

Operator POST_RCCM

1 Goal

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 calculations on structures 2D or 3D;
- criteria of tiredness of the §B3600 in postprocessing of calculations of pipings.

The criteria of level 0 aim at securing the material against the damage of excessive deformation, plastic instability and elastic and elastoplastic instability. These criteria require the calculation of the equivalent constraints of membrane P_m , of local membrane Pl and of membrane plus inflection $P_m + Pb$.

Criteria of level A aim at securing the material against the damage of progressive deformation and tiredness. Except tiredness, they require the calculation of the amplitude of variation of linearized constraint, noted Sn , and possibly of the quantity Sn^* and of the thermal ratchet. For tiredness, they require in more calculation of the amplitude of variation of constraint, noted Sp .

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

- maybe of the tables of constraints on a segment of analysis built afterwards of thermomechanical calculations 2D or 3D (TYPE_RESU_MECA=' EVOLUTION');
- maybe of the tables of constraints on a segment of analysis corresponding to unit loadings and the associated torques of loading (TYPE_RESU_MECA=' UNITAIRE');
- that is to say the thermomechanical computation result on a line of piping (TYPE_RESU_MECA=' TUYAUTERIE').

Product a structure of data of the type table.

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

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2 Syntax

```
TABL_POST_RCCM = POST_RCCM(  
    ◇ TYPE_RESU = / 'VALE_MAX', [DEFECT]  
                  / 'DETAILS',  
    ◇ INFORMATION /1 , [DEFECT]  
                  /2 ,  
    ◇ TITLE = title, [KN]  
    ◆ TYPE_RESU_MECA = / 'EVOLUTION', [DEFECT]  
                       / 'UNITAIRE',  
                       / 'PIPING',  
# if TYPE_RESU_MECA = 'EVOLUTION'  
    ◆ OPTION = / 'PM_PB',  
               / 'SN',  
               / 'FATIGUE_ZH210',  
               / 'STARTING',  
    ◆ MATER = chechmate , [to  
subdue]  
    ◇ SY_MAX = symax, [R]  
    ◆ TRANSITOIRE=_F (  
        ◇ TABL_RESU_MECA = tabmeca, [table]  
        ◇ TABL_SIGM_THER = tabth , [table]  
        ◇ TABL_RESU_PRES = tabpres, [table]  
        ◇ TABL_SIGM_THETA = tabsigt, [table]  
        ◇ NB_OCCUR = / nocc, [I]  
                    / 1, [DEFECT]  
        ◇ / TOUT_ORDRE = 'YES',  
          / INST = linst , [l_R]  
          / LIST_INST = linst , [listr8]  
        ◇ CRITERION = / 'RELATIVE', [DEFECT]  
                      ◇ PRECISION = / prec, [R]  
                          / 1.E-6, [DEFECT]  
                      / 'ABSOLUTE',  
                      ◆ PRECISION = prec, [R]  
    )
```

```
# if TYPE_RESU_MECA = 'UNIT'
  ◆ OPTION      = / 'PM_PB',
                  / 'SN',
                  / 'TIREDNESS',
  ◆ MATER       = chechmate ,
                  [to subdue]
  ◇ SY_MAX      = symax,
                  [R]
  ◆ TYPE_KE     = / 'KE_MECA',
                  / 'KE_MIXTE'
                  [DEFECT]
  ◆ CHAR_MECA = _F (
    ◆ NUME_CHAR = numchar,
                  [I]
    ◇ NOM_CHAR  = nomchar,
                  [KN]
    / ◆ MX      = MX ,
      ◆ MY      = my ,
      ◆ MZ      = mz ,
      ◇ FX      = fx ,
      ◇ FY      = fy ,
      ◇ FZ      = fz ,
      [R]
    / ◆ MX_CORP = MX ,
      ◆ MY_CORP = my ,
      ◆ MZ_CORP = mz ,
      ◇ FX_CORP = fx ,
      ◇ FY_CORP = fy ,
      ◇ FZ_CORP = fz ,
      ◆ MX_TUBU = MX ,
      ◆ MY_TUBU = my ,
      ◆ MZ_TUBU = mz ,
      ◇ FX_TUBU = fx ,
      ◇ FY_TUBU = fy ,
      ◇ FZ_TUBU = fz ,
      [R]
    ),
  ◆ RESU_MECA_UNIT= _F (
    / ◆ TABL_MX = tabsigmx ,
      ◆ TABL_MY = tabsigmy ,
      ◆ TABL_MZ = tabsigmz ,
      ◇ TABL_FX = tabsigfx ,
      ◇ TABL_FY = tabsigfy ,
      ◇ TABL_FZ = tabsigfz ,
      ◆ TABL_PRES = tabsigpr ,
      [table]
    / ◆ TABL_MX_CORP = tabsigmx ,
      ◆ TABL_MY_CORP = tabsigmy ,
      ◆ TABL_MZ_CORP = tabsigmz ,
      ◇ TABL_FX_CORP = tabsigfx ,
      ◇ TABL_FY_CORP = tabsigfy ,
      ◇ TABL_FZ_CORP = tabsigfz ,
      ◆ TABL_MX_TUBU = tabsigmx ,
      ◆ TABL_MY_TUBU = tabsigmy ,
      ◆ TABL_MZ_TUBU = tabsigmz ,
      ◇ TABL_FX_TUBU = tabsigfx ,
      ◇ TABL_FY_TUBU = tabsigfy ,
      ◇ TABL_FZ_TUBU = tabsigfz ,
      ◆ TABL_PRES = tabsigpr ,
      [table]
    ),
  ◇ RESU_THER= _F (
    ◆ NUME_RESU_THER = numtran,
                      [I]
    ◆ TABL_RESU_THER = table,
                      [table]
    ),
```

```
◇ 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 = /'YES', [DEFECT]
                /'NOT', [KN]
  ◆ PRES_A = pressed , [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 = list_num_tran , [L_I]
  ),
```

```

# if TYPE_RESU_MECA = 'PIPING'
  ◆ OPTION      = 'TIREDNESS',
  ◆ MODEL       = model , [model]

  ◆ ZONE_ANALYSE=_F (
    ◇ / ALL      = 'YES', [DEFECT]
    / GROUP_MA   = gma1, [groupma]
    / MESH       = ma1, [mesh]
  ◆ CARA_ELEM = will cara, [cara_elem]
  ◆ TYPE_KE    = / 'KE_MECA', [DEFECT]
    / 'KE_MIXTE'
  ◆ CHAM_MATER= chmat, [cham_mater]
  ◆ RESU_MECA=_F (
    ◆ NUME_CHAR = numchar, [I]
    ◇ NOM_CHAR  = nomchar, [KN]
    ◆ / RESULT = resu , / [evol_elas]
    / [evol_noli]

    ◆ / TOUT_ORDRE = 'YES',
    / NUME_ORDRE = lordre , [1_I]
    / INST       = linst , [1_R]
    / NOEUD_CMP  = lnoecmp, [1_K16]
    # If INST:
    ◇ CRITERION = / 'RELATIVE', [DEFECT]
    ◇ PRECISION = / prec, [R]
    / 1.E-6, [DEFECT]
    / 'ABSOLUTE',
    ◆ PRECISION = prec, [R]
    ◆ NOM_CHAM  = / 'EFGE_ELNO',
    / 'SIEF_ELNO',
    / CHAM_GD   = cham_effo, [cham_elem]
  )
  ◆ INDI_SIGM=_F (
    ◇ C1        = / 1. , [DEFECT]
    / c1, [R]
    ◇ C2        = / 1. , [DEFECT]
    / c2, [R]
    ◇ C3        = / 0.5, [DEFECT]
    / c3, [R]
    ◇ K1        = / 1. , [DEFECT]
    / k1, [R]
    ◇ K2        = / 1. , [DEFECT]
    / k2, [R]
    ◇ K3        = / 1. , [DEFECT]
    / k3, [R]
    ◆ / ALL      = 'YES', [DEFECT]
    / GROUP_MA   = gma1, [groupma]
    / MESH       = ma1, [mesh]
    ◇ / GROUP_NO = gno1, [groupno]
    / NODE       = 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]
  ◆ / ALL = 'YES', [DEFECT]
  / GROUP_MA = gma1, [groupma]
  / MESH = ma1, [mesh]
◇ / GROUP_NO = gno1, [groupno]
  / NODE = 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 = / 'YES', [DEFECT]
  / 'NOT', [KN]
  ◆ PRES_A = pressed , [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 = list_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 table produced as a result:

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

3.2 Operand **TITLE**

◆ TITLE = title

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

3.3 Operand **INFORMATION**

◆ INFORMATION = /1
 /2

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

3.4 Types of results: keyword **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 calculations (MECA_STATIQUE, STAT_NON_LINE) on a modeling 2D or 3D. The results are transmitted via tables of constraints, 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 tiredness (option SN) and of tiredness (option FATIGUE_ZH210) on segments;
- for the geometrical singularities: calculation of the factor of starting (option STARTING) on a circular line of cut around the singularity.

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

Results of the unit type: 'UNIT'

This kind of result requires the preliminary calculation of the constraints for loadings unit (efforts 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 constraints related to the thermal transients considered. These efforts can be calculated with Code_Aster, that is to say resulting from database OAR.

Each situation is then defined starting from its two stabilized mechanical states (described by the value of the torque of effort) and of a thermal transient. The accessible criteria are the criteria of level 0 (option PM_PB), of level A except tiredness (option SN) and of tiredness (option TIREDDNESS) on segments.

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

Results of type piping: 'PIPING'

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This kind of result is dedicated to the postprocessing of mechanical calculations (`MECA_STATIQUE` , `STAT_NON_LINE` , `COMB_SISM_MODAL`) on a line of piping. Calculation with tiredness is done according to the rules of the B3600 paragraph.

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

3.5 Produced table

The order `POST_RCCM` generate a concept of the type `table`. The order `IMPR_TABLE` [U4.91.03] allows to print the contents of the table. 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 calculations 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 materials necessary to the calculation of the criteria are to be defined by the order `DEFI_MATERIAU` [U4.43.01]. The computed values and the limiting values are stored in the table `tabl_post_rccm`, that one prints using the order `IMPR_TABLE` [U4.91.03].

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

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

The operator `DEFI_MATERIAU` [U4.43.01] however the definition of the material characteristics authorizes according to the temperature (keyword factor `RCCM_FO`). Actually, this possibility is reserved for the use of the option '`UNIT`' in which one indicates the temperature of the transients.

With the option '`EVOLUTION`', the user must define the material characteristics, for postprocessing, only by the keyword factor `RCCM` order `DEFI_MATERIAU`. Indeed, to use this option '`EVOLUTION`', the user has to provide in data input only constraints, the thermal evolution being ignored even if it exists in the preceding stages of calculation.

With the 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 calculations (`MECA_STATIQUE`, `STAT_NON_LINE`) on a modeling 2D or 3D. The results are transmitted via tables of constraints, extracted on the segments from analysis. These tables of constraints can be created by the orders `POST_RELEVE_T` or `MACR_LIGN_COUPE`. The possible options of calculation are:

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

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

4.1.1 Operand MATER

◆ `MATER` = `chechmate`

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

Notice on the curves of tiredness:

For the small amplitudes of constraints, the difficulty of the prolongation of the curve of tiredness can arise: for example, for the curves of tiredness of the RCCM beyond 10^6 cycles, the corresponding constraint, 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 tiredness is defined in the properties material (keyword `TIREDDNESS/WOHLER`) as being the number of cycle to the rupture according to the half-amplitude of the constraint `Salt`. The small amplitudes of constraints 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', is calculated by supposing that the first value of the curve of Wohler provided is the limit of endurance of material. In other words, very forced alternate smaller than the first value indicated in `DEFI_FONCTION` will correspond to a factor of null use. The method adopted here thus corresponds well to the concept of limit of endurance;
- if `PROL_GAUCHE` = 'LINEAR', 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 concept 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 law power).

4.1.2 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 calculation of the thermal ratchet (cf § 4.1.4.2). If elastic limit `SY_MAX` is not defined, one takes the value defined under the operand `SY_02` keyword `RCCM` in `DEFI_MATERIAU` [U4.43.01]; if this operand is not either defined, the calculation of the thermal ratchet is impossible.

4.1.3 Option `PM_PB`

Option allowing to calculate the criteria of level 0 who aim at securing the material against the damage of excessive deformation, plastic instability and elastic and elastoplastic instability. These criteria require the calculation of the equivalent constraints of membrane P_m , of membrane local Pl , of inflection Pb and of membrane plus inflection $P_m + Pb$.

The operands necessary are `MATER`, the table of the constraints `TABL_RESU_MECA` (built by `POST_RELEVE_T` or `MACR_LIGN_COUPE` after mechanical calculation on the place of post - treatment) and possibly the table of the constraints `TABL_SIGM_THER` built starting from a calculation with the thermal loading only.

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.

The limiting values are Sm and $1.5Sm$, Sm being the working stress function of material and temperature, given by the keyword `SM` keyword `RCCM` in `DEFI_MATERIAU` [U4.43.01].

Note:

- 1) *The calculation of PM and $PMPB$ is only done starting from the primary constraints, therefore except constraints of thermal origin. If `TABL_SIGM_THER` is informed, one supposes that the result indicated in `TABL_RESU_MECA` corresponds to a thermomechanical calculation and one thus withdraws the thermal stresses to him. If only `TABL_RESU_MECA` is informed, calculation is done directly starting from the constraints indicated in the table.*

4.1.4 Option `SN`

Option allowing to calculate the criteria of level A (except tiredness) which aims 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 the operand `TABL_SIGM_THER`) one carries out also the calculation of S_n^* .

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

The operands necessary are `MATER` and the table of the constraints `TABL_RESU_MECA` (built by `POST_RELEVE_T` or `MACR_LIGN_COUPE` after mechanical calculation on the place of post - treatment) to inform in the keyword `TRANSIENT`.

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.

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

Note:

The keyword `TABL_RESU_MECA` can be repeated several times under only one keyword `TRANSIENT`. For the calculation of S_n and S_n^ , there will be however no combination between the situations thus defined: each table of constraints will be treated successively.*

4.1.4.1 Calculation of S_n^*

If the operand `TABL_SIGM_THER` keyword factor `TRANSIENT` is present, one carries out also the calculation of S_n^* .

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 the table `TABL_SIGM_THER` correspond to those of the table `TABL_RESU_MECA`.

4.1.4.2 Calculation of the thermal ratchet

If operands `TABL_SIGM_THER` and `TABL_RESU_PRES` keyword factor `TRANSIENT` are present, one carries out also the calculation 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 the operand `SY_MAX` of `POST_RCCM`; maybe by the operand `SY_02` keyword `RCCM` in `DEFI_MATERIAU` [U4.43.01]. If no elastic limit is defined, the calculation of the thermal ratchet is impossible.

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

In table result appear, for each end of each segment of analysis, the limit elastic `SY`, the amplitude of variation of the thermal constraint of origin `SP_THER`, the maximum of general membrane stress due to the pressure `SIGM_M_PRES` and two acceptable values maximum of the amplitude of variation of the thermal stress calculated either by supposing a linear temperature variation in the wall (`VALE_MAXI_LINE`), that is to say by supposing a parabolic temperature variation in the 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 the additional RCC-M `ZH210`.

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The amplitude of variation of constraint in each end of the segment of analysis is calculated starting from the tables of constraints `TABL_RESU_MECA`, for each combination of moments 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].

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

Note:

The keyword `TABL_RESU_MECA` can be repeated several times under only one keyword `TRANSIENT`. For the fatigue analysis, the results contained in each table of constraints will be combined between them.

*For the operands `NUME_ORDRE`, `INST` or `LIST_INST`, a possible confusion is the use of the list of the moments of thermomechanical calculations (`MECA_STATIQUE`, `STAT_NON_LINE`) instead of the list of the moments corresponding **with the extreme states** waited by operator `POST_RCCM`. In the first case, every moment of calculations is then regarded as extrema of constraints and leads to computing times which can be important.*

4.1.6 Option STARTING

Option allowing to calculate the factor of starting on the level of a singular zone. For this option, the constraints are to be provided as starter in the table `TABL_SIGM_THETA` and must correspond to the extraction of the constraints, in local reference mark, on a circular line of cut of diameter `D_AMORC` (parameter material defined in the RCC-M) around the geometrical singularity. The tables of constraints can be created by using the operator `MACR_LIGN_COUPE` (`TYPE=' ARC '`).

For this option, it is also obligatory to define in the properties materials (keyword `RCCM`) coefficients of the law of starting (`A_AMORC` and `B_AMORC`), the diameter of the circle on which the constraints are extracted (`D_AMORC`) and the coefficient between constraint and effective constraint (`R_AMORC`).

4.2 Keyword TRANSIENT

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

4.2.1 Operand ENTITLE

Allows to give a name to the transient. This name will be displayed in the produced table.

4.2.2 Operand TABL_RESU_MECA

◇ `TABL_RESU_MECA = tabmeca`

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

4.2.3 Operand TABL_SIGM_THER

◇ `TABL_SIGM_THER = tabth`

Table of the constraints on the segment of analysis, built for example by `POST_RELEVE_T` or `MACR_LIGN_COUPE` on a result got with a thermal loading only. This keyword allows in particular the calculation of S_n^* [§4.1.4.1].

4.2.4 Operand TABL_SIGM_THETA

◇ `TABL_SIGM_THETA = sigt`

This operand is to be used only in the case of the option `STARTING` [§4.1.6]. It corresponds to the table of the constraints, in local reference mark, on a circular line of cut around the geometrical singularity. The table must obligatorily comprise the columns `ANGLE`, `ABSC_CURV`, `INST` and `SIZZ`, where `SIZZ` corresponds to the constraint `sigma_thêta_thêta` in the local reference mark of the line of cut. The diameter of the circle on which the constraints are extracted is a parameter material (operand `D_AMORC` of `DEFI_MATERIAU/RCCM`)

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

4.2.5 Operand `TABL_RESU_PRES`

◇ `TABL_RESU_PRES = tabpres`

Table of the constraints on the segment of analysis, built for example by `POST_RELEVE_T` or `MACR_LIGN_COUPE` on a result got with the direct loading of compression. This keyword allows the calculation of the thermal ratchet [§4.1.4.2].

4.2.6 Operand `NB_OCCUR`

◇ `NB_OCCUR = / nocc,`
`/ 1, [DEFECT]`

Many occurrences for the calculation of the factor of use.

4.2.7 Operands `TOUT_ORDRE / INST / LIST_INST / PRECISION / CRITERION`

◇ `TOUT_ORDRE, INST, LIST_INST`

These keywords allow the selection of the moments corresponding to the fields gathered in the tables of constraints `tabmeca`, `HT` and `/ou sigp` under the reference symbols previously specified.

◇ `PRECISION, CRITERION`

Keywords (optional) defining the precision ($1.E-6$ by default into relative) and the search criterion (`RELATIVE` by default) of a sequence number starting from a value of moment.

4.3 Production run

It is checked that the moments of calculation of the table `tabth` are identical to those of the table `tabmeca`. On the other hand, one cannot check only the thermal transients which contributed to the mechanical results `tabth` and `tabmeca` are identical. It is to the user to ensure coherence (including on the data materials).

Note:

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

It is thus strongly recommended not to remove the coordinates of the points in the tables of statements of constraints.

4.4 Example of use

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

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

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- 1) definition of the parameters of material and the curve of tiredness,
- 2) definitions of the mechanical and thermal loadings,
- 3) linear thermomechanical calculation or not linear,
- 4) (if calculation of Sn^*) mechanical calculation with thermal loading only,
- 5) (if calculation of the thermal ratchet) mechanical calculation 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 continuation):

```
SN1=POST_RCCM (MATER=MAT,  
              TYPE_RESU=' VALE_MAX',  
              TYPE_RESU_MECA=' EVOLUTION',  
              OPTION=' SN',  
              TITRE=' SN, RESULT: RESU2b WITH RESUTH',  
              TRANSITOIRE=_F ( TABL_RESU_MECA = T_RESU2b,  
                              TABL_SIGM_THER = T_RESUTHb, )  
              )  
  
IMPR_TABLE (TABLE = sn1)
```

An example of use of the operator POST_RCCM with results of the type EVOLUTION for the option STARTING 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 PIPING

5.1 Opening remarks concerning the stages preliminary to this postprocessing

From several mechanical computation results (MECA_STATIQUE, STAT_NON_LINE, COMB_SISM_MODAL) on a line of piping, one calculates criteria of tiredness by the option TIREDNESS.

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

- Geometry of the line of piping.
- The material field: it is the map of materials assigned to the groups of meshes of the grid by AFFE_MATERIAU which it is necessary to add the curve of tiredness, E_REFE, M_KE and N_KE (keywords RCCM).
- AFFE_CARA_ELEM allows 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:
 - 1) Many occurrences of each situation (thus of each stabilized state).
 - 2) Pressure and average temperature of each stabilized state.
 - 3) List of the mechanical loadings of each stabilized state.
 - 4) The group of membership of the situation.
 - 5) The associated thermal transient.
- Results of calculations for each mechanical loading (including the earthquake), located by its number, with for information the name of the loading case: field by elements with the nodes of generalized efforts, for each loading (EFGE_ELNO, or SIEF_ELNO).
- For each node, a reference to a definite thermal result below.
- Results of thermal calculations: calculations finite elements 2D or 3D which gives information depend at the same time on the geometry and the transient. There is thus a thermal calculation by type of junction, and type of transient. In practice two are carried out POST_RELEVE_T by transient and different type of thickness or geometry: one POST_RELEVE_T with the option EXTRACTION, and a second with the option AVERAGE

Preliminary calculations to carry out are thus:

- Calculations of type beam (elastic design) for each loading (one makes use only of the moments, expressed in a local reference mark with each element, locates presumed identical for all the results) composing each of the two stabilized states of each situation.
- A seismic calculation (inertial answer and displacements of anchoring) (only one type of earthquake taken into account).
- The calculation of each thermal transient, in as many grids 2D or 3D that there are different thicknesses or components.

Operands and keywords of the option TIREDNESS were selected in order to allow a later use in link with tool OAR. They are thus inspired by the specifications of database OAR [bib3].

5.2 Operand CHAM_MATER

♦ CHAM_MATER = chmat

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

Notice on the curves of tiredness:

For the small amplitudes of constraints, the difficulty of the prolongation of the curve of tiredness can arise: for example, for the curves of tiredness of the RCCM beyond 10^6 cycles, the corresponding constraint, 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 concept of limit of endurance: if the amplitude of constraint is lower than the first X-coordinate of the curve of tiredness, then one takes a factor of null use.

5.3 Operand CARA_ELEM

♦ CARA_ELEM = will cara

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

5.4 Operand MODEL

♦ MODEL = model

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

5.5 Operand TYPE_KE

♦ TYPE_KE = / 'KE_MECA', [DEFECT]
/ '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 Keyword ZONE_ANALYSE

This keyword makes it possible to limit the fatigue analysis to meshes or groups of mesh of the line of piping.

5.6.1 Operands ALL/GROUP_MA/MESH

◇ / ALL = 'YES' ,
/ GROUP_MA = gma1 , [groupma]
/ MESH = ma1 , [mesh]

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

These keyword make it possible to restrict the analysis with meshes or groups of meshes, which makes it possible to save computing time.

5.7 Keyword RESU_MECA

This keyword factor makes it possible to define the results of mechanical calculations. 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 keyword SITUATION).

5.7.2 Operand NOM_CHAR

Name (optional) of the mechanical loading.

5.7.3 Operand RESULT/CHAM_GD

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

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

The results of calculations for each loading (fields by elements with the nodes of generalized efforts) can be defined:

- that is to say a field by element: `cham_effo` who is of type `EFGE_ELNO`, or `SIEF_ELNO`,
- that is to say a structure of data `result` (exit of `MECA_STATIQUE` or `STAT_NON_LINE`) with parameters of extraction: moment, `NOM_CHAM='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 efforts relating to the earthquake are the moments for each component of each earthquake, resulting from a quadratic combination `NOEUD_CMP= ('COMBI', 'QUAD')` for the inertial answer; and of the nodes and the directions (for example `NOEUD_CMP= ('N1', 'DX')`) for displacements of anchorings.

5.8 Operand INDI_SIGM

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

```
        / GROUP_MA      = gma1      ,      [groupma]
        / MESH          = ma1        ,      [mesh]
    ◇ / GROUP_NO       = gno1      ,      [groupno]
        / NODE          = no1        ,      [node]
    ◇ TYPE_ELEM_STANDARD = / 'DRO' ,      [KN]
                                / 'NECK' ,      [KN]
                                / 'TRN' ,      [KN]
                                / 'TEE' ,      [KN]
    )
```

Values of the indices of constraints to be used in the analysis of tiredness (values codified in the RCC - Mr. B3683, variable according to the type of junction). The user provides for each group of meshes, or each node of each mesh, the values of C1, C2, C3, K1, K2, K3, knowing that the values by default are those which correspond to the right parts of pipings, 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 the meshes of GMA1 )
_F ( MAILLE=' MA2' , NOEUD=' NO2' , C1=1.2 , C2=1.4 ) ,
(assignment of particular indices for the node NO2 mesh MA2 )
```

TYPE_ELEM_STANDARD is a keyword optional, purely informative, allowing to clearly show more in the table 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 Keyword RESU_THER

This keyword factor makes it possible to define the results of thermal calculations. It is répétable as many times as there are different thermal calculations 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 keyword SITUATION).

5.9.2 Operand TABL_RESU_THER

◆ TABL_RESU_THER = table [table]

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

◆ TABL_MOYE_THER = table [table]

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

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

5.9.3 Operands ALL / GROUP_MA/MESH/GROUP_NO/NODE

```
◇ / ALL = 'YES' ,  
  / GROUP_MA = gma1 , [groupma]  
  / MESH = ma1 , [mesh]  
◇ / GROUP_NO = gno1 , [groupno]  
  / NODE = no1 , [node]
```

The table and the transient are associated is with a group of meshes, (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 = tab11,  
               TABL_MOYE_THER = tab111,  
               GROUP_MA=' gma1'),  
              _F (NUME_RESU_THER = 1,  
               TABL_RESU_THER = tab12,  
               TABL_MOYE_THER = tab122,  
               MESH = 'ma1' ,  
               NODE = 'no2' )
```

5.10 Keyword EARTHQUAKE

This keyword factor makes it possible to define the situations of earthquake. There can be one earthquake 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 keyword OCCURRENCE 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 earthquake, regarded as under-cycles in the calculation of the factor of use.

NUME_GROUPE allows to define the number of group to which the situation belongs. There can be one earthquake by group of situations.

The temperature of reference TEMP_REF situation of earthquake is useful only if the properties materials depend on the temperature (apertureRand RCCM_FO of DEFI_MATERIAU).

5.10.2 Operand CHAR_ETAT

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

CHAR_ETAT allows to define the list of the mechanical numbers of loadings associated with the situation of earthquake. These numbers correspond to the keyword NUME_CHAR keyword factor CHAR_MECA. They must correspond to the results of inertial calculation using COMB_SISM_MODAL, and of each displacement of anchoring under earthquake, obtained either using MODE_STATIQUE, that is to say on a case-by-case basis.

5.11 Keyword SITUATION

This keyword 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 keyword OCCURRENCE file OAR and indicates the number of occurrences of the situation.

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

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 passage.

For the situations of passage, 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 = pressed , [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 calculation of the properties materials to the two stabilized states; operands TEMP_REF_A and TEMP_REF_B are thus useful only if the properties materials 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 the keyword NUME_CHAR keyword factor CHAR_MECA.

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

5.11.5 Operand NUME_RESU_THER

- ◇ NUME_RESU_THER = list_num_tran [L_I]

List of numbers of tables resulting from thermal calculations associated with the situation. With each situation a thermal transient (or several in the case of various sections is associated with 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* tables which represent the calculation of the same thermal transient in various places of the line (for each thickness or each discontinuity). These numbers must belong to the list of the numbers provided under the keyword NUME_RESU_THER keyword factor RESU_THER.

5.11.6 Operand COMBINABLE

◆ COMBINABLE = / 'YES' , [DEFECT]
/ 'NOT' , [KN]

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

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 UNIT

6.1 Preliminaries

It is supposed here that the calculation of the component was carried out in *Code_Aster* (exploitation of a statement of the constraints on a segment chosen by the user), or comes from one request to the database OAR [bib1], in which can be stored profiles of constraints. One uses here a common specification of the form of the results resulting from these two ways.

Calculations 2D or 3D of the component are to be made only for unit loadings (efforts 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 efforts and moments resulting from calculation beam of piping, for all the loadings intervening in the situations of calculation. Attention, **the reference mark used for calculation 2D or 3D must be coherent with that in which the total efforts resulting from calculation beam are expressed.**

Preliminary calculations to carry out in *Code_Aster* or to extract from database OAR (so available):

- Calculation of the constraints for each unit loading, by a model 2D or elastic 3D.
- Calculation of each thermal transient, on the same grid 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 tiredness, 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 of the 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 earthquake), located by its number, with for information the name of, and the torque loading case of generalized efforts correspondent to this loading, to apply to the limits of the model.
- Results of calculations for each unit mechanical loading (extraction of the values of the constraints on a segment chosen by the user of the model 2D or 3D).
- Results of thermal calculations: extraction of the constraints on a segment of the model finite elements 2D or 3D. There is thus a thermal calculation by transient.

Note:

Method UNIT of the operator POST_RCCM consider the mechanical and thermal constraints separately contrary to the method 'EVOLUTION' which considers the total constraints. What results in maximizing the maximum amplitudes of variation of constraints considered and, consequently, the elastoplastic concentration factor Ke used in the calculation of the factor of use.

Conservatism, wanted, of the method 'UNIT' can thus S' prove excessive. It is advisable to be vigilant on its use when the amplitudes of variation of the calculated constraints 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 damage of excessive deformation, plastic instability and elastic and elastoplastic instability. These

criteria require the calculation of the equivalent constraints of membrane P_m , of membrane local Pl , of inflection P_b and of membrane plus inflection $P_m + P_b$.

6.1.2 Option SN

Option allowing to calculate the criteria of level A (except tiredness) which aims 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 Sn . Under certain conditions, this option also allows the calculation of Sn^* (if presence of the keyword factor RESU_THER) and of the thermal ratchet (if presence of the keyword factor RESU_THER and of a pressure PRES_A/PRES_B under the keyword factor SITUATION).

Note:

With the option 'SN', calculation is done without combination between the definite situations: each situation will be treated successively. To have the sizes with combination between each situation, it is necessary to use L'option 'TIREDNESS'.

6.1.3 Option TIREDNESS

Fatigue analyses (option 'TIREDNESS') 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 produced result are described in the paragraph 6.10.1.

6.2 Operand MATER

♦ MATER = chechmate

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

Notice on the curves of tiredness:

The question of the prolongation of the curve of tiredness and the concept 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 calculation of the thermal ratchet (cf § 4.1.4.2). If elastic limit SY_MAX is not defined, one takes the value defined under the operand SY_02 keyword RCCM in DEFI_MATERIAU [U4.43.01]; if this operand is not either defined, the calculation of the thermal ratchet is impossible.

6.4 Operand TYPE_KE

♦ TYPE_KE = / 'KE_MECA', [DEFECT]
/ '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 Keyword CHAR_MECA

This keyword factor makes it possible to define, for each mechanical loading appearing in the situations, the torques applied to the limits of the model, resulting from calculations of type beam. It is repeatable 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 keyword 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 efforts resulting from calculations of the line of piping, standard beam, for each loading, to apply to the profiles of constraints provided under RESU_MECA_UNIT, by linear combination.

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

Among these efforts one finds also the results of calculations for each earthquake: moments for each component of each earthquake, the inertial answer and displacements of anchorings.

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

◆	MX_CORP	=	MX	,	[R]
◆	MY_CORP	=	my	,	[R]
◆	MZ_CORP	=	mz	,	[R]
◇	FX_CORP	=	fx	,	[R]
◇	FY_CORP	=	fy	,	[R]
◇	FZ_CORP	=	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 efforts applied to the body and the pipe of a pricking. Their significance is identical to that of the operands MX, MY, ... used for the lines of piping.

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

6.6 Keyword RESU_MECA_UNIT

◆	RESU_MECA_UNIT=	_F	(
	/	◆	TABL_MX = tabsigmx , [table]
		◆	TABL_MY = tabsigmy , [table]

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

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

This keyword factor makes it possible to provide the profiles of constraints on the segment chosen, resulting from unit mechanical calculations is on the line of piping (TABL_MX, TABL_MY...), that is to say on pricking (TABL_MX, BODY, TABL_MX_TUBU...).

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

Let us note that it is of use in calculations RCCM of type piping to consider only the moments, this is why the keywords of the type TABL_FX, TABL_FY, TABL_FZ are optional. TABL_PRES correspondent with a calculation under pressure interns unit, without forgetting the basic effect.

6.7 Keyword RESU_THER

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

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 keyword SITUATION).

6.7.2 Operand TABL_RESU_THER

```
♦ TABL_RESU_THER = table [tabl_post_releve]
```

Table resulting from POST_RELEVE_T, containing for each transitory thermal calculation, the statement of the constraints due to the thermal loading on the section of the grid 2D or 3D chosen by the user at various moments of the transient. The origin of the section must be the internal skin.

6.8 Keyword EARTHQUAKE

Only one loading of the type EARTHQUAKE 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 with each occurrence with the earthquake, considered as under-cycles in the calculation of the factor of use.

Notice on the earthquake:

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

6.8.2 Operands CHAR_ETAT

- ◆ CHAR_ETAT = (list_num_char_meca), [L_I]

List of the mechanical numbers of loadings (corresponding to the keyword `NUME_CHAR` keyword factor `CHAR_MECA`) associated with the situation of earthquake.

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 earthquake.

6.9 Keyword SITUATION

This keyword 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 = pressed , [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 calculation of the properties materials to the two stabilized states; operands `TEMP_REF_A` and `TEMP_REF_B` are thus useful only if the properties materials 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 the keyword `NUME_CHAR` keyword factor `CHAR_MECA`.

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

6.9.4 Operand NUME_RESU_THER

◇ NUME_RESU_THER = list_num_tran [L_I]

List of thermal numbers of transients associated with the situation. There can be 0 or 1 transient section by section of line (what corresponds to groups of meshes) for each situation. These numbers correspond to the keyword NUME_RESU_THER keyword 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 passage.

For the situations of passage, num1 and num2 the two numbers of groups connected by this situation indicate. This situation belongs to the two groups between which it defines the passage. A situation of passage 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 passage between these groups.

Note:

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

6.9.6 Operand COMBINABLE

◆ COMBINABLE = / 'YES' , [DEFECT]
/ 'NOT' , [KN]

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

6.10 Produced table and example

6.10.1 Produced table

The table produced by POST_RCCM depends onOPTION of calculation and type of result requested under the operand TYPE_RESU:

- if TYPE_RESU='VALE_MAX' (option by default): the table is simple and comprises only the maximum parameters (PM , SN , FU) at the two ends on the whole of 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 earthquake. For the option TIREDNESS, 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 table are is the maximum values of PM, PB and PMPB ('VALE_MAX'), that is to say these sizes for each situation ('DETAILS').
- Option 'SN': the parameters of the table are is the maximum values of S_n and S_n^* ('VALE_MAX'), that is to say these sizes for each situation with or without earthquake ('DETAILS').

If they are calculated, the sizes associated with the thermal ratchet appear in the table. For each end of each segment of analysis appear the elastic limit S_Y , the amplitude of variation of the thermal constraint of origin SP_THER , the maximum of general membrane stress due to the

pressure SIGM_M_PRES and two acceptable values maximum of the amplitude of variation of the thermal stress calculated either by supposing a linear temperature variation in the wall (VALE_MAXI_LINE), that is to say by supposing a parabolic temperature variation in the wall (VALE_MAXI_PARAB).

- Option 'TIREDNESS': if TYPE_RESU='DETAILS', it is recommended to print the table with successive filters so that it is easily exploitable.
 - **Impression of the maximum one:** S I TYPE_RESU='MAX' or with a filter in IMPR_TABLE : FILTRE=_F (NOM_PARA='TYPE', VALE_K='MAXI'), the produced table 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.
 - **Impression of the sizes 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 table contains the following parameters for each situation (with or without earthquake): PM, PB, PMB, SN, SN*, SP, KE_MECA, SALT and FACT_USAGE.
 - **Impression of the sizes 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 table contains the following parameters for each combination of situations (with or without earthquake): SN, SP1_IJ, SP2_IJ, SALT1_IJ and SALT2_IJ. Columns NUME_SITU_I and NUME_SITU_J the situations considered define. SP1_IJ and SP2_IJ correspond respectively to the 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 calculations

Many additional information can be found in the file message if INFO=2, in particular for the option TIREDNESS.

One can thus follow the treatment successively:

- situation of earthquake (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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