratchet (cf § 4.1.4.2). If elastic limit SY_MAX is not defined, one SY_02 takes the value defined under the operand of key word RCCM in DEFINI_MATERIAU [U4.43.01]; if this operand is not either defined, the computation of the thermal ratchet is impossible.

6.4 Operand TYPE_KE

◆ TYPE_KE=/ "KE_MECA", [DEFAULT]
/"KE_MIXTE"

the elastoplastic factor of correction Ke can be calculated in two ways [R7.04.03]:

- KE_MECA : it is the original method, only available in the previous versions to version 7.2;
- KE_MIXTE : this method breaks up the amplitude of variation of the alternating loads into a thermal part and a mechanical part. It is authorized since the modifying 1997 of the RCCM.

6.5 Key word CHAR_MECA

This key word factor makes it possible to define, for each mechanical loading appearing in the situations, the torsors applied to the limits of the model, resulting from computations of type beam. It is répétable as many times as there are mechanical loadings different as a whole from the situations.

6.5.1 Operand NUME_CHAR

Number of the mechanical loading. This number is used to define the loadings associated with each situation (see key word SITUATION).

6.5.2 Operand NOM_CHAR

Name (optional) of the mechanical loading.

6.5.3 Operands MX/MY/MZ/FX/FY/FZ

◆	MX=mx	,	[R]
◆	MY=my	,	[R]
◆	MZ=mz	,	[R]
◇	FX=fx	,	[R]
◇	FY=fy	,	[R]
◇	FZ=fz	,	[R]

generalized Forces resulting from computations from line of pipework, standard beam, for each loading, to apply to the profiles of stresses provided under RESU_MECA_UNIT, by linear combination.

Attention, this supposes that these values are provided in a coherent reference with that used for the modelization 2D or 3D of the component.

Among these forces one finds also the results of computations for each seisme: moments for each component of each seisme, the inertial response and displacements of anchorages.

6.5.4 Operands MX_CORP/MX_TUBU, MY_CORP/MY_TUBU, ...

◆	MX_CORP=mx	,	[R]
◆	MY_CORP=my	,	[R]
◆	MZ_CORPS=mz	,	[R]
◇	FX_CORPS=fx	,	[R]
◇	FY_CORP=fy	,	[R]
◇	FZ_CORPS=fz	,	[R]
◆	MX_TUBU=mx	,	[R]
◆	MY_TUBU=my	,	[R]
◆	MZ_TUBU=mz	,	[R]
◇	FX_TUBU=fx	,	[R]
◇	FY_TUBU=fy	,	[R]
◇	FZ_TUBU=fz	,	[R]

generalized Forces applied to the body and the pipe of a bypass. Their meaning identical to that of the operands , MY,... is MX used for the lines of pipework.

In the case or these operands are used, the tables of results corresponding (TABL_MX_TUBU, TABL_MX_CORP,...) must be specified under key word RESU_MECA_UNIT.

6.6 Key word RESU_MECA_UNIT

◆	RESU_MECA_UNIT= F (
	/	◆	TABL_MX=tabsigmx	,	[array]
		◆	TABL_MY=tabsigmy	,	[array]

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

```

    ♦ TABL_MZ=tabsigmz           ,           [array]
    ♦ TABL_FX=tabsigfx          ,           [array]
    ♦ TABL_FY=tabsigfy          ,           [array]
    ♦ TABL_FZ=tabsigfz          ,           [array]
    ♦ TABL_PRES=tabsigpr        ,           [array]

/ ♦ TABL_MX_CORP=tabsigmx      ,           [array]
  ♦ TABL_MY_CORP=tabsigmy      ,           [array]
  ♦ TABL_MZ_CORP=tabsigmz      ,           [array]
  ♦ TABL_FX_CORP=tabsigfx      ,           [array]
  ♦ TABL_FY_CORP=tabsigfy      ,           [array]
  ♦ TABL_FZ_CORP=tabsigfz      ,           [array]
  ♦ TABL_MX_TUBU=tabsigmx      ,           [array]
  ♦ TABL_MY_TUBU=tabsigmy      ,           [array]
  ♦ TABL_MZ_TUBU=tabsigmz      ,           [array]
  ♦ TABL_FX_TUBU=tabsigfx      ,           [array]
  ♦ TABL_FY_TUBU=tabsigfy      ,           [array]
  ♦ TABL_FZ_TUBU=tabsigfz      ,           [count]
  ♦ TABL_PRES=tabsigpr         ,           [array]
    )
    
```

This key word factor allows to provide the profiles of stresses on the segment chosen, resulting from unit mechanical computations is on line of pipework (TABL_MX, TABL_MY...), that is to say on bypass (TABL_MX, CORPS, TABL_MX_TUBU...).

For the realization of these computations, it is recommended 3D to apply to the limits of the model connections of type 3D-beam with specific discrete elements. One of these elements is embedded, and to the other, one applies unit generalized forces. In the case of a bypass, one of the ends of the body is blocked, the generalized forces being applied to the other end of the body and the end of the pipe.

Let us note that it is of use in computations RCCM of type pipework to consider only the moments, this is why the key words of the type TABL_FX, TABL_FY, TABL_FZ are optional. TABL_PRES corresponding to a computation under pressure interns unit, without forgetting the basic effect.

6.7 Key word RESU_THER

This key word factor makes it possible to define the results of thermal computations. It is répétable as many times as there are different thermal computations.

6.7.1 Operand NUME_RESU_THER

♦ NUME_RESU_THER=numtran [I]

Number of the thermal transients. This number is used to identify the thermal transient associated with each situation (see key word SITUATION).

6.7.2 Operand TABL_RESU_THER

♦ TABL_RESU_THER=table [tabl_post_releve]

Counts resulting from POST_RELEVE_T, containing for each transitory thermal computation, the statement of the stresses due to the thermal loading on the section of the mesh 2D or 3D chosen by the user at various times of the transient. The origin of the section must be the internal skin.

6.8 Key word SEISME

Only one loading of the type SEISME can be defined by group of situations.

6.8.1 Operands NUME_SITU/NOM_SITU/NB_OCCUR/NB_CYCL_SEISME

♦ NUME_SITU=numsitu [I]
 ♦ NOM_SITU=nomsitu [kN]

- ◆ NB_OCCUR=nbocc , [I]
- ◆ NB_CYCL_SEISME = nbsss, [I]

Number of the situation, and name (indicative). nbocc corresponds to the number of occurrences of the situation. NB_CYCL_SEISME is the number of cycles associated for each occurrence with the seisme, considered as under-cycles in the computation of the factor of use.

Notice on the seisme:

Only one loading of the type SEISME can be defined by group of situations. On the other hand it is possible SEISME to define several groups of situations comprising each one in more the one loading of the type.

6.8.2 Operands CHAR_ETAT

- ◆ CHAR_ETAT= (list_num_char_meca), [L_I]

List of the mechanical numbers of loadings (corresponding to key word NUME_CHAR of the key word factor CHAR_MECA) associated with the situation of seisme.

The mechanical loadings are combined with a quadratic sum.

6.8.3 Operand NUME_GROUPE

- ◆ NUME_GROUPE=numgroup , [I]

Number of group of situation for the seisme.

6.9 Key word SITUATION

This key word factor makes it possible to define the situations. It is répétable as many times as there are situations.

6.9.1 Operands NUME_SITU/NOM_SITU/NB_OCCUR

- ◆ NUME_SITU=numsitu , [I]
- ◆ NOM_SITU=nomsitu , [kN]
- ◆ NB_OCCUR=nbocc , [I]

Number of the situation, and name (indicative). nbocc corresponds to the number of occurrences of the situation.

6.9.2 Operands PRES_A/PRES_B/TEMP_REF_A/TEMP_REF_B

- ◆ PRES_A=pressa , [R]
- ◆ PRES_B=pressb , [R]
- ◆ TEMP_REF_A=tempa , [R]
- ◆ TEMP_REF_B=tempb , [R]

Temperatures (stabilized) and pressures associated with each of the two stabilized states of the situation. The temperatures are used for the computation of materials properties with the two stabilized states; operands TEMP_REF_A and TEMP_REF_B are thus useful only if materials properties depend on the temperature (operand RCCM_FO of DEFI_MATERIAU).

6.9.3 Operands CHAR_ETAT_A/CHAR_ETAT_B

- ◆ CHAR_ETAT_A= (list_num_char_meca), [L_I]
- ◆ CHAR_ETAT_B= (list_num_char_meca), [L_I]

List of the mechanical numbers of loadings associated in each stabilized state. These numbers correspond to key word NUME_CHAR of the key word factor CHAR_MECA.

In the general case, only one mechanical loading is associated in each stabilized state.

6.9.4 Operand NUME_RESU_THER

◇ NUME_RESU_THER=liste_num_tran [L_I]

Lists numbers of thermal transients associated with the situation. There can be 0 or 1 transient section by section of line (what corresponds to mesh groups) for each situation. These numbers correspond to key word NUME_RESU_THER of the key word factor RESU_THER.

If for a given situation, there are physically two transients for a section, like heating-cooling for example, it is of use in B3600 to combine these two transients in only one.

6.9.5 Operand NUME_GROUPE/NUME_PASSAGE

◇ NUME_GROUPE=numgroup , [I]
◇ NUME_PASSAGE=(num1, num2), [L_I]

Number of group of situation for each situation. The situations of two different groups cannot be combined between them, except if there exists a situation of transition.

For the situations of transition, num1 and num2 indicate the two numbers of groups connected by this situation. This situation belongs to the two groups between which it defines the transition. A situation of transition is defined, like any other situation, by two lists of loadings and a thermal transient.

A situation can belong to two different groups without to be a situation of transition between these groups.

Note:

| It is not possible to define more than three different groups of situations.

6.9.6 COMBINABLE operand

◆COMBINABLE=/ "OUI" , [DEFAULT]
/ "NON" , [kN]

This key word indicates if a situation is combinable with the others inside its group (general case). If COMBINABLE=' NON ', that means that the situation is a under-cycle.

6.10 Count produced and example

6.10.1 Counts produced

the array produced by POST_RCCM depends on the Computation option and the type on result required under operand TYPE_RESU:

- if TYPE_RESU=' VALE_MAX' (option by default): the table is simple and comprises only the maximum parameters (PM , SN , \overline{FU}) at the two ends on all the situations considered;
- if TYPE_RESU=' DETAILS' : the table is much richer. It comprises all the calculated parameters, for each combination of situation, with or without seisme. For the option FATIGUE , it is then strongly recommended to print the table with successive filters so that it is easily exploitable.

- Option "PM_PB": the parameters of the array are either the maximum values of PM, PB and PMPB ("VALE_MAX"), or these quantities for each situation ("DETAILS").
- Option "SN": the parameters of the array are either the maximum values of S_n and S_n^* ("VALE_MAX"), or these quantities for each situation with or without seisme ("DETAILS").

If they are calculated, the quantities associated with the thermal ratchet appear in the array. For each end of each segment of analysis appear the elastic limit S_Y , the amplitude of variation of the stress of origin thermal SP_THER , the maximum of general membrane stress due to pressure $SIGM_M_PRES$ and two acceptable values maximum of the amplitude of variation of the thermal

stress calculated either by supposing a linear variation in temperature in wall (VALE_MAXI_LINE), or by supposing a parabolic variation in temperature in wall (VALE_MAXI_PARAB).

- Option " TIRES ": if TYPE_RESU=' DETAILS' , it is recommended to print the table with successive filters so that it is easily exploitable.
 - **Printing of the maximum one:** S | TYPE_RESU=' MAX' or with a filter in IMPR_TABLE :
FILTRE=_F (NOM_PARA=' TYPE', VALE_K=' MAXI'), the produced array contains the following parameters: PM_MAX, PB_MAX, PMB_MAX, SM, SN/3SM, SN_MAX, SN*_MAX, SP_MAX, KE_MAX, SALT_MAX and FACT_USAGE_CUMU.
 - **Printing of the quantities of each situation:** with a filter in IMPR_TABLE :
FILTRE= (_F (NOM_PARA=' TYPE', VALE_K=' SITU'),
_F (NOM_PARA=' SEISME', VALE_K=' AVEC' or " SANS")),
the produced array contains the following parameters for each situation (with or without seisme): PM, PB, PMB, SN, SN*, SP, KE_MECA, SALT and FACT_USAGE.
 - **Printing of the quantities of each combination of situations:** with a filter in IMPR_TABLE :
FILTRE= (_F (NOM_PARA=' TYPE', VALE_K=' COMB'),
_F (NOM_PARA=' SEISME', VALE_K=' AVEC' or " SANS")),
the produced array contains the following parameters for each combination of situations (with or without seisme): SN, SP1_IJ, SP2_IJ, SALT1_IJ and SALT2_IJ. Columns NUME_SITU_I and NUME_SITU_J define the situations considered. SP1_IJ and SP2_IJ correspond respectively to parameter SP of the two definite fictitious transients to combine the situations I and J. In the same way for SALT1_IJ and SALT2_IJ.

6.10.2 Follow-up of computations

Of much additional information can be found in the message file if INFO=2, in particular for the option FATIGUE.

One can thus follow the processing successively:

- situation of seisme (PM, SN, SALT ,...)
- of each situation
- of each combination of situations

At the conclusion of this first stage, the matrix of the factors of use of each combination of situations is built. One can then visualize the successive elimination of the situations more penalizing until exhaustion of the numbers of occurrence.

6.10.3 Example

tests RCCM04 and RCCM07 provide complete examples of use. For more information, one will be able to also refer to the document [U2.09.03].

7 Bibliography

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