# Operator POST_K_BETA

## 1 Goal

Analysis of harmfulness of defect by the method K-beta for the defects of type the elliptic or semi-elliptic located under the coating of the tanks of the pressurized water reactors.

The objective of this method is to evaluate on a healthy grid (without defect with a grid) and in postprocessing of a mechanical study (axisymmetric or 3D) in linear elasticity, the elastoplastic factor of intensity of the constraints on the level of each of the two points of the defect, i.e. with level of the point side coating and on the level of the point side base metal. The sizes obtained at exit of this method can then be used to determine thereafter the factors of margin with respect to the rupture by comparison with the critical tenacity of the mode of rupture under consideration on the level of the point of the defect considered.

POST_K_BETA initially calculate the elastic stress intensity factor to the two points of the defect, the constraints with the nodes resulting from the mechanical resolution and residual stresses given by the user. Then, in the second time, the operator calculates the factor of intensity of the constraints corrected plastically starting from his elastic equivalent via the method known as of the “correction β”. This method is specific to the defects under coating stuck to the interface or slightly shifted (side coating or side base metal) compared to the interface and allows to take account of the influence on the defect of the phenomenon of plasticization occurring the level of the point side coating and the point side base metal [R7.02.10].

Product a concept of the type table_sdaster.

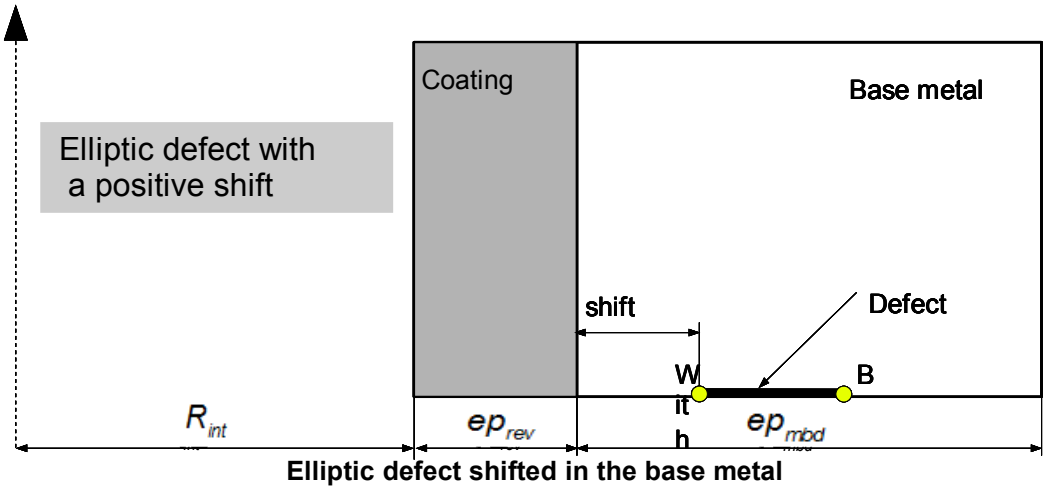
# 2 Syntax

```
tk [table_sdaster]  =  POST_K_BETA  (

          ♦  GRID   =  my,                              [grid]

          ♦  MATER_REV =  mat_rev,                          [material]

          ♦  EPAIS_REV =  epais_rev,                    [R]

          ◊  MATER_MDB =  mat_mdb,                          [material]

          ◊  EPAIS_MDB =  epais_mdb,                    [R]

          ♦  CRACK  =  _F  (
                       ♦  FORM_FISS    =  /    ' ELLIPSE ', [DEFECT]
                                          /    ' SEMI_ELLIPSE ',
                       ◊  SHIFT     =  /   -2.10 -4,  [DEFECT]
                                          /d shelling, [R]
                       ♦  DEPTH  =  depth, [R]
                       ♦  LENGTH    =  length,       [R]
                       ♦  ORIENTATION  =  /    ' CIRC ',
                                          /    ' LONGI ',
                       ),

          ♦  K1D       =  _F  (
                       ◊  TABL_MECA_REV=  table_rev,    [table_sdaster]
                       ♦  TABL_MECA_MDB=  table_mdb,    [table_sdaster]
                       ♦  TABL_THER     =  table_ther,  [table_sdaster]
                       ♦  INTITULE      =  heading,     [K]
                       ),

          ◊  TITLE     =  title,                        [l_K]
                                  );
```

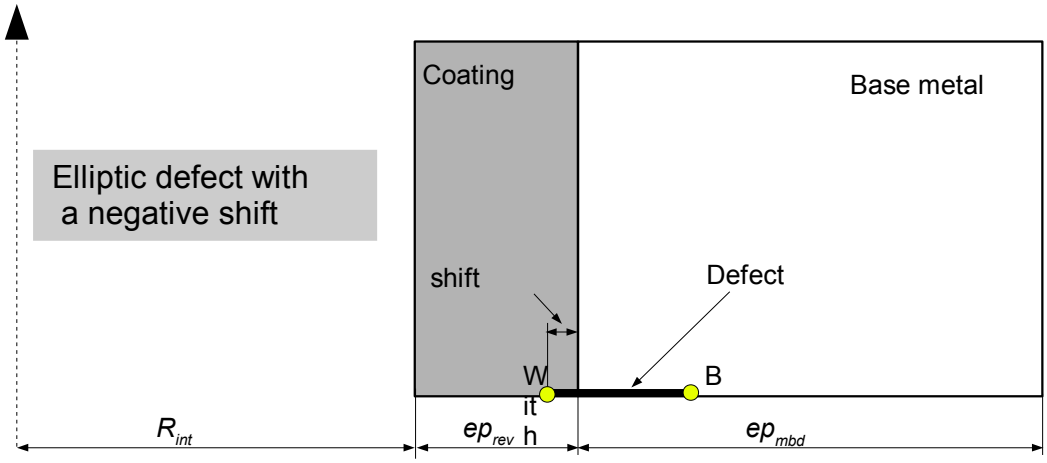
# 3 Operands

The operator POST_K_BETA perhaps used within the framework of axisymmetric or three-dimensional modelings.

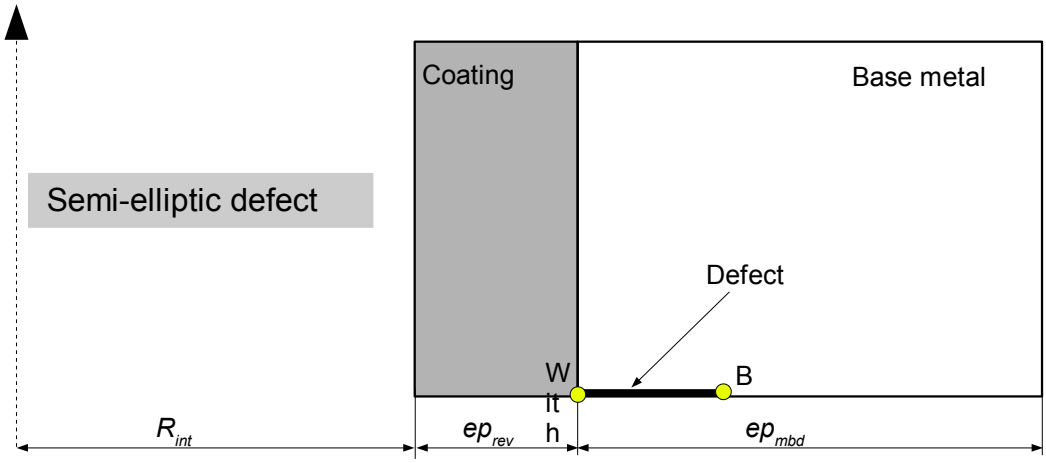
On the figures below we present a schematization of a slice of tank with the presence of an elliptic defect (shift negative and positive) or of a semi-elliptic defect.




**Elliptic defect shifted in the base metal**




**Elliptic defect shifted in the coating**




**Semi-elliptic defect located under the coating**

## 3.1 Operand GRID

Concept of the type grid.

## 3.2 Operand MATER_REV

Name of the concept of the type material defining material constituting the coating. Necessary to recover:

- The Young modulus, for the calculation of the coefficients of influence (semi-elliptic defect),
- Yield stresses, for the plastic correction of the stress intensity factors.

## 3.3 Operand EPAIS_REV

Thickness of the coating. Necessary for:

- The calculation of the stress intensity factors in the case of the method of the coefficients of influence (semi-elliptic defect)
- Correction of the stress intensity factors by the factors of edges and for the plastic correction.

## 3.4 Operand MATER_MDB

Name of the concept of the type material defining material constituting the base metal. Necessary to recover the Young modulus, for the calculation of the coefficients of influence (semi-elliptic defect).

## 3.5 Operand EPAIS_MDB

Thickness of the base metal, necessary for the correction of the stress intensity factors by the method of the coefficients of influence (semi-elliptic defect).

## 3.6 Keyword CRACK

Keyword factor for the geometrical characterization of the defect. It can be used only once.

### 3.6.1 Operand FORM_FISS

Form of the defect: 'ELLIPSE' for an elliptic defect,
'SEMI_ELLIPSE' for a semi-elliptic defect,

### 3.6.2 Operand SHIFT

This operand is used only in the case of a defect of form 'ELLIPSE'. From the interface coating/base metal, it makes it possible to shift the crack in:

- Coating: SHIFT negative,
- Base metal: SHIFT positive or null.

### 3.6.3 Operand DEPTH

Radial dimension of the defect.

### 3.6.4 Operand LENGTH

The second dimension of the defect (axial or orthoradiale according to the orientation of the defect).

### 3.6.5 Operand ORIENTATION

Characterization of the orientation of the defect: 'CIRC' for a circumferential defect,
'LONGI' for a longitudinal defect.

## 3.7 Keyword K1D

Keyword factor for the characterization of the thermomechanical transient. The repetition of this keyword is possible.

### 3.7.1 Operands TABL_MECA_REV and TABL_MECA_MDB

**Defect of form 'ELLIPSE' with negative shift:**

For this kind of defect, two tables TABL_MECA_REV and TABL_MECA_MDB are obligatory, they provide the transient of the constraints undergone by the tank during the history on the loading, respectively the side coating (of the point With defect at the interface) and side base metal (of the interface to the point B defect).

**Defect of form 'ELLIPSE' with positive shift:**

For this kind of defect, the table TABL_MECA_MDB is obligatory, it provides the transient of the constraints undergone by the tank during the history on the loading, respectively the side coating (of the point With defect) and side base metal (with the point B defect).

**Defect of form 'SEMI_ELLIPSE' :**

For this kind of defect, the table TABL_MECA_MDB is obligatory, it provides the transient of the constraints undergone by the tank during the history on the loading, respectively the side coating (of the point With defect: interface enters the coating and the base metal) and side base metal (to the point B defect).

The common parameters necessary to these tables are:

- 'INST' [R],
- 'SIXX' [R] (in 3D with 'LONGI'),
- 'SIYY' [R] (in 3D with 'LONGI' or in 2D with 'CIRC'),
- 'SIXY' [R] (in 3D with 'LONGI'),
- 'SIZZ' [R] (in 2D with 'LONGI' or in 3D with 'CIRC').

Necessary parameters specific to:

- TABL_MECA_REV soNT :
  - 'COOR_X' [R],
  - 'COOR_Y' [R]

- TABL_MECA_MDB are :
  - 'ABSC_CURV' [R]

The reader is invited to consult the documentation of the orders POST_RELEVE_T [U4.81.21] and MACR_LIGN_COUPE [U4.81, 13] for more information on the direction of the parameters.

In the case of a defect of form 'SEMI_ELLIPSE' the macro-order MACR_LIGN_COUPE must be used with the keywords TYPE=' SEGMENT' and NB_POINTS=5. Lmethod of the coefficients of influence requires the evaluation of a polynomial of degree 5 representative has the evolution of the normal constraint to the segment representing the crack [R7.02.10]. The macro-order MACR_LIGN_COUPE allows the user to define the places or the constraint is recorded and this independent of the grid used at the time of the thermomechanical study.

### 3.7.2 Operand TABL_THER

Table providing the thermal transient in the tank during the history of the loading of point A to the point B.

The parameters necessary of this table are:

- 'INST' [R],
- 'ABSC_CURV' [R],
- 'TEMP' [R].

The reader is invited to consult the documentation of the orders POST_RELEVE_T [U4.81.21] and MACR_LIGN_COUPE [U4.81.13] for more information on the direction of the parameters.

### 3.7.3 Operand ENTITLE

Heading to specify the group of nodes considered.

## 3.8 Operand TITLE

Title attached to the concept produced by this operand [U4.03.01].

# 4 Produced table

The produced table is function of the form of the defect. The parameters of the produced table are described in the tables according to:

| Form of the defect: FORM_FISS = 'ELLIPSE' | | |
|---|---|---|
| **PARAMETER** | **TYPE** | **DESCRIPTION** |
| GROUP_NO | K32 | heading to specify the name of the group of nodes considered, |
| INST | R | moment |
| K1_REV | R | factor of intensity of the elastic constraints to the forefront of crack side coating (point With) |
| KCP_REV | R | factor of intensity of the constraints with plastic correction to the forefront of crack side coating (point With) |
| TEMPPF_REV | R | temperature to the forefront of crack side coating (point With) |
| K1_MDB | R | factor of intensity of the elastic constraints to the forefront of crack side base metal (point B) |
| KCP_MDB | R | factor of intensity of the constraints with plastic correction to the forefront of crack side base metal (point B) |
| TEMPPF_MDB | R | temperature to the forefront of crack side base metal (point B) |

| Form of the defect: FORM_FISS = 'SEMI_ELLIPSE' | | |
|---|---|---|
| **PARAMETER** | **TYPE** | **DESCRIPTION** |
| GROUP_NO | K32 | heading to specify the name of the group of nodes considered, |
| INST | R | moment |
| K1_REV | R | factor of intensity of the elastic constraints to the forefront of crack side coating (point With) |
| KCP_REV | R | factor of intensity of the constraints with plastic correction to the forefront of crack side coating (point With) |
| TEMPPF_REV | R | temperature to the forefront of crack side coating (point With) |
| K1_MDB | R | factor of intensity of the elastic constraints to the forefront of crack side base metal (point B) |
| KCP_MDB | R | factor of intensity of the constraints with plastic correction to the forefront of crack side base metal (point B) |
| TEMPPF_MDB | R | temperature to the forefront of crack side base metal (point B) |
| K1C_REV | R | factor of intensity of the constraints to the forefront of crack side coating (point C) |
| KCPC_REV | R | factor of intensity of the constraints with plastic correction to the forefront of crack side coating (point C) |
| TEMPPC_REV | R | temperature to the forefront of crack side coating (point C) |

# 5 Examples

## 5.1 Elliptic defect with a negative shift

Examples of use of the order POST_K_BETA are provided in the case test EPICU01.

Before the use of the order POST_K_BETA, it is necessary to record the constraints and the temperatures along the defect.

Statement of the constraints on the part of the defect located in the coating.

```
S1_G=MACR_LIGN_COUPE (RESULTAT=SIG,
                  LIST_INST = LINST_ME, NOM_CHAM=' SIGM_ELNO',
                  VIS_A_VIS=_F (GROUP_MA_1=' R',),
                  LIGN_COUPE= (
                     _F (TYPE=' SEGMENT', NB_POINTS=2, INTITULE=' GLOBAL1',
                        COOR_ORIG= (2.0013, 0.0,),
                        COOR_EXTR= (2.0015, 0.0,),
                  )))
```

Statement of the constraints on the part of the defect located in the base metal.

```
S2_G=MACR_LIGN_COUPE (RESULTAT=SIG,
                  LIST_INST = LINST_ME, NOM_CHAM=' SIGM_ELNO',
                  VIS_A_VIS=_F (GROUP_MA_1=' ME,),
                  LIGN_COUPE= (
                     _F (TYPE=' SEGMENT', NB_POINTS=2, INTITULE=' GLOBAL2',
                        COOR_ORIG= (2.0015, 0.0,),
                        COOR_EXTR= (2.0073, 0.0,),
                  )))
```

Statement of the temperatures along the defect.

```
TEMP_G=MACR_LIGN_COUPE (RESULTAT=TEMP,
                     LIST_INST = LINST_TH, NOM_CHAM=' TEMP',
                     LIGN_COUPE= (
                              _F (TYPE=' SEGMENT', NB_POINTS=10, INTITULE='
GLOBAL3',
                           COOR_ORIG= (2.0013, 0.0,),
                           COOR_EXTR= (2.0073, 0.0,),)))
```

After having taken these various readings, the calculation of the stress intensity factor can be done indeed using the order POST_K_BETA.

```
TB_KBETA = POST_K_BETA (   GRID   = E-MAIL,
                           MATER_REV = MAME_RE2,
                           EPAIS_REV = EPREV,
                           CRACK  = _F (FORM_FISS = 'ELLIPSE',
                                        DEPTH = 6. ,
                                        LENGTH   = 60. ,
                                        SHIFT   = -1.E-05,
                                        ORIENTATION= 'CIRC'),
                            K1D          = (_F (   TABL_MECA_REV = S1_G,
                                        TABL_MECA_MDB = S2_G,
                                        TABL_THER     = TEMP_G,
                                        ENTITLE      = 'NOEINF',),),
                           TITLE     =  'FIC BY METHOD K-BETA'
                         )
```

## 5.2 Elliptic defect with a positive shift

Examples of use of the order POST_K_BETA are provided in the case test EPICU02.

Before the use of the order POST_K_BETA, it is necessary to record the constraints and the temperatures along the defect.

Tables TABL_MECA_MDB and TABL_THER are obtained directly by using the macro-order MACR_LIGN_COUPE on the segment support of the active defect point With defect side coating to the point B dimensioned base metal.

```
S1G = MACR_LIGN_COUPE (RESULTAT=SIG,
                       NOM_CHAM=' SIGM_ELNO',
                       LIGN_COUPE=_F (TYPE=' SEGMENT',
                                      NB_POINTS=5,
                                      COOR_ORIG= (Pointe_A, 0. , 0.),
                                      COOR_EXTR= (Pointe_B, 0. , 0.)))

TEMPG = MACR_LIGN_COUPE (RESULTAT=TEMP,
                         NOM_CHAM=' TEMP',
                         LIGN_COUPE=_F (TYPE=' SEGMENT',
                                        NB_POINTS=5,
                                        COOR_ORIG= (Pointe_A, 0. , 0.),
                                        COOR_EXTR= (Pointe_B, 0. , 0.)))
```

After having taken these various readings, the calculation of the stress intensity factor can be done indeed using the order POST_K_BETA.

```
KBETA = POST_K_BETA (GRID  = E-MAIL,
                     MATER_REV = MAME_RE2,
                     EPAIS_REV = EPREV,
                     CRACK   =_F (FORM_FISS     = 'ELLIPSE',
                                  DEPTH    =  0,006,
                                  SHIFT      =  0.01,
                                  LENGTH      =  0.06,
                                  ORIENTATION   = 'LONGI'),
                       K1D     = (_F (TABL_MECA_MDB   =  S1G,
                                  TABL_THER       =  TEMPG,
                              ENTITLE = 'node lower NOEINF')),
                         TITLE     = 'FIC BY METHOD K-BETA')
```

## 5.3 Semi-elliptic defect

Examples of use of the order POST_K_BETA are provided in the case test EPICU03.

Before the use of the order POST_K_BETA, it is necessary to record the constraints and the temperatures along the defect.

Tables TABL_MECA_MDB and TABL_THER are obtained directly by using the macro-order MACR_LIGN_COUPE on the segment support of the active defect point With defect side coating to the point B dimensioned base metal.

```
S1G = MACR_LIGN_COUPE (RESULTAT=SIG,
                       VIS_A_VIS=_F (GROUP_MA_1=' ME),
                       NOM_CHAM=' SIGM_ELNO',
                       LIGN_COUPE=_F (TYPE=' SEGMENT',
                                      NB_POINTS=5,
                                      COOR_ORIG= (Pointe_A, 0. , 0.),
                                      COOR_EXTR= (Pointe_B, 0. , 0.)))


TEMPG = MACR_LIGN_COUPE (RESULTAT=TEMP,
                         NOM_CHAM=' TEMP',
                         LIST_INST=LINST_TH,
                         LIGN_COUPE=_F (TYPE=' SEGMENT',
                                        NB_POINTS=5,
                                        COOR_ORIG= (Pointe_A, 0. , 0.),
                                        COOR_EXTR= (Pointe_B, 0. , 0.)))
```

After having taken these various readings, the calculation of the stress intensity factor can be done indeed using the order POST_K_BETA.

```
KBETA    = POST_K_BETA (GRID  = E-MAIL,
                        MATER_REV = MAME_RE2,
                        MATER_MDB = MAME_MET,
                        EPAIS_REV = EPREV,
                        EPAIS_MDB = EPMDB,
                        CRACK   =_F (FORM_FISS     = 'SEMI_ELLIPSE',
                                     DEPTH    =  0,005,
                                     LENGTH      =  0,025,
                                     ORIENTATION   = 'LONGI'),
                           K1D     = (_F (TABL_MECA_MDB   =  S1G,
                                      TABL_THER       =  TEMPG,
```

```
                    ENTITLE = 'node lower NOEINF')),
                TITLE     = 'FIC BY METHOD K-BETA')
```

Indeed, contrary to the methodology of determination of the elastic factor of intensity of the constraints for the elliptic defect, the method of the coefficients of influence used here for the determination of the elastic factor of intensity of the constraints of the defect semi-elliptic requires to inform in more the keywords MATER_MDB and EPAIS_MDB (cf paragraphs 3.4 and 3.5).