

## Operator POST\_USURE

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### 1 Goal

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To calculate volume and depth of wear according to the power of wear.

The power of wear is given or calculated by the operator `DYNA_TRAN_MODAL` [U4.53.21]. It is necessary to provide a law of wear, a geometry of contact and a list of moments.

Product a structure of data of the type `table_sdaster`.

## 2 Syntax

```
tresu [table_sdaster] = POST_USURE (

# definition of the Node of impact or a power of wear
  ◆ / ◆ RESU_GENE = tg, [tran_gene]
  ◆ NODE = noeu, [node]
  ◇ INST_INIT = / 0. , [DEFECT]
  / t0, [R]
  ◇ INST_FIN = T1, [R]
  ◇ NB_BLOC = / 1, [DEFECT]
  / Nb, [I]

  / ◆ PUIS_USURE = been able, [R]

# definition of the law of wear
  ◆ / ◆ LOI_USURE = 'ARCHARD', [KN]
  / ◆ MOBILE = _F (
  ◆ COEF_USURE = k_t, [R]
  ),
  ◇ OBSTACLE = _F (
  ◆ COEF_USURE = k_o, [R]
  ),
  / ◆ MATER_USURE = 'mat1_mat2', [KN]
  ◇ USURE_OBST = / 'NOT', [DEFECT]
  / 'YES',

# division figure of game in sectors
  / ◆ SECTOR = _F (
  ◆ COEF_USURE_MOBILE = k_t, [R]
  ◆ COEF_USURE_OBST = k_o, [R]
  ◇ ANGL_INIT = ang_i, [R]
  ◆ ANGL_FIN = ang_f, [R]
  ),

  / ◆ LOI_USURE = 'KWU_EPRI', [KN]
  / ◆ MOBILE = _F (
  ◆ COEF_FNOR = k1_t, [R]
  ◆ COEF_VTAN = k2_t, [R]
  ◆ COEF_USURE = k3_t, [R]
  ◇ COEF_K = / k_t, [R]
  / 5. , [DEFECT]
  ◇ COEF_C = / c_t, [R]
  / 10. , [DEFECT]
  ),
```

```

        ◇ OBSTACLE = _F (
            ◆ COEF_FNOR = k1_o, [R]
            ◆ COEF_VTAN = k2_o, [R]
            ◆ COEF_USURE= k3_o, [R]
            ◇ COEF_K = / k_o, [R]
            / 5. , [DEFECT]
            ◇ COEF_C = / c_o, [R]
            / 10. ,
[DEFECT]
        )
/   ◆ MATER_USURE = 'mat1_mat2', [KN]
    ◇ USURE_OBST = / 'NOT', [DEFECT]
        / 'YES',
    ◇ FNOR_MAXI = fn, [R]
    ◇ VTAN_MAXI = vg, [R]
/   ◆ LOI_USURE = 'EDF_MZ', [KN]
/   ◆ MOBILE = _F (
            ◆ COEF_USURE=/a_t, [R]
            / 1.E-13, [DEFECT]
            ◇ COEF_B =/b_t, [R]
            / 1.2, [DEFECT]
            ◇ COEF_N =/n_t, [R]
            / 2.44E-08,
            ◇ COEF_S =/s_t, [R]
            / 1.14E-16,
        ),
    ◇ OBSTACLE = _F (
            ◆ COEF_USURE=/a_o, [R]
            / 1.E-13, [DEFECT]
            ◇ COEF_B =/b_o, [R]
            / 1.2, [DEFECT]
            ◇ COEF_N =/n_o, [R]
            / 2.44E-08,
            ◇ COEF_S =/s_o, [R]
            / 1.14E-16,
        ),
/   ◆ MATER_USURE = 'mat1_mat2', [KN]
    ◇ USURE_OBST = / 'NOT', [DEFECT]
        / 'YES',

# definition of the moments of calculation depth of wear
    ◆ / INST = l_inst, [l_R]
    / LIST_INST = linst, [listr8]
    / COEF_INST = coeff, [R]

# definition of a title
    ◇ TITLE = 'montitre', [l_Kn]

# impression of information
    ◇ INFORMATION = / 1, [I]
        / 2, [DEFECT]

```

```
# definition of the table to in the case of enrich calculation with
evolution # by the games
  ◊ ETAT_INIT = _F (
    ◆ TABL_USURE = tresu, [table_sdaster]
    ◊ INST_INIT = all, [R]
  ),

# definition of the contact
  ◆ / ◆ CONTACT = 'GRAPPE_ALESAGE', [KN]
    ◆ RAYON_MOBILE = r_t, [R]
    ◆ RAYON_OBST = r_o, [R]
  / ◆ CONTACT = 'GRAPPE_1_ENCO', [KN]
  / ◆ CONTACT = 'GRAPPE_2_ENCO', [KN]

  / ◆ CONTACT = 'TUBE_BAV', [KN]
    ◆ RAYON_MOBILE = r_t, [R]
    ◆ LARGEUR_OBST = l_o, [R]
    ◊ ANGL_INCLI = Eng, [R]

  / ◆ CONTACT = 'TUBE_ALESAGE', [KN]
    ◆ RAYON_MOBILE = r_t, [R]
    ◆ RAYON_OBST = r_o, [R]
    ◆ LARGEUR_OBST = l_o, [R]
    ◊ ANGL_INCLI = Eng, [R]

  / ◆ CONTACT = 'TUBE_3_ENCO', [KN]
    ◆ RAYON_MOBILE = r_t, [R]
    ◆ RAYON_OBST = r_o, [R]
    ◆ LARGEUR_OBST = l_o, [R]
    ◆ ANGL_ISTHME = angli, [R]
    ◊ ANGL_INCLI = Eng, [R]

  / ◆ CONTACT = 'TUBE_4_ENCO', [KN]
    ◆ RAYON_MOBILE = r_t, [R]
    ◆ RAYON_OBST = r_o, [R]
    ◆ LARGEUR_OBST = l_o, [R]
    ◆ ANGL_ISTHME = angli, [R]
    ◊ ANGL_INCLI = Eng, [R]

  / ◆ CONTACT = 'TUBE_TUBE', [KN]
    ◆ RAYON_MOBILE = r_t, [R]
    ◊ ANGL_INCLI = Eng, [R]

# loading of a new tube
  / ◊ TUBE_NEUF = 'YES' [DEFECT]

)
```

## 3 Operands

We draw here attention to some delicate points of the use of POST\_USURE.

- 1) The result of POST\_USURE does not depend on the final mechanical state of calculation but of all the history of the shocks. It is thus very important to take into account **all** moments of calculations, i.e. not to ask selective filing in DYNA\_TRAN\_MODAL.
- 2) The result of POST\_USURE is very sensitive to the parameters of calculations, in particular to the wealth of the modal base, and the step of time. It is thus strongly advised to test various modal bases (increasingly rich) and various steps of time (increasingly small). For example, for the step of time, one will be able to test various spaced values of a factor 10, then 2, in order to determine a beach of step of time over which the result is stable.
- 3) In the case of a vibratory calculation, one can have a result which is not representative of real wear if the experiment is not long enough. In the same way, in the case of excitations generated by chance, it is advised to carry out several pullings before drawing the conclusions of dimensioning.

### 3.1 Node of impact and power of wear

#### 3.1.1 Operand PUIS\_USURE

- ◆ PUIS\_USURE = been able

The power of wear is:

- exit of the result of a transitory calculation by modal recombination, produced by the operator DYNA\_TRAN\_MODAL [U4.53.21] (operands following),
- or given by the user who uses the operand then PUIS\_USURE.

#### 3.1.2 Operand RESU\_GENE

- ◆ RESU\_GENE = tg

Result of a transitory calculation by modal recombination, produced by the operator DYNA\_TRAN\_MODAL [U4.53.21].

#### 3.1.3 Operand NODE

- ◆ NODE = noeu

Definition of the node of shock post-to be treated.

#### 3.1.4 Operand INST\_INIT

- ◇ INST\_INIT = t0

Moment of beginning of the average of the signals (cf [§4]).  
(T<sub>0</sub> = 0. value by default).

#### 3.1.5 Operand INST\_FIN

- ◇ INST\_FIN = T1

Moment of end of the average of the signals.

#### 3.1.6 Operand NB\_BLOC

- ◇ NB\_BLOC = Nb

Many temporal blocks of division interval [T<sub>0</sub>, T<sub>1</sub>] for the average of the signals (1 by default).

## 3.2 Law of wear 'ARCHARD'

### 3.2.1 Operand LOI\_USURE

◆ LOI\_USURE = 'ARCHARD'

Defines the law of wear in order to calculate worn volume.

The coefficient of wear of the law of Archard is provided by the user or is taken in a database.

### 3.2.2 Keyword MOBILE

◆ MOBILE

Definition of the coefficient of wear of the mobile.

#### 3.2.2.1 Operand COEF\_USURE

◆ COEF\_USURE = k\_t

Value of the coefficient of wear of the mobile.

### 3.2.3 Keyword OBSTACLE

◇ OBSTACLE

Definition of the coefficient of wear of the obstacle.

#### 3.2.3.1 Operand COEF\_USURE

◆ COEF\_USURE = k\_o

Value of the coefficient of wear of the obstacle.

### 3.2.4 Operand MATER\_USURE

◆ MATER\_USURE = 'mat1\_mat2'

Recovery of the coefficients in a data bank:

mat1: being the material of the bunch or tube (the mobile),  
mat2: being the material of the obstacle.

### 3.2.5 Operand USURE\_OBST

◇ USURE\_OBST = / 'YES'  
/ 'NOT' [DEFECT]

Indicate if one wants to take into account the wear of the obstacle.

## 3.3 Law of wear 'KWU\_EPRI'

### 3.3.1 Operand LOI\_USURE

◆ LOI\_USURE = 'KWU\_EPRI'

Defines the law of wear in order to calculate worn volume.

### 3.3.2 Keyword MOBILE

◆ MOBILE

Definition of the coefficient of wear of the mobile (provided by the user or taken in the database).

### 3.3.2.1 Operands COEF\_\*

- ◆ COEF\_FNOR = k1\_t  
Definition of the dimensional coefficient of correction in the case of pure impacts.
- ◆ COEF\_VTAN = k2\_t  
Definition of the dimensional coefficient of correction in the case as of slips.
- ◆ COEF\_USURE= k3\_t  
Definition of the coefficient of wear of reference.
- ◇ COEF\_K = / k\_t  
/ 5. [DEFECT]  
Definition of the constant.
- ◇ COEF\_C = / c\_t  
/ 10. [DEFECT]  
Definition of the constant.

### 3.3.3 Keyword OBSTACLE

- ◇ OBSTACLE  
Definition of the coefficient of wear of the obstacle (provided by the user or taken in the database).

### 3.3.3.1 Operands COEF\_\*

- ◆ COEF\_FNOR = k1\_o  
Definition of the dimensional coefficient of correction in the case of pure impacts.
- ◆ COEF\_VTAN = k2\_o  
Definition of the dimensional coefficient of correction in the case as of slips.
- ◆ COEF\_USURE= k3\_o  
Definition of the coefficient of wear of reference.
- ◇ COEF\_K = / k\_o  
/ 5. [DEFECT]  
Definition of the constant.
- ◇ COEF\_C = / c\_o  
/ 10. [DEFECT]  
Definition of the constant.

### 3.3.4 Operand MATER\_USURE

- ◆ MATER\_USURE = 'mat1\_mat2'  
Recovery of the coefficients in a data bank =  
mat1 = being the material of the bunch or the tube (the mobile),  
mat2 = being the material of the obstacle.

## 3.3.5 Operand USURE\_OBST

◇ USURE\_OBST = / 'YES'  
/ 'NOT' [DEFECT]

Indicate if one wants to take into account the wear of the obstacle.

## 3.3.6 Operands FNOR\_MAXI/VTAN\_MAXI

◇ FNOR\_MAXI = fn

Definition of the maximum normal force to take into account for the distribution of the 5 classes for the law of wear KWU\_EPRI.

◇ VTAN\_MAXI = vg

Definition the speed of slip maximum to take into account for the distribution of the 5 classes for the law of wear KWU\_EPRI.

## 3.4 Law of wear 'EDF\_MZ'

### 3.4.1 Operand LOI\_USURE

◆ LOI\_USURE = 'EDF\_MZ'

Defines the law of wear in order to calculate worn volume.

### 3.4.2 Keyword MOBILE

◆ MOBILE

Definition of the coefficient of wear of the mobile (provided by the user or taken in the database).

#### 3.4.2.1 Operands COEF\_\*

◆ COEF\_USURE = / a\_t  
/ 1.E-13 [DEFECT]

Definition of the coefficient of wear A.

◇ COEF\_B = / b\_t  
/ 1.2 [DEFECT]

Definition of the exhibitor of the power of wear B.

◇ COEF\_N = / n\_t  
/ 2.44E-08 [DEFECT]

Definition of the rate of deceleration N.

◇ COEF\_S = / S\_t  
/ 1.14E-16 [DEFECT]

Definition of the threshold S.

## 3.4.3 Keyword OBSTACLE

◇ OBSTACLE

Definition of the coefficient of wear of the obstacle (provided by the user or taken in the database).

### 3.4.3.1 Operands COEF\_\*

◆ COEF\_USURE = / a\_o  
/ 1.E-13 [DEFECT]

Definition of the coefficient of wear A.

◇ COEF\_B = / b\_o  
/ 1.2 [DEFECT]

Definition of the exhibitor of the power of wear B.

◇ COEF\_N = / n\_o  
/ 2.44E-08 [DEFECT]

Definition of the rate of deceleration N.

◇ COEF\_S = / s\_o  
/ 1.14E-16 [DEFECT]

Definition of the threshold S.

## 3.4.4 Operand MATER\_USURE

◆ MATER\_USURE = 'mat1\_mat2'

Recovery of the coefficients in a data bank =

mat1 = being the material of the bunch or the tube (the mobile),

mat2 = being the material of the obstacle.

## 3.4.5 Operand USURE\_OBST

◇ USURE\_OBST = / 'YES'  
/ 'NOT' [DEFECT]

Indicate if one wants to take into account the wear of the obstacle.

## 3.5 Operand CONTACT

◆ CONTACT = géom

Definition of the geometry of contact.

According to the type of contact, various geometrical relations between worn volumes and worn depths.

### 3.5.1 Operand CONTACT = 'GRAPPE\_ALESAGE'

The bunch is centered in a boring. The trace of wear has a section in the shape of lunule. Worn volume is brought back to a surface used in a section.

### 3.5.2 Operand CONTACT = 'GRAPPE\_1\_ENCO'

The bunch is centered compared to the obstacle.

The map of guidance is made of a notch. Worn volume is brought back to a surface used in a section.

The coefficients are founded at the same time on the experimental results and those of the experience feedback. They apply only to the control rods.

### 3.5.3 Operand CONTACT = 'GRAPPE\_2\_ENCO'

The bunch is centered compared to the obstacle.

The map of guidance is made of two notches diametrically opposite. Worn volume is brought back to a surface used in a section.

The coefficients are founded at the same time on the experimental results and those of the experience feedback. They apply only to the control rods.

### 3.5.4 Operand CONTACT = 'TUBE\_BAV'

#### Case 1:

The tube is presented vertically, the bar impacts perpendicular to the tube, one supposes that the bar does not wear (USURE\_OBST = 'NOT').

#### Case 2:

The bar is presented tilted (operand ANGL\_INCLI) compared to the tube, the bar impacts perpendicular to the tube, one supposes that the bar does not wear.

#### Case 3:

The tube is presented vertically, the bar impacts perpendicular to the tube, one takes into account the wear of the bar (USURE\_OBST = 'YES').

#### Case 4:

The bar is presented tilted (operand ANGL\_INCLI) compared to the tube, the bar impacts perpendicular to the tube, one takes into account the wear of the bar.

## 3.5.5 Operand CONTACT = 'TUBE\_ALESAGE'

### Case 1:

The tube is centered perfectly in an animated boring of a pure orbital movement and wears in a uniform way on all the periphery in contact with the obstacle.

### Case 2:

The tube is centered in an animated boring of a movement of impact-slips of the elliptic type which leads to the formation of traces of wear of the cylindrical type diametrically opposite on the tube and having a section in the shape of lunule.

### Case 3:

The tube, animated of a movement of impact-slips, presents this time a slope compared to the support (operand ANGL\_INCLI). One obtains two symmetrical traces of wear in the shape of V on the tube.

## 3.5.6 Operand CONTACT = 'TUBE\_3\_ENCO'

### Case 1:

The initial contact is carried out against an edge of one of the isthmuses of a trifoliate boring. One supposes the tube perfectly centered compared to his obstacle. The trace of wear does not extend to the entire isthmus. One does not take into account the wear of the obstacle.

### Case 2:

Same assumptions as for case 1 except the position of the tube compared to the obstacle. One supposes this time that the tube presents an angle of inclination (operand ANGL\_INCLI).

## 3.5.7 Operand CONTACT = 'TUBE\_4\_ENCO'

### Case 1:

The initial contact is carried out against an edge of one of the isthmuses of quadrifoliate boring. One supposes the tube perfectly centered compared to his obstacle. The trace of wear does not extend to the entire isthmus. One does not take into account the wear of the obstacle.

### Case 2:

Same assumptions as for case 1 except the position of the tube compared to the obstacle. One supposes this time that the tube presents an angle of inclination (operand ANGL\_INCLI).

## 3.5.8 Operand CONTACT = 'TUBE\_TUBE'

Following the rupture of a stopped tube, there can be contact between this tube and one of its neighbors. The wear of the two tubes by accommodation of surfaces in contact led to the creation of two plane surfaces.

## 3.6 Operand **RAYON\_MOBILE**

◆ `RAYON_MOBILE = r_t`

Definition of the ray of the mobile (obligatory parameter).

## 3.7 Operand **RAYON\_OBST**

◆ `RAYON_OBST = r_o`

Definition of the ray of the obstacle (obligatory parameter if the wear of the obstacle is taken into account).

## 3.8 Operand **LARGEUR\_OBST**

◆ `LARGEUR_OBST = l_o`

Definition of the width of the obstacle (parameter obligatory for the operands `TUBE_*`).

## 3.9 Operand **ANGL\_INCLI**

◇ `ANGL_INCLI = Eng`

Definition of the angle of inclination mobile/obstacle (optional parameter = value 0. is taken by default).

## 3.10 Operand **ANGL\_ISTME**

◆ `ANGL_ISTHME = angli`

Definition of the angle of the isthmus of the geometry of contact (parameter obligatory for the operands `TUBE_3_ENCO` and `TUBE_4_ENCO`).

## 3.11 Operands **INST/LIST\_INST/COEF\_INST**

◆ `INST = l_inst`

Definition of the moments of calculation in the shape of a list of values.

◆ `LIST_INST = linst`

Definition of the moments of calculation in the form of a concept of the type `listr8`.

◇ `COEF_INST = coeff`

The moments given are to be multiplied by a coefficient `coeff` given, which makes it possible to pass easily from the units SO to the natural units for a calculation of wear (the month of the year).

## 3.12 Operand **ETAT\_INIT**

### 3.12.1 Keyword **TABL\_USURE**

◆ `TABL_USURE = tresu` [`table_sdaster`]

Definition of the table which one wishes to reactualize.

## 3.12.2 Keyword **INST\_INIT**

◇ `INST_INIT = all` [R]

Definition of the moment from which one wishes to reactualize the table.

## 3.13 Operand **SECTOR**

◇ `SECTOR =`

Definition of the various quantities necessary to cut out the figure of game in angular sectors.

### 3.13.1 Keyword **COEF\_USURE\_MOBILE**

◆ `COEF_USURE_MOBILE = K_t` [R]

Definition of the coefficient of wear of the mobile within the meaning of the law of Archard for the sector.

### 3.13.2 Keyword **COEF\_USURE\_OBST**

◆ `COEF_USURE_OBST = K_o` [R]

Definition of the coefficient of wear of the obstacle within the meaning of the law of Archard for the sector.

### 3.13.3 Keyword **ANGL\_INIT**

◇ `ANGL_INIT = ang_i` [R]

Definition of the initial angular value of the sector.

### 3.13.4 Keyword **ANGL\_FIN**

◆ `ANGL_FIN = ang_f` [R]

Definition of the final angular value of the sector.

## 3.14 Operands **TITLE/INFORMATION**

◇ `TITLE = 'montitre'`

Title which one wants to give to the result [U4.03.01].

◇ `INFORMATION = / 1`  
`/ 2`

Level of impression

- 1 pas d' impression.
- 2 impression volumes and depths of wear at the specified moments

## 3.15 Produced table

The order POST\_USURE generate a concept of the type counts, whose contents are:

INST: moments to which the user wishes to know the volume and the depth of wear,  
V\_usur\_tube: volume used on the level of the tube (for each moment specified by the user),  
V\_usur\_obst: volume used on the level of the obstacle (for each moment specified by the user),  
P\_usur\_tube: depth of wear on the level of the tube (for each moment specified by the user).

The order IMPR\_TABLE [U4.91.03] allows to print the results.

## 3.16 Loading of a new tube

For the treatment of the wear of the control rods, the user has the possibility of taking into account the change of a tube by a new tube by informing the keyword TUBE\_NEUF = 'YES'

If the user informs this keyword, the operator modifies the values of wear of the tube (V\_USUR\_TUBE, P\_USUR\_TUBE, V\_USUR\_TUBE\_SECT, P\_USUR\_TUBE\_SECT, V\_USUR\_TUBE\_CUMU = 0) in the table resulting from POST\_USURE.

## 4 Checking - Execution

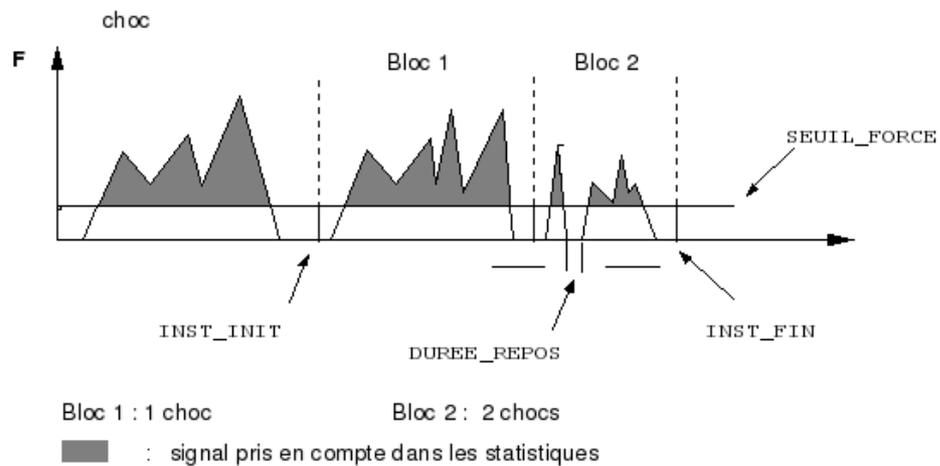
### 4.1 Operand MATER\_USURE

It is checked that the material couple provided by the user is in the database.

### 4.2 Operands RESU\_GENE / INST\_INIT / INST\_FIN / NB\_BLOC

The value of INST\_FIN is compared with the final moment  $t_f$  result tran\_gene. The value of INST\_FIN reserve is  $\min(t_f, t_1)$ .

If the value of INST\_INIT  $t_0$  is higher than the value of INST\_FIN, one stops in error.



## 5 Example

```
dateu = DEFI_LIST_REEL (BEGINNING = 0.25,  
                        INTERVAL = _F (JUSQU_A = 1. , NUMBER = 20),  
                                     _F (JUSQU_A = 5. , NUMBER = 10),  
                                     _F (JUSQU_A = 10. , NUMBER = 5 )  
                        )  
  
#  
us1 = POST_USURE (     PUIS_USURE = 0,312,  
                      LOI_USURE = 'ARCHARD',  
                      NB_BLOC = 4,  
                      MOBILE = _F (COEF_USURE = 30.e-15 ),  
                      OBSTACLE = _F (COEF_USURE = 20.e-15),  
                      CONTACT = 'GRAPPE_1_ENCO',  
                      RAYON_MOBILE = 0.00485,  
                      RAYON_OBST = 0.00545,  
                      LIST_INST = dateu,  
                      COEF_INST = 31557600. ,  
                      TITLE = 'NO1 = Wear per years',  
                      INFORMATION = 2  
                      )  
  
#  
us2 = POST_USURE (     RESU_GENE = dynamoda,  
                      NODE = 'NO1',  
                      LOI_USURE = 'EDF_MZ',  
                      MOBILE = _F (     COEF_USURE = 1.e-13,  
                                     COEF_B = 1.2,  
                                     COEF_N = 2.44e-08,  
                                     COEF_S = 1.14e-16,  
                                     ),  
                      OBSTACLE = _F (     COEF_USURE = 1.e-13,  
                                     COEF_B = 1.2,  
                                     COEF_N = 2.44e-08,  
                                     COEF_S = 1.14e-16  
                                     ),  
                      USURE_OBST = 'YES',  
                      CONTACT = 'GRAPPE_1_ENCO',  
                      RAYON_MOBILE = 0.00485,  
                      RAYON_OBST = 0.00545,  
                      LIST_INST = dateu,  
                      COEF_INST = 31557600. ,  
                      TITLE = 'NO1 = Wear per year',  
                      INFORMATION = 2  
                      )
```