# SSLV135 – Criteria of starting in fatigue under multiaxial loadings for a structure

**Summarized:**

This benchmark aims to test the operator CALC_FATIGUE who calculates the damage for all the points of strcuture.

The geometry treated here is a cube without default with which one carries out a followed linear elastic mechanical computation by the computation of the critical plane of shears in each Gauss point and each node.

- modelization a: criteria MATAKE_MODI_AC, DANG_VAN_MODI_AC, VMIS_TRESCA, criterion in formula, periodic and biaxial loading proportional;
- modelization b: criterion MATAKE_MODI_AV, DANG_VAN_MODI_AV, FATESOCI_MODI_AV, criterion in formula, loading NON-periodical and biaxial proportional ;
- modelization C: criteria MATAKE_MODI_AC and DANG_VAN_MODI_AV, criterion in formula, loading multiaxial, non-proportional ;
- modelization D : criterion in formula, to test new quantities, elastoplastic and periodic uniaxial loading.
- modelization E : criterion in formula, to test new quantities (in stresses) , elastoplastic biaxial loading and NON-periodical.
- modelization F : criterion in formula, to test new quantities (in strains) , elastic biaxial loading with variable amplitude and elastoplastic uniaxial loading and NON-periodical.
- modelization G: criteria MATAKE_MODI_AC, DANG_VAN_MODI_AC, MATAKE_MODI_AV, DANG_VAN_MODI_AV, FATESOCI_MODI_AV. One tests the change of the direction of the critical plane on which the damage or the shears is maximum.

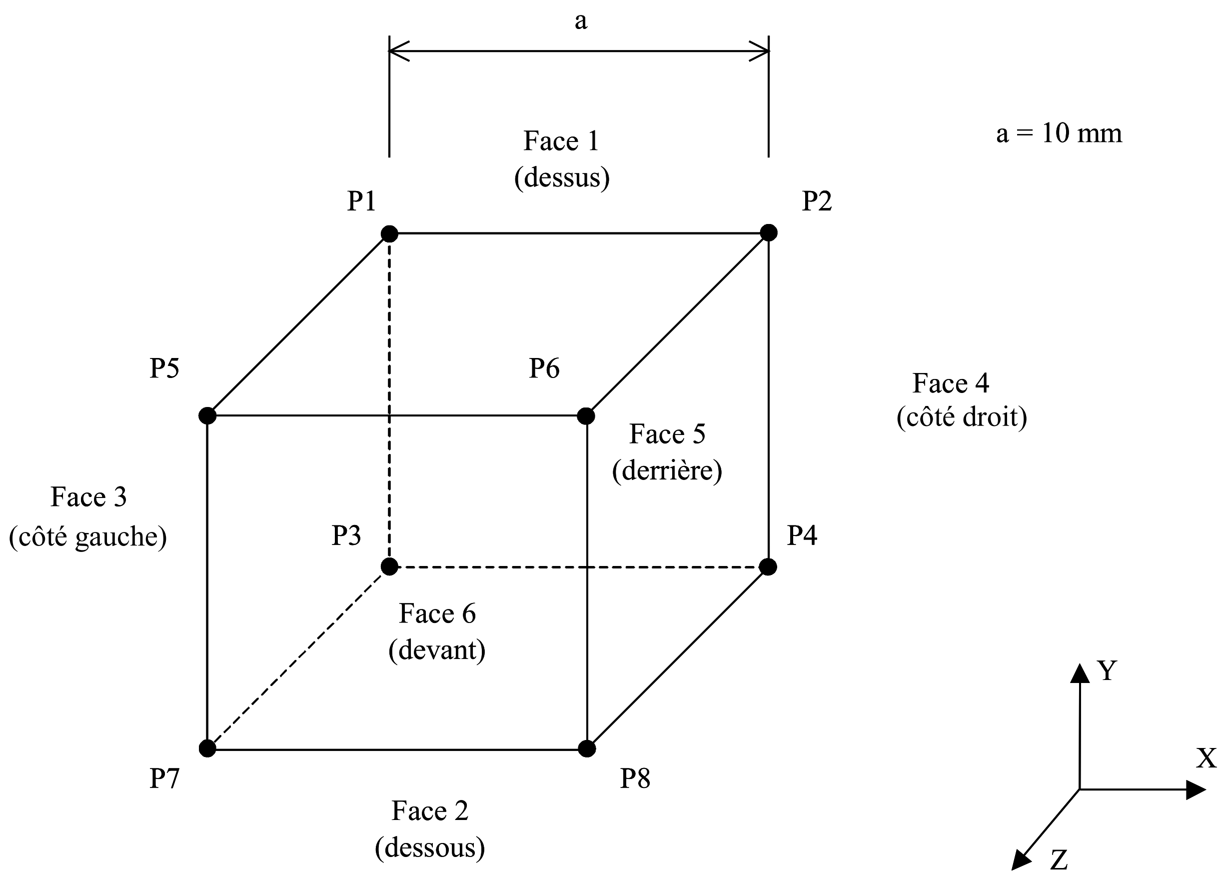
The criteria in the modelization A are said “to plane of critical shears”, they are adapted to the periodic loadings. The criteria in the modelization B can be qualified criteria “with plane of critical damage”, they can be used when the loading is not periodical. Criterion VMIS_TRESCA is not a criterion of fatigue, it determines the variation of maximum amplitude of the tensor of the stresses. The criteria formulates some allowing the user to build predefined criteria according to the quantities are also tested.

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

# 1 Problem of reference

## 1.1 Geometry




the cube has $10\,mm$ side.

## 1.2 Material properties

### 1.2.1 Modelizations: A, B, C and F

Young Modulus: $E=200000\,MPa$
Poisson's ratio: $\nu=0.3$

### 1.2.2 Modelization D

the Young modulus and the Poisson's ratio are identical to those of the other modelizations.
Yield stress of the material: $\sigma_o=150.0\,MPa$
The elastoplastic behavior of Von Mises with linear isotropic hardening with the slope of curve of hardening: $H=50000.0\,MPa$

### 1.2.3 Modelization E

the modulus Young and the Poisson's ratio is identical to those of the other modelizations.
Yield stress of the material: $\sigma_o=900.0\,MPa$
The elastoplastic behavior of Von Mises with linear isotropic hardening with the slope of curve of hardening: $H=50000.0\,MPa$

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

### 1.2.4 Modelization F

In this modelization, two different materials are considered. First is similar to paragraph 1.2.1 (i.e. purely elastic), and second is similar to the material used in the modelization E (1.2.3).

### 1.2.5 Modelization G

In this modelization, two different materials are considered.
The first material is elastic with the Young modulus: $E=193000\,MPa$ and the Poisson's ratio: $\nu=0.3$
The second material is elastoplastic, the modulus Young and the Poisson's ratio is identical to the first material. Yield stress of the material: $\sigma_o=208.0\,MPa$ . The elastoplastic behavior of Von Mises with linear isotropic hardening with the slope of curve of hardening: $H=50000.0\,MPa$

## 1.3 Curves of Wöhler and Manson-Whetstone sheath

the modelizations use all the curves of Wöhler (i.e. a curve in stress) and of Manson-Whetstone sheath (i.e. a curve in strain).

Here the curve of Wöhler (alternate traction and compression controlled in stress):

| Half amplitude of stress ( $MPa$ ) | 138.0 | 152.0 | 165.0 | 180.0 | 200.0 | 250.0 | 295.0 |
|---|---|---|---|---|---|---|---|
| Half Number of | cycles | 1.0E+6 | 5.0E+5 | 2.0E+5 | 1.0E+5 | 5.0E+4 | 2.0E+4 |
| 1.2E+4 amplitude of stress ( $MPa$ ) | 305.0 | 340.0 | 430.0 | 540.0 | 690.0 | 930.0 | 1210.0 |
| Half Number of | cycles | 1.0E+4 | 5.0E+3 | 2.0E+3 | 1.0E+3 | 5.0E+2 | 2.0E+2 |
| 1.0E+2 amplitude of stress ( $MPa$ ) | 1590.0 | 2210.0 | 2900.0 | | | | |
| Many cycles | 5.0E+1 | 2.0E+1 | 1.0E+1 | | | | |

**Table 1.3-1: Curve of Wöhler**

Here the curve of Manson-Whetstone sheath (alternate traction and compression controlled in strain):

| Strain | 0.00226 | 0.0023 | 0.0025 | 0.0027 | 0.003 | 0.0035 |
|---|---|---|---|---|---|---|
| Number of cycles | 5.8E+6 | 4.6E+6 | 2.39284E+5 | 1.49535E+5 | 7.3544E+4 | 3.3821E+4 |
| Strain | 0.006 | 0.0085 | 0.010 | 1.000 | | |
| Many cycles | 2.85E+3 | 1.068E+3 | 5.62E+2 | 1.0 | | |

**Table 1.3-2: Curve of Manson-Whetstone sheath**

## 1.4 Boundary conditions and loadings

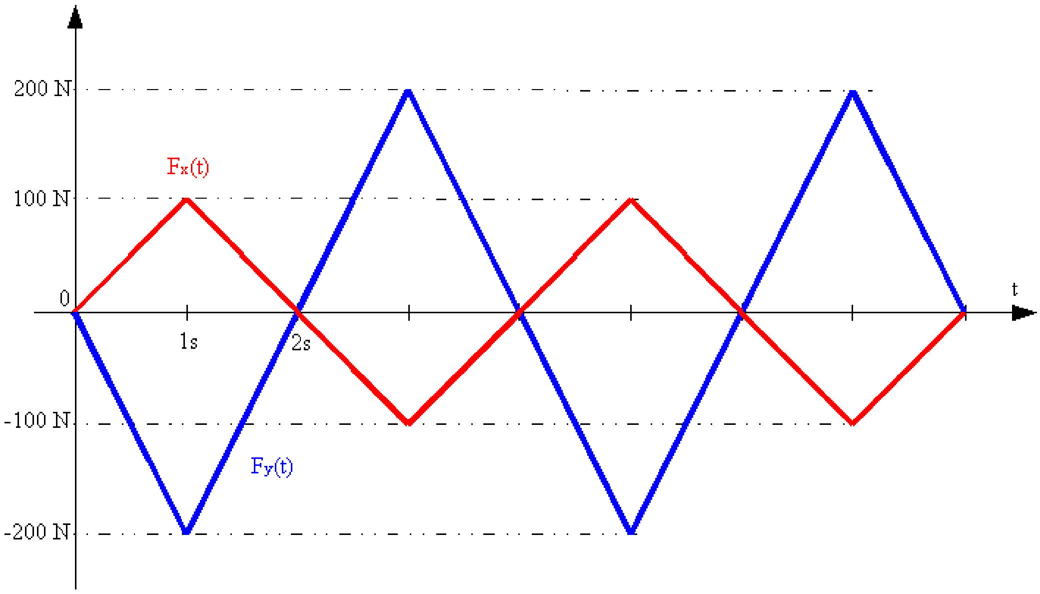
### 1.4.1 Modelizations: A, B

- displacements according to the axis $X$ of face 3 are blocked ( $DX=0.0$ ).
- Displacements according to the axis $Y$ of face 2 are blocked ( $DY=0.0$ ).
- Displacements of the point $P3$ are blocked according to the axis $Z$ ( $DZ=0.0$ ).
- We apply an alternate biaxial loading (traction and compression) according to the axes $X$ and $Y$. $Fx(t)$ represent the alternate forces applied to face 4 according to the axis $X$ and $Fy(t)$ represents the alternate forces applied to the face $1$ according to the axis $Y$.

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

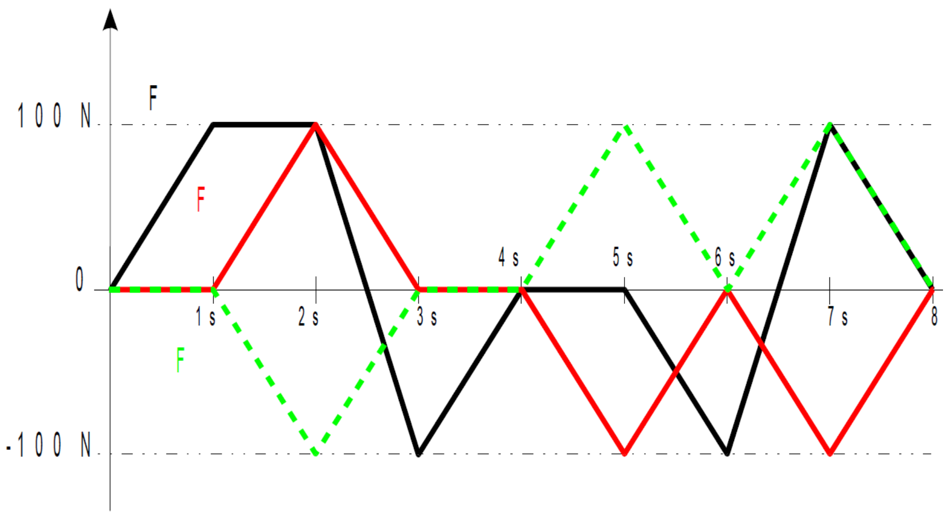
Loading for these modelizations:




### 1.4.2 Modelization C

- displacements according to the axis $X$ of face 3 are blocked ( $DX=0.0$ ).
- Displacements according to the axis $Y$ of face 3 are blocked ( $DY=0.0$ ).
- Displacements according to the axis $Z$ of face 2 are blocked ( $DZ=0.0$ ).
- We apply a multiaxial loading: traction and compression according to the axis $X$, shears according to the axes $Y$ and $Z$. $Fx(t)$ represent the forces applied to face 4 according to the axis $X$, $Fy(t)$ represents the forces applied to face 4 according to the axis $Y$ and $Fz(t)$ represents the forces applied to face 1 according to the axis $Z$.

Loading for this modelization:




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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

### 1.4.3 Modelization D

- displacements according to the axis $X$ face 3 are blocked ( $DX=0.0$ ).
- Displacements according to the axis $Y$ of face 3 are blocked ( $DY=0.0$ ).
- Displacements according to the axis $Z$ of face 2 are blocked ( $DZ=0.0$ ).
- In this modelization, we apply a periodic uniaxial loading.

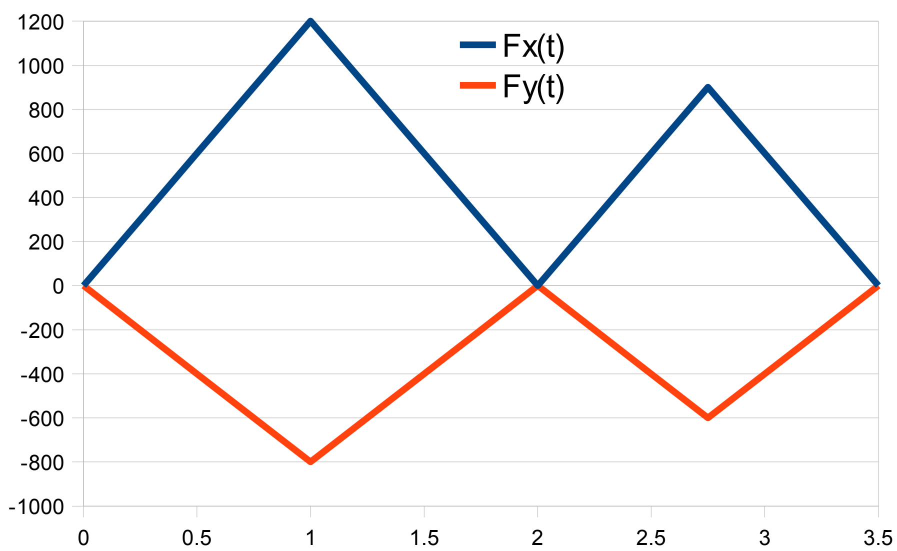
| $t$ | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| $Fx(t)$ | 0 | 200 | 0 | -200 | 0 | 200 |

One notes that this load history involves a plastic strain in computation. It is also noted that the monotonous load history between $t=0$ and $t=1$ (the part of the monotonic loading) is not taken into account in the fatigue analysis.

### 1.4.4 Modelization E

- displacements blocked here are the same ones as in the modelization O
- We apply a biaxial loading here NON-periodical.

| $t$ | 0 | 1 | 2 | 2.75 | 3.5 |
|---|---|---|---|---|---|
| $Fx(t)$ | 0 | 1200 | 0 | | 0 |
| $Fy(t)$ | 0 | -800 | 0 | -600 | 0 |




### 1.4.5 Modelization F

- displacements blocked here are the same ones as in the modelization O
- In this modelization, we apply three distinct loadings. First is biaxial, the two others are uniaxial.

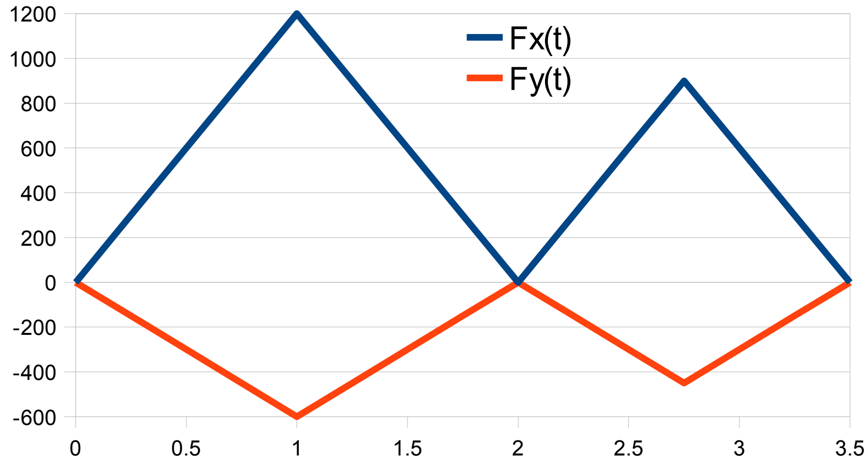
**First loading** (association of `TR_CS` and `COEF` in the command file):

| $t$ | 0 | 1 | 2 | 2.75 | 3.5 |
|---|---|---|---|---|---|

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

| | | | | | |
|---|---|---|---|---|---|
| $Fx(t)$ | 0 | 1200 | 0 | | 0 |
| $Fy(t)$ | 0 | -600 | 0 | -450 | 0 |




**Second loading** (association of `TR_CS2` and `COEF2` in the command file):

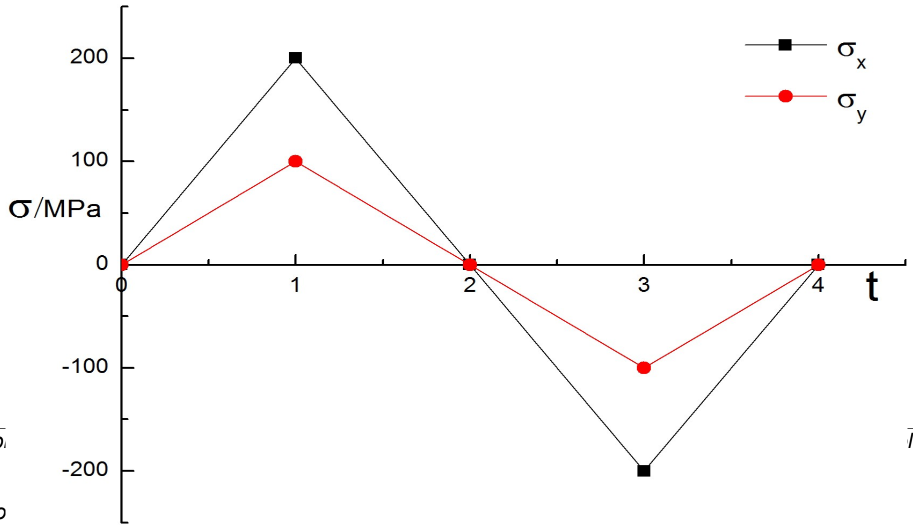
| $t$ | 0 | 1 | 2,5625 | 3,5625 | 5,5625 |
|---|---|---|---|---|---|
| $Fx(t)$ | 0 | 1200 | -675 | 900 | -675 |

**Third loading** (association of `TR_CS2` and `COEF3` in the command file):

| $t$ | 0 | 1 | G | 2 | 3 |
|---|---|---|---|---|---|
| $Fx(t)$ | formula | 0 | 1800 | -600 | 2400 |

### 1.4.6 -1200 Modelization

- displacements blocked here are the same ones as in the modelization A
- We apply an alternate biaxial loading (traction and compression) according to the axes $X$ and $Y$. $\sigma_x$ the alternate forces applied to face 4 according to the axis $X$ and $\sigma_y$ represents the alternate forces applied to the face $1$ according to the axis $Y$.
- To study effects of the average constraint on the directional sense of the critical plane, only of the loadings biaxial, proportional according to directions of $X$ and $Y$ are considered.



- Two parameters are defined

$$\lambda=\frac{\sigma_{y,a}}{\sigma_{x,a}}$$

$$\alpha=\frac{\sigma_{y,m}}{\sigma_{y,a}}=\frac{\sigma_{x,m}}{\sigma_{x,a}}$$

where $\sigma_{x,a}$ , $\sigma_{y,a}$ represent amplitudes of the stresses according to $X$ and $Y$ , respectively. $\sigma_{x,m}$ and $\sigma_{y,m}$ represent the values of the average constraints according to $X$ and $Y$ directions, respectively. One takes $\sigma_{x,a}=200\,MPa$ , $\lambda=1$ and $\alpha$ varies from -1 to 10 with a interval of 0,5.

## 1.5 Initial conditions

Without object for a static analysis.

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

# 2 Reference solution

## 2.1 Method of calculating used for the reference solution

In the case of an alternate biaxial loading where the pressures applied are such as: $\sigma_x=\lambda\,\sigma_y$ , with $|\lambda|>1$ and $\lambda<0$ , it is shown [bib1] that it half amplitude of maximum shears $\Delta\tau/2=\left(\Delta\sigma_x+\Delta\sigma_y\right)/4$ , where $\Delta\sigma_x/2$ and $\Delta\sigma_y/2$ represent the half amplitudes of pressures applied according to the axes $x$ and $y$ . Moreover, there are two critical planes in which the shears are maximum:

## 2.2 Results of reference for the modelizations to see

the references [bib1] and [R7.04.04].

**Half amplitude of maximum shears:**
**N** 1 **N2**

| $\Delta\sigma_x/2$ ( $MPa$ ) | $\Delta\sigma_y/2$ ( $MPa$ ) | $\Delta\tau/2$ ( $MPa$ ) |
|---|---|---|
| 100.200.150 | | |

**Note::**

*The half amplitude of maximum shears is identical for the two critical planes.*

**Normal vectors with the two critical planes:**

| | $n_1$ | $n_2$ |
|---|---|---|
| Component $x$ | $-1/\sqrt{2}$ | $1/\sqrt{2}$ |
| Component $y$ | $1/\sqrt{2}$ | $1/\sqrt{2}$ |
| component $z$ | 0 | 0 |

**normal Maximum stresses in the fields of the norms** $n_1$ **and** $n_2$ **:**

$N_{\max}(n_1)=50\ MPa$ and $N_{\max}(n_2)=50\ MPa$ .

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

**Hydrostatic pressure maximum, independent with respect to the planes of norms $n_1$ and $n_2$ :**

$$P=33.33333\ MPa\ .$$

**Normal average constraints in the fields of the norms $n_1$ and $n_2$ :**

$$N_m(n_1)=0\ MPa \text{ and } N_m(n_2)=0\ MPa\ .$$

**Normal maximum strains in the fields of the norms $n_1$ and $n_2$ :**

$$\varepsilon_{\max}(n_1)=1.75\ 10^{-4} \text{ and } \varepsilon_{\max}(n_2)=1.75\ 10^{-4}$$

**normal average Strains in the fields of the norms $n_1$ and $n_2$ :**

$$\varepsilon_m(n_1)=0 \text{ and } \varepsilon_m(n_2)=0\ .$$

## Criterion `MATAKE_MODI_AC`

$$\frac{\Delta\tau(n_i)}{2}+a\ N_{\max}(n_i)\le b\ ,\ \ i=1,2$$

where $a=1$ and $b=2$ .

**Equivalent stresses within the meaning of MATAKE in the fields of the norms $n_1$ and $n_2$ :**

$$\sigma_{eq}(n_i)=\left(\frac{\Delta\tau(n_i)}{2}+a\ N_{\max}(n_i)\right)\frac{f}{t}\ ,\ \ i=1,2$$

where $f$ and $t$ represent, respectively, the limit of endurance in alternating bending and the limit of endurance in alternate torsion. Here $f/t$ is equal to $1{,}5$ . Consequently we have:

$$\sigma_{eq}(n_1)=300\ MPa \text{ and } \sigma_{eq}(n_2)=300\ MPa\ .$$

**Many cycles to the fracture in the fields of the norms $n_1$ and $n_2$ :**

From the curve of Wöhler, cf [Table 1.2-1], and equivalent stresses within the meaning of MATAKE, we obtain:

$$Nb_{cr}(n_1)=Nb_{cr}(n_2)=10946\ cycles\ .$$

**Damage in the fields of the norms $n_1$ and $n_2$ :**

$$ENDO(n_1)=ENDO(n_2)=9.13565\ 10^{-5}\ .$$

Criterion of Dang Van adapted to the periodic loadings : `DANG_VAN_MODI_AC`

$$\frac{\Delta\tau(n_i)}{2}+a\ P\le b\ ,\ \ i=1,2$$

where $a=1$ and $b=2$ .

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

**Equivalent stresses within the meaning of DANG VAN in the fields of the norms $\mathbf{n}_1$ and $\mathbf{n}_2$ :**

$$\sigma_{eq}(n_i)=\left(\frac{\Delta\tau(n_i)}{2}+a\ P\right)\frac{c}{t}\ ,\ \ i=1,\ 2$$

where $c$ and $t$ represent, respectively, the limit of endurance in alternate shears and the limit of endurance in alternate traction and compression. Here $c/t$ is equal to $1,5$ . Consequently we have:

$$\sigma_{eq}(n_1)=275\ MPa \text{ and } \sigma_{eq}(n_2)=275\ MPa\ .$$

Many cycles to the fracture in the fields of the norms $n_1$ and $n_2$
From the curve of Wöhler, cf [Table 1.2-1], and from the equivalent stresses within the meaning of DANG VAN, we obtain:

$$Nb_{cr}(n_1)=Nb_{cr}(n_2)=14903\ cycles\ .$$

Damage in the fields of the norms $n_1$ and $n_2$ :

$$ENDO(n_1)=ENDO(n_2)=6.709959\ 10^{-5}\ .$$

For the option `COURBE_GRD_VIE = "FORM_VIE"` and `FORMULE_VIE = WHOL_F` where the curve of life is provided by a formula, the results of reference have identical to those called with the name except those of `NBRUPT` and `ENDO` as one uses a curve of different life.

- curve `WHOL_F` of formula (grandeur_équivalente = $4098.3\times(NBRUP^{-0.2693})$ ) is initially provided by a tabulated function to compute: of the values of reference of `NBRUPT` and `ENDO`.
- curve `MANCO2` of formula (grandeur_équivalente = $0.2\times(NBRUP^{-0.1619})$ ) is initially provided by a tabulated function to compute: of the values of reference of `NBRUPT` and `ENDO`.

## 2.3 Results of reference for the modelization B

Criterion of MATAKE adapted to the nonperiodic loadings: `MATAKE_MODI_AV`
For this criterion it does not have of results analytical there.

Criterion of Dang Van adapted to the nonperiodic loadings: `DANG_VAN_MODI_AV`
For this criterion it does not have of results analytical there.
See the references [bib2] and [R7.04.04].

**Half amplitude of stress:**

| $\Delta\sigma_x/2$ ( $MPa$ ) | $\Delta\sigma_y/2$ ( $MPa$ ) |
|---|---|
| 100.200 | |

Criterion of FATEMI and SOCIE adapted to the nonperiodic loadings: `FATESOCI_MODI_AV`
For this criterion it does not have of results analytical there.
See the references [bib3] and [R7.04.04].

**Half amplitude of stress:**

| $\Delta\sigma_x/2$ ( $MPa$ ) | $\Delta\sigma_y/2$ ( $MPa$ ) |
|---|---|
| 100.200 | |

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

Criterion of Von Mises and TRESCA applied in search of the maximum variation of a stress tensor. The loading can be periodic or not: `VMIS_TRESCA`

See the reference [R7.04.04].

**Half amplitude of stress:**

| $\Delta\sigma_x/2$ ( $MPa$ ) | $\Delta\sigma_y/2$ ( $MPa$ ) |
|---|---|
| 100.200 | |

**Criterion of Von Mises:**

Within the space of stresses with six dimensions:

$$\sigma_s=\sqrt{\frac{1}{2}\left[\left(\sigma_{xx}-\sigma_{yy}\right)^2+\left(\sigma_{yy}-\sigma_{zz}\right)^2+\left(\sigma_{zz}-\sigma_{xx}\right)^2+6\left(\sigma_{xy}^2+\sigma_{xz}^2+\sigma_{yz}^2\right)\right]}\ ,$$

with $\sigma_{xx}=200\ MPa$ , $\sigma_{yy}=-400\ MPa$ and $\sigma_{zz}=\sigma_{xy}=\sigma_{xz}=\sigma_{yz}=0$ , one obtains:

| $\sigma_s$ ( $MPa$ ) |
|---|
| 529.15026221292 |

**Criterion of Tresca:**

Within the space of principal stresses with three dimensions:

$$\sigma_s=\underset{i\neq j}{Sup}\left(\left|\sigma_i-\sigma_j\right|\right)\ ,$$

with $\sigma_{xx}=200\ MPa$ , $\sigma_{yy}=-400\ MPa$ and $\sigma_{zz}=\sigma_{xy}=\sigma_{xz}=\sigma_{yz}=0$ , one obtains:

| $\sigma_s$ ( $MPa$ ) |
|---|
| 600 |

## 2.4 Results of reference for the modelization C

There is not result of reference for the modelization G. This modelization has as single purpose to test the routines `cer3pt.f and` raxini.f `. Results`

## 2.5 of reference for the modelization D One starts

with a computation of the stress, the total deflection and the plastic strain with command CALC_CHAMP . The results are listed in the following Table by knowing that the other components are equal to zero. The results

are got with the node. formulate $N1$

| $t$ | $\sigma_{xx}$ | $\epsilon_{xx}^{tot}$ | $\epsilon_{yy}^{tot}$ | $\epsilon_{zz}^{tot}$ | $\epsilon_{xx}^{p}$ | $\epsilon_{yy}^{p}$ | $\epsilon_{zz}^{p}$ |
|---|---|---|---|---|---|---|---|
| +00 2.50E<br>- 01 5.00E<br>- 01 7.50E<br>- 01 1.00E<br>+00 1.25E | +00 5.00E<br>+01 1.00E<br>+02 1.50E<br>+02 2.00E<br>+02 1.50E | +00 2.50E<br>- 04 5.00E<br>- 04 7.50E<br>- 04 1.75E<br>- 03 1.50E | +00 -7.50<br>E-05 -1.50<br>E-04 -2.25<br>E-04 -6.75<br>E-04 -6.00 | +00 -7.50<br>E-05 -1.50<br>E-04 -2.25<br>E-04 -6.75<br>E-04 -6.00 | +00 -1.48<br>E-20 -4.57<br>E-19 -2.29<br>E-19 7.50E<br>- 04 7.50E | +00 -7.40<br>E-20 2.71E<br>- 19 2.15E<br>- 19 -3.75<br>E-04 -3.75 | +00 -5.98<br>E-20 2.84E<br>- 20 -2.71<br>E-20 -3.75<br>E-04 -3.75 |



*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| +00 1.50E | +02 1.00E | - 03 1.25E | E-04 -5.25 | E-04 -5.25 | - 04 7.50E | E-04 -3.75 | E-04 -3.75 |
| +00 1.75E | +02 5.00E | - 03 1.00E | E-04 -4.50 | E-04 -4.50 | - 04 7.50E | E-04 -3.75 | E-04 -3.75 |
| +00 2.00E | +01 1.98E | - 03 7.50E | E-04 -3.75 | E-04 -3.75 | - 04 7.50E | E-04 -3.75 | E-04 -3.75 |
| +00 2.25E | - 08 -5.00 | - 04 5.00E | E-04 -3.00 | E-04 -3.00 | - 04 7.50E | E-04 -3.75 | E-04 -3.75 |
| +00 2.50E | E+01 -1.00 | -04 2.50E | E-04 -2.25 | E-04 -2.25 | - 04 7.50E | E-04 -3.75 | E-04 -3.75 |
| +00 2.75E | E+02 -1.50 | - 04 -7.50 | E-04 2.25E | E-04 2.25E | - 04 -7.14 | E-04 7.02E | E-04 1.17E |
| +00 3.00E | E+02 -2.00 | E-04 -1.75 | - 04 6.75E | - 04 6.75E | E-13 -7.50 | - 13 3.75E | - 14 3.75E |
| +00 3.25E | E+02 -1.50 | E-03 -1.50 | - 04 6.00E | - 04 6.00E | E-04 -7.50 | - 04 3.75E | - 04 3.75E |
| +00 3.50E | E+02 -1.00 | E-03 -1.25 | - 04 5.25E | - 04 5.25E | E-04 -7.50 | - 04 3.75E | - 04 3.75E |
| +00 3.75E | E+02 -5.00 | E-03 -1.00 | - 04 4.50E | - 04 4.50E | E-04 -7.50 | - 04 3.75E | - 04 3.75E |
| +00 4.00E | E+01 3.26E | E-03 -7.50 | - 04 3.75E | - 04 3.75E | E-04 -7.50 | - 04 3.75E | - 04 3.75E |
| +00 4.25E | - 09 5.00E | E-04 -5.00 | - 04 3.00E | - 04 3.00E | E-04 -7.50 | - 04 3.75E | - 04 3.75E |
| +00 4.50E | +01 1.00E | E-04 -2.50 | - 04 2.25E | - 04 2.25E | E-04 -7.50 | - 04 3.75E | - 04 3.75E |
| +00 4.75E | +02 1.50E | E-04 7.50E | - 04 -2.25 | - 04 -2.25 | E-04 6.51E | - 04 -2.64 | - 04 -3.87 |
| +00 5.00E | +02 2.00E | - 04 1.75E | E-04 -6.75 | E-04 -6.75 | - 12 7.50E | E-12 -3.75 | E-12 -3.75 |
| +00 0.00E | +02 0.00E | - 03 0.00E | E-04 0.00E | E-04 0.00E | - 04 0.00E | E-04 0.00E | E-04 Let us define |

certain quantities first of all: the deviator

- of the tensor of the stresses: formulate $s=\sigma-\frac{1}{3}tr(\sigma).I$ identity $I$ the deviator of the tensor of
- the strains is the matrix: formulate $e=\epsilon-\frac{1}{3}tr(\epsilon).I$ identity One $I$ is the matrix stresses

*that the results in interval of time between 0 and 1 second are for the monotonous part of the loading and are not taken into account in the computation of the quantities for the cyclic behavior. Then*

, here reference solutions for: "DEPSPE

": `half-amplitude` of the equivalent plastic strain: formulate

$$\frac{\Delta\varepsilon_{eq}^{p}}{2}=\frac{1}{2}max_{t1}\,max_{t2}\sqrt{\frac{2}{3}(\epsilon^{p}(t_1)-\epsilon^{p}(t_2)):(\epsilon^{p}(t_1)-\epsilon^{p}(t_2))}=7.5\mathrm{E}-4$$

`1": half-amplitude` of the first principal strain (with the taking into account of the sign): formulate

$$\frac{\epsilon_{max}^{1}-\epsilon_{min}^{1}}{2}=7.625\mathrm{E}-04$$

`1": maximum` normal stress as regards the principal strain: formulate

$$max_t(\sigma(t).n_1(t).n_1(t))=200\,MPa$$

`": half` - amplitude of the hydrostatic pressure (formula $P_a$

$$P_a=\frac{P_{max}-P_{min}}{2}=66.6666\,MPa$$

`": density` of dissipated energy: formulate

$$W_{cy}=\int_{cylce}\sigma:\dot{\epsilon}^{p}\,dt=0.45$$

`": density` of energy of the elastic distortions: formulate

$$W_e=\int_{cylce}\langle s:\dot{e}^{e}\langle\,dt=0.173333$$

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

″: `half-amplitude` of the equivalent stress: formulate

$$\frac{\Delta\sigma_{eq}}{2}=\frac{1}{2}max_{t1}\,max_{t2}\sqrt{\frac{3}{2}(\boldsymbol{s}(t_1)-\boldsymbol{s}(t_2)):(\boldsymbol{s}(t_1)-\boldsymbol{s}(t_2))}=200\,MPa$$

1″: `half-amplitude` of the first principal stress (with the taking into account of the sign): formulate

$$\frac{\sigma^1_{max}-\sigma^1_{min}}{2}=100\,MPa$$

1″: `maximum` normal strain as regards the principal stress: formulate

$$max_t(\boldsymbol{\epsilon}(t).\boldsymbol{n}_1(t).\boldsymbol{n}_1(t))=1.75\text{E}-3$$

2S″: `half-amplitude` of the second invariant of the strain: formulate

$$J_2(\Delta\epsilon)=\frac{1}{2}max_{t1}\,max_{t2}\sqrt{\frac{2}{3}(\boldsymbol{e}(t_1)-\boldsymbol{e}(t_2)):(\boldsymbol{e}(t_1)-\boldsymbol{e}(t_2))}=1.616666\text{E}-3$$

″: `half-amplitude` of half-forced Tresca: “DEPTRE

$$\frac{\sigma^{Tresca}_{max}-\sigma^{Tresca}_{min}}{4}=50\,MPa$$

″: `half-amplitude` of the Tresca half-strain: “EPSPAC

$$\frac{\epsilon^{Tresca}_{max}-\epsilon^{Tresca}_{min}}{4}=6.0625\text{E}-4$$

″: `plastic strain` accumulated: Results

$$p=3.67423\text{E}-3$$

## 2.6 of reference for the modelization E the results

are got with the node. 0.00 $N1$ E

| $t$ | $\sigma_{xx}$ | $\sigma_{yy}$ | $\epsilon^{tot}_{xx}$ | $\epsilon^{tot}_{yy}$ | $\epsilon^{tot}_{zz}$ | $\epsilon^{p}_{xx}$ | $\epsilon^{p}_{yy}$ | $\epsilon^{p}_{zz}$ |
|---|---|---|---|---|---|---|---|---|
| +0 2.50E | +00 3.00E | +00 -2.00 | +00 1.80E | +00 -1.45 | +00 -1.50 | +00 -6.73 | +00 -2.69 | +00 2.84E |
| - 1 5.00E | +02 6.00E | E+02 -4.00 | - 03 3.60E | E-03 -2.90 | E-04 -3.00 | E-19 -4.71 | E-18 -4.39 | - 19 2.61E |
| - 1 7.50E | +02 9.00E | E+02 -6.00 | - 03 1.10E | E-03 -9.26 | E-04 -1.15 | E-19 5.61E | E-18 -4.91 | - 19 -7.01 |
| - 1 1.00E | +02 1.20E | E+02 -8.00 | - 02 1.88E | E-03 -1.60 | E-03 -2.05 | - 03 1.16E | E-03 -1.02 | E-04 -1.45 |
| +0 1.25E | +03 9.00E | E+02 -6.00 | - 02 1.70E | E-02 -1.45 | E-03 -1.90 | - 02 1 .1 | E-02 - 1. | E-03 - 1. |
| +0 1.50E | +02 6.00E | E+02 -4.00 | - 02 1.52E | E-02 -1.31 | E-03 -1.75 | 6 E-0 2 1. 1 | 02E-02 | 4 5th-03 - |
| +0 1.75E | +02 3.00E | E+02 -2.00 | - 02 1.34E | E-02 -1.16 | E-03 -1.60 | 6th-02 1. 1 | -1.02 | 1. |
| +0 2.00E | +02 2.30E | E+02 -3.07 | - 02 1.16E | E-02 -1.02 | E-03 -1.45 | 6th-02 1. 1 | E-02 -1.02 | 4 5th-03 - |
| +0 2.25E | - 13 3.00E | E-13 -2.00 | -02 1.34E | E-02 -1.16 | E-03 -1.60 | 6th-02 1. 1 | E-02 -1.02 | 1. |
| +0 2.50E | +02 6.00E | E+02 -4.00 | - 02 1.52E | E-02 -1.31 | E-03 -1.75 | 6th-02 1. 1 | E-02 -1.02 | 4 5th-03 - |
| +0 2.75E | +02 9.00E | E+02 -6.00 | - 02 1.70E | E-02 -1.45 | E-03 -1.90 | 6th-02 1. 1 | E-02 -1.02 | 1. |
| +0 3.00E | +02 6.00E | E+02 -4.00 | - 02 1.52E | E-02 -1.31 | E-03 -1.75 | 6th-02 1. 1 | E-02 -1.02 | 4 5th-03 - |
| +0 3.25E | +02 3.00E | E+02 -2.00 | - 02 1.34E | E-02 -1.16 | E-03 -1.60 | 6th-02 1. 1 | E-02 -1.02 | 1. |
| +0 3.50E | +02 -4.35 | E+02 -8.66 | - 02 1.16E | E-02 -1.02 | E-03 -1.45 | 6th-02 1. 1 | E-02 -1.02 | 4 5th-03 - |
| +0 0.00E | E-14 0.00E | E-13 0.00E | - 02 0.00E | E-02 0.00E | E-03 | 6th-02 | E-02 -1.02 | 1. |
| | | | | | 0.00E | 0.00E | E-02 0.00E | 4 5th-03 - |
| | | | | | | | | 1. |
| | | | | | | | | 4 5th-03 - |
| | | | | | | | | 1. |
| | | | | | | | | 4 5th-03 - |

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 1.<br>4 5th-03 -<br>1.<br>4 5th-03<br>One<br>stresses |

*that the results in interval of time between 0 and 1 second are for the monotonous part of the loading and are not taken into account in the computation of the quantities for the cyclic behavior. For*

the reference solutions we calculated the damage (via ENDO1 ) `with` the various quantities available for a nonperiodic loading: "SIPR

`1_1": first` principal stress of the first top of under cycle (formula $\sigma_1(1)$ SIPR
`1_2": first` principal stress of the second top of under cycle (formula $\sigma_1(2)$ One uses

the half-amplitude of the stress of the top of the first cycle, namely and $600\,MPa$ the half-amplitude of the stress of the top of the second cycle, namely then $450\,Mpa$ one adds the damages associated with these two amplitudes. One evaluates
the criterion here following: formulate $\frac{|SIPR1-SIPR2|}{2}$

- the formula of Basquin: formulate $\text{grandeur équivalente}=4098.3\times(NBRUP^{-0.2693})$
  and for $NBRUP\,1=1255$ the damage: then $D1=7.968963\text{E}-04$ and for $NBRUP\,2=3652$ the damage: that is to say $D2=2.738186E-04$ a total damage equal to: with $D=1.0707149\text{E}-03$
- an interpolation of the curve of Wöhler: one finds
  and for $NBRUP1=742$ the damage: . One $D=1.347073\text{E}-03$ finds and for $NBRUP2=1742$ the damage: that is to say $D=5.741842\text{E}-04$ a total damage equal to: "SITN $D=1.9212575\text{E}-03$

`1_1": normal stress` on the level associated with formula $\epsilon_1^{tot}(1)$ top with the under-cycle and "SITN
`1_2": normal stress` on the level associated with formula $\epsilon_1^{tot}(2)$ top with the under-cycle: One uses

the half-amplitude of the associated stress formulates $\epsilon_1^{tot}(1)$ namely and $600\,MPa$ the half-amplitude of the associated stress formulates $\epsilon_1^{tot}(2)$ namely then $450\,MPa$ one adds the damages associated with these two amplitudes. One evaluates
the criterion here following: formulate $\frac{|SITN1-SITN2|}{2}$

- the formula of Basquin: formulate $\text{grandeur équivalente}=4098.3\times(NBRUP^{-0.2693})$
  and for $NBRUP\,1=1255$ the damage: then $D1=7.968963\text{E}-04$ and for $NBRUP2=3652$ the damage: that is to say $D2=2.738186E-04$ a total damage equal to: with $D=1.0707149\text{E}-03$
- an interpolation of the curve of Wöhler: one finds
  and for $NBRUP1=742$ the damage: one finds $D=1.347073\text{E}-03$ and for $NBRUP2=1742$ the damage: that is to say $D=5.741842\text{E}-04$ a total damage equal to: "SIPN $D=1.9212575\text{E}-03$

`1_1": normal stress` on the level associated with formula $\epsilon_1^p(1)$ top with the under-cycle and "SIPN
`1_2": normal stress` on the level associated with formula $\epsilon_1^p(2)$ top with the under-cycle: One uses

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

the value the half-amplitude of the associated stress formulates $\epsilon_1^p(1)$ namely has and $600\,Mp$ the half-amplitude of the associated stress formulates $\epsilon_1^p(2)$ namely One evaluates $450\ Mpa$
the criterion here following: formulate $\dfrac{SIPN1-SIPN2}{2}$

- the formula of Basquin: formulate $\text{grandeur\_equivalente}=4098.3\times(NBRUP^{-0.2693})$
  and for $NBRUP1=1255$ the damage: then $D1=7.968963\mathrm{E}-04$ and for $NBRUP\,2=3652$ the damage: that is to say $D2=2.738186\,E-04$ a total damage equal to: with $D=1.0707149\mathrm{E}-03$
- an interpolation of the curve of Wöhler: one finds
  and for $NBRUP1=742$ the damage: one finds $D=1.347073\mathrm{E}-03$ and for $NBRUP2=1742$ the damage: that is to say $D=5.741842\mathrm{E}-04$ a total damage equal to: “SIGEQ $D=1.9212575\mathrm{E}-03$

`_1”: equivalent stress` of the first top of the under-cycle formulates $\sigma_{eq}(1)$ SIGEQ
`_2”: equivalent stress` of the second top of the under-cycle formulates $\sigma_{eq}(2)$ calculates

the equivalent stress for SIGEQ_1: then

$$\frac{\Delta\sigma_{eq}}{2}=\frac{1}{2}max_{t1}\,max_{t2}\sqrt{\frac{3}{2}(\mathbf{s}(t_1)-\mathbf{s}(t_2)):(\mathbf{s}(t_1)-\mathbf{s}(t_2))}=871.78\,MPa$$

for SIGEQ `_2: formulate`

$$\frac{\Delta\sigma_{eq}}{2}=\frac{1}{2}max_{t1}\,max_{t2}\sqrt{\frac{3}{2}(\mathbf{s}(t_1)-\mathbf{s}(t_2)):(\mathbf{s}(t_1)-\mathbf{s}(t_2))}=653.83\,MPa$$

evaluates the criterion here following: formulate $\dfrac{SIGEQ1-SIGEQ2}{2}$

- the formula of Basquin: formulate $\text{grandeur\_equivalente}=4098.3\times(NBRUP^{-0.2693})$
  3 and $NBRUP1=31$ for the damage: then $D1=3.1908789\,E-03$ and for $NBRUP2=912$ the damage: that is to say $D2=1.0964061\,E-03$ a total damage equal to: with $D=4.287285\,E-03$
- an interpolation of the curve of Wöhler: one finds
  and for $NBRUP1=244$ the damage: one finds $D=4.1\mathrm{E}-03$ and for $NBRUP2=582$ the damage: that is to say $D=1.7175686\mathrm{E}-03$ a total damage equal to: Results $D=5.8176\,E-03$

## 2.7 of reference for the modelization F the results

are got with the node. Results $N1$

•**obtained with SOL_NL : `0.00` E**

| $t$ | $\sigma_{xx}$ | $\sigma_{yy}$ | $\epsilon_{xx}^{tot}$ | $\epsilon_{yy}^{tot}$ | $\epsilon_{zz}^{tot}$ |
|---|---|---|---|---|---|
| +0 2.50E | +00 3.00E | +00 -1.50 | +00 1.725 | +00 -1.20 | +00 -2.25 |
| - 1 5.00E | +02 6.00E | E+02 -3.00 | E-03 3.45E | E-03 -2.40 | E-04 -4.50 |
| - 1 7.50E | +02 9.00E | E+02 -4.50 | - 03 5.175 | E-03 -3.60 | E-04 -6.75 |
| - 1 1.00E | +02 1.20E | E+02 -6.00 | E-03 6.90E | E-03 -4.80 | E-04 -9.00 |
| +0 1.25E | +03 9.00E | E+02 -4.50 | - 03 5.175 | E-03 -3.60 | E-04 -6.75 |
| +0 1.50E | +02 6.00E | E+02 -3.00 | E-03 3.45E | E-03 -2.40 | E-04 -4.50 |
| +0 1.75E | +02 3.00E | E+02 -1.50 | - 03 1.725 | E-03 -1.20 | E-04 -2.25 |
| +0 2.00E | +02 8.82E | E+02 8.82E | E-03 -7,92 | E-03 - 1. | E-04 -1.85 |
| +0 2.25E | - 26 3.00E | - 26 -1.50 | E-33 1.725 | 39 E 32 -1.20 | E-32 -2.25 |
| +0 2.50E | +02 6.00E | E+02 -3.00 | E-03 3.45E | E-03 -2.40 | E-04 -4.50 |
| +0 2.75E | +02 9.00E | E+02 - 4.5 | - 03 5 .1 | E-03 - 3. | E-04 -6.75 |

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

| | | | | | |
|---|---|---|---|---|---|
| +0 3.00E<br>+0 3.25E<br>+0 3.50E<br>+0 0.00E | +02 6.00E<br>+02 3.00E<br>+02 7.88E<br>- 14 0.00E | 0E+ 02 -3.00<br>E+02 -1.50<br>E+02 -5.15<br>E-13 0.00E | 75 E-0 3<br>3.45E<br>- 03 1.725<br>E-03 1.26E<br>- 18 0.00E | 60 E-0 3<br>-2.40<br>E-03 -1.20<br>E-03 -2.60<br>E-18 0.00E | E-04 -4.50<br>E-04 -2.25<br>E-04 3.52E<br>- 19 “EPSN |

`1_1”: normal` strain on the level associated with formula $\sigma_1(1)$ top with the under-cycle and “EPSN
`1 _2 ”: normal` strain on the level associated with formula $\sigma_1(2)$ top with the under-cycle: One uses

the total half-strain most important met during the first under cycle, that is to say here and $0.00345$ the total half-strain the most important met during second under cycle: . And $0.0025875$ one evaluates the criterion here following: formulate $\frac{|EPSN1-EPSN2|}{2}$

- the formula of Manson: formulate $\text{grandeur\_equivalente}=0{,}022524751\,x\,(NBRUP^{-0{,}1619})$ and for $NBRUP1=107892$ the damage: one finds $D1=9.268535\,E-06$ and for $NBRUP2=637811$ the damage: that is to say $D2=1.5678624479\,E-06$ a total damage equal to: with $D=1.08363973\,E-05$
- an interpolation of the curve of Manson-Whetstone sheath: one finds 4 and $NBRUP1=3636$ for the damage: one finds $D1=2.74994\,E-05$ and for $NBRUP2=193932$ the damage: D2 = 5.156443564 E-06 are a total damage equal to: “ETPR $D=3.2655868578\,E-05$

`1_1”: first` principal total deflection of the first top of the under-cycle formulates $\epsilon_1^{tot}(1)$
`1_2”: first` principal total deflection of the second top of the under-cycle formulates $\epsilon_1^{tot}(2)$ uses

the total half-strain most important met during the first under cycle, that is to say here and $0.00345$ the total half-strain the most important met during second under cycle: . And $0.0025875$ one evaluates the criterion here following: formulate $\frac{|ETPR1-ETPR2|}{2}$

- the formula of Manson: formulate $\text{grandeur\_equivalente}=0.022524751\text{x}\,(NBRUP^{-0.1619})$ and for $NBRUP1=107892$ the damage: one finds $D1=9.268535\,E-06$ and for $NBRUP2=637811$ the damage: that is to say $D2=1.5678624479\,E-06$ a total damage equal to: with $D=1.08363973\,E-05$
- an interpolation of the curve of Manson-Whetstone sheath: one finds

and for $NBRUP1=36364$ the damage: one finds $D1=2.74994\,E-05$ and for $NBRUP2=193932$ the damage: that is to say $D2=5.156443564\,E-06$ a total damage equal to: “ETEQ $D=3.2655868578\,E-05$

`_1”: equivalent` total deflection of the first top of the under-cycle formulates $\epsilon_{eq}^{tot}(1)$
`_2”: equivalent` total deflection of the second top of the under-cycle formulates $\epsilon_{eq}^{tot}(2)$

the equivalent total deflection for the first under-cycle with the formula: formulate $\epsilon_{eq}=\sqrt{\frac{2}{3}e:e}$ formula is found $\frac{1}{2}\epsilon_{eq}^{tot}(1)=0.0034394767$ the second under-cycle: formulate $\frac{1}{2}\epsilon_{eq}^{tot}(2)=0.0025796$



*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

- the formula of Manson: formulate $\text{grandeur\_equivalente} = 0.022524751 \times (NBRUP^{-0.1619})$ and for $NBRUP1 = 109947$ the damage: one finds $D1 = 9.09528647\,E-06$ and for $NBRUP2 = 649960$ the damage: that is to say $D2 = 1.5385558\,E-06$ a total damage equal to: with $D = 1.0633842276096\,E-05$
- an interpolation of the curve of Manson-Whetstone sheath: one finds and for $NBRUP1 = 36929$ the damage: one finds $D1 = 2.707933\,E-05$ and for $NBRUP2 = 197585$ the damage: that is to say $D2 = 5.061111575\,E-06$ a total damage equal to: Results $D = 3.214044324622\,E-05$

- **obtained with SOL_NL `2: 0.00` E**

| $t$ | $\sigma_{xx}$ | $\epsilon_{xx}^{tot}$ | $\epsilon_{yy}^{tot}$ | $\epsilon_{zz}^{tot}$ |
|---|---|---|---|---|
| +0 5.00E | +00 6.00E | +00 3.00E | +00 -9.00 | +00 -9.00 |
| - 1 1.00E | +02 1.20E | - 03 1.05E | E-04 -4.05 | E-04 -4.05 |
| +0 1.50E | +03 6.00E | - 02 7.50E | E-03 -3.15 | E-03 -3.15 |
| +0 2.00E | +02 -9. | - 03 4.50E | E-03 -2.25 | E-03 -2.25 |
| +0 2.5625 | 12th-1 3 -6.75 | - 03 -1.91 | E-03 -6.75 | E-03 -6.75 |
| E+0 3.0625 | E+02 1.125 | E-13 3.9375 | E-04 -1.86 | E-04 -1.86 |
| E+0 3.5625 | E+02 9.00E | E-03 7.875 | E-03 -3.0375 | E-03 -3.0375 |
| E+0 4.0625 | +02 1.125 | E-03 3.9375 | E-03 - 1.86 | E-03 - 1.86 |
| E+0 4.5625 | E+02 -6.75 | E-03 -1.91 | E-03 - 6.75 | E-03 -6.75 |
| E+0 0.00E | E+02 0.00E | E-13 0.00E | E-0 4 0.00E | E-04 “EPSN |

`1_1": normal` strain on the level associated with formula $\sigma_1(1)$ top with the under-cycle and “EPSN
`1_2": normal` strain on the level associated with formula $\sigma_1(2)$ top with the under-cycle: One uses

the total half-strain most important met during the first under cycle, that is to say here and $0.00525$ the half total deflection the most important met during second under cycle: . And $0.0039375$ one evaluates the criterion here following: formulate $\frac{|EPSN1 - EPSN2|}{2}$

- the formula of Manson: formulate $\text{grandeur\_equivalente} = 0.022524751 \times (NBRUP^{-0.1619})$ and for $NBRUP1 = 8067$ the damage: one finds $D1 = 1.239547\,E-04$ and for $NBRUP2 = 47691$ the damage: that is to say $D2 = 2.0968145\,E-05$ a total damage equal to: with $D = 1.4492229\,E-04$
- an interpolation of the curve of Manson-Whetstone sheath: one finds and for $NBRUP1 = 5260$ the damage: one finds $D1 = 1.901065\,E-04$ and for $NBRUP2 = 19698$ the damage: that is to say $D2 = 5.0767\,E-05$ a total damage equal to: “ETPR $D = 2.408735\,E-04$

`1_1": first` principal total deflection of the first top of the under-cycle formulates $\epsilon_1^{tot}(1)$
`1_2": first` principal total deflection of the second top of the under-cycle formulates $\epsilon_1^{tot}(2)$ uses

the total half-strain most important met during the first under cycle, that is to say here and $0.00345$ the total half-strain the most important met during second under cycle: . And $0.0025875$ one evaluates the criterion here following: formulate $\frac{|ETPR1 - ETPR2|}{2}$

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

- the formula of Manson: formulate $\text{grandeur\_equivalente}=0.022524751\text{x}(NBRUP^{-0.1619})$ and for $NBRUP1=8067$ the damage: one finds $D1=1.239547E-04$ and for $NBRUP2=47691$ the damage: that is to say $D2=2.0968145E-05$ a total damage equal to: with $D=1.4492229E-04$
- an interpolation of the curve of Manson-Whetstone sheath: one finds and for $NBRUP1=5260$ the damage: one finds $D1=1.901065E-04$ and for $NBRUP2=19698$ the damage: that is to say $D2=5.0767E-05$ a total damage equal to: "ETEQ $D=2.408735E-04$

_1": `equivalent` total deflection of the first top of the under-cycle formulates $\epsilon_{eq}^{tot}(1)$
_2": `equivalent` total deflection of the second top of the under-cycle formulates $\epsilon_{eq}^{tot}(1)$

the equivalent total deflection for the first under-cycle with the formula: formulate $\boldsymbol{\epsilon}_{eq}=\sqrt{\frac{2}{3}\boldsymbol{e}:\boldsymbol{e}}$ formula is found $\frac{1}{2}\epsilon_{eq}^{tot}(1)=0.004625$ the second under-cycle, one finds formula $\frac{1}{2}\epsilon_{eq}^{tot}(2)=0.0034125$

- the formula of Manson: formulate $\text{grandeur\_equivalente}=0.022524751\times(NBRUP^{-0.1619})$ and for $NBRUP1=17650$ the damage: one finds $D1=5.6657E-05$ and for $NBRUP2=115427$ the damage: that is to say $D2=8.66351E-06$ a total damage equal to: with $D=6.53204991E-05$
- an interpolation of the curve of Manson-Whetstone sheath: one finds and for $NBRUP1=9411$ the damage: one finds $D1=1.062557E-04$ and for $NBRUP2=38423$ the damage: that is to say $D2=2.60258665E-05$ a total damage equal to: Results $D=1.322816E-04$

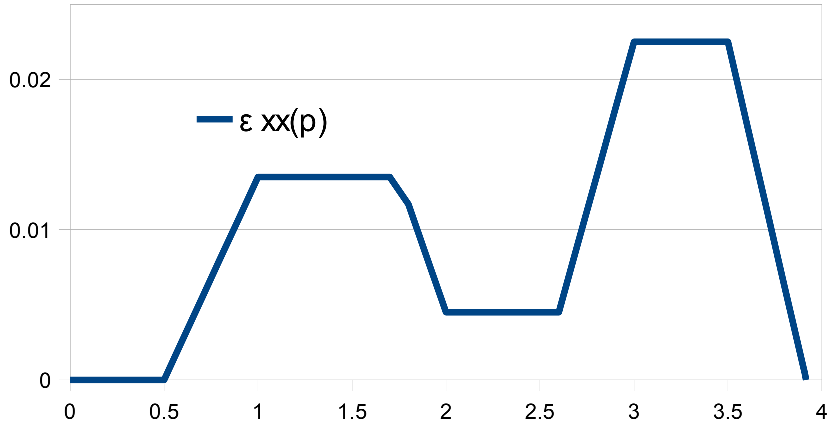
•**obtained with SOL_NL** `3: 0.00` **E**

| $t$ | $\sigma_{xx}$ | $\epsilon_{xx}^{tot}$ | $\epsilon_{yy}^{tot}$ | $\epsilon_{zz}^{tot}$ | $\epsilon_{xx}^{p}$ | $\epsilon_{yy}^{p}$ | $\epsilon_{zz}^{p}$ |
|---|---|---|---|---|---|---|---|
| +0 5.00E<br>- 1 1.00E<br>+0 1.50E<br>+0 2.00E<br>+0 2.50E<br>+0 3.00E<br>+0 3.50E<br>+0 3.91667<br>E+0 0.00E | +00 9.00E<br>+02 1.80E<br>+03 6.00E<br>+02<br>-6.00E+02<br>9.00E<br>+02 2.40E<br>+03 6.00E<br>+02 -9.00<br>E+02 0.00E | +00 4.50E<br>- 03 2.25E<br>- 02 1.65E<br>- 02 1.50E<br>- 03 9.00E<br>- 03 3.45E<br>- 02 2.55E<br>- 02 -4.50<br>E-03 0.00E | +00 -1.35<br>E-03 -9.45<br>E-03 -7.65<br>E-03 -1.35<br>E-03 -3.60<br>E-03 -1.485<br>E-02 -1.215<br>E-02 1.35<br>E-03 0.00E | +00 -1.35<br>E-03 -9.45<br>E-03 -7.65<br>E-03 -1.35<br>E-03 -3.60<br>E-03 -1.485<br>E-02 -1.215<br>E-02 1.35E<br>- 03 0.00E | +00 1.51E<br>- 18 1.35E<br>- 02 1.35E<br>- 02 4.50E<br>- 03 4. 50<br>E-0 3 2. 25<br>E-02 2. 25<br>E-02 -5.55<br>E-11 0.00E | +00<br>1.09E<br>- 18 -6.75<br>E-03 -6.75<br>E-03 - 2.<br>25 E-0 3<br>-2.25<br>E-03 -1.125<br>E-02 -1.125<br>E-02 2.69E<br>- 11 0.00E | +00 -7.51<br>E-19 -6.75<br>E-03 -6.75<br>E-03 - 2.<br>25 E-0 3<br>-2.25<br>E-03 -1.125<br>E-02 -1.125<br>E-02 2. 86<br>E 11 With<br>this<br>intention |

a better idea of what interests us here, namely formula $\epsilon_{xx}^{p}$ the maximum values of the plastic strain are according to the direction, here $xx$ evolution of formula $\epsilon_{xx}^{p}$ time: "EPR

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)



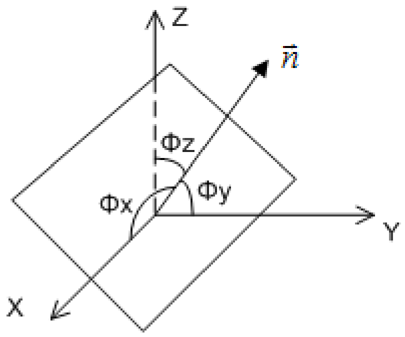

`1_1":` `first` principal plastic strain of the first top of the under-cycle and "EPR $\epsilon_1^p(1)$
`1_2":` `first` principal plastic strain of the second top of the under-cycle formulates $\epsilon_1^p(2)$ evaluates the criterion here following: formulate $\frac{|EPPR1-EPPR2|}{2}$

, here the value of formula $\epsilon_{xx}^p$ null at the end of the first under cycle, therefore for formula $\frac{EPPR1}{2}$ : formulate $\frac{0.0135-0.0045}{2}=0.0045$ formula $\frac{EPPR2}{2}$ obtains more directly: . with $0{,}01125$

- the formula of Manson: formulate $\text{grandeur\_equivalente}=0.022524751\times(NBRUP^{-0.1619})$ and for $NBRUP1=20905$ the damage: one finds $D1=4.7836\,E-05$ and for $NBRUP2=73$ the damage: that is to say $D2=1.37307\,E-02$ a total damage equal to: with $D=1.377855\,E-02$
- an interpolation of the curve of Manson-Whetstone sheath: one finds and for $NBRUP1=10672$ the damage: one finds $D1=9.37\,E-05$ and for $NBRUP2=478$ the damage: that is to say $D2=2.092\,1444\,E-03$ a total damage equal to: Results $D=2.185844\,E-03$

## 2.8 of reference for the modelization G the analytical

solutions of the directional sense of the critical plane are in [bib4]. Down the direction of the critical plane is laid by angles (formulated $\phi_x$ $\phi_y$ $\phi_z$ the vector norm of the critical plane and the axes as shown in the figure above. It is noted





Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

that for criteria DANG_VAN_MODI_AC and of MATAKE_MODI_AC , the critical plane is the plane of the maximum shears. For the criteria of DANG_VAN_MODI_AV , MATAKE_MODI_AC and FATESOCI_MODI_AV the critical plane is the plane of the maximum damage. With

the conditions of the loadings listed in Section 1.4.6, the analytical solutions of reference for this modelization are following the Criterion

- of DANG_VAN_MODI_AC the angle
  between the vector norm of the critical plane and the axis is $Z$ degrees $45$ . Criterion
- of MATAKE_MODI_AC the angle
  between the vector norm of the critical plane and the axis formula $Z$ formula $45$ . Criterion
- of DANG_VAN_MODI_AV the angle
  between the vector norm of the critical plane and the axis formula $Z$ formula $45$ . Criterion
- of MATAKE_MODI_AV the angle
  between the vector norm of the critical plane and the axis formulates $Z$ formula $\alpha$

$$\phi_z = \arccos\left(\frac{\sqrt{2}}{2}\sqrt{1-\sqrt{1-\frac{1}{a^2+2a^2\alpha+a^2\alpha^2+1}}}\right)$$

formulated $a$ a property matérial obtained by parameter MATAKE_A and formulated $a=0.05$ in this benchmark. Criterion

- of FATESOCI_MODI_AV the angle
  between the vector norm of the critical plane and the axis formulates $Z$ formula $\alpha$

$$\phi_z = \arccos\left(\frac{\sqrt{2}}{4}\sqrt{5+A_1-\sqrt{1+A_1{}^2+8}}\right)$$

. $A_1 = \dfrac{2S_y}{a\sigma_{x,a}(1+\alpha)}$ The elastic limit formulated $S_y=208\,MPa$ $a=0.05$ , the parameter of FATSOC_A east J $a/S_y=0.00024$

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

## 2.9 bibliographical References

1.ANGLES. “multiaxial Criteria of starting in fatigue to great number D cycles, critical plane, DANG VAN”, Project FATMAV, Note EDF HT-64/03/015A, 2003 ANGLES

2.J., PAPACONSTANTINOU T. “multiaxial Criteria of starting in fatigue to great number D cycles under nonperiodic loading”, Project FATMAV, Note EDF HT-64/04/006A, 2004 ANGLES

3.J. “Synthesis on the criteria of starting in fatigue multiaxial to great number D cycles developed in Code_Aster *”, Project* Tires Thermal, Note EDF HT-64/05/019A, 2005 LEI B

4.. , TRAN V. - X. “Carryforward one the 2nd semi anual meeting for the collaborative PhD project between EDF R & D and Tsinghua University (July 2012 – January 2013)”, Report CR-AMA-13.021 Modelization

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

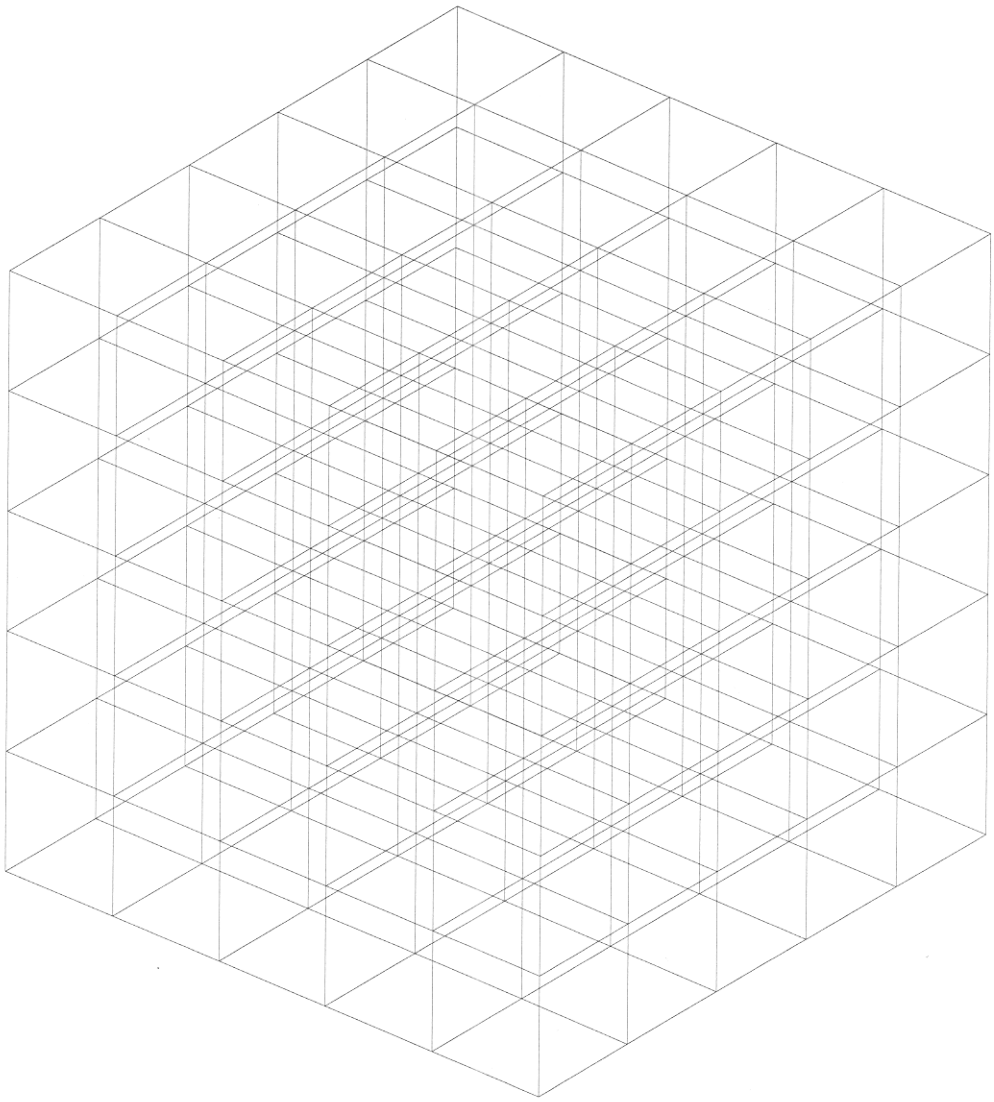
*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

# 3 A Characteristic

## 3.1 of the modelization This benchmark

tests criteria MATAKE_MODI_AC , DANG_VAN_MODI_AC , VMIS_TRESCA, criterion formulates some for the periodic and biaxial loading proportional ; Characteristics

## 3.2 of the mesh Modelization



3D: 125 quadratic volume elements: HEXA8. Appear

**of the mesh of the cube The mesh**

of the cube was obtained from the version 2000 of mesh generator GIBI. Many

nodes: 216 Number
of meshes

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

: 465 Quantities

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

## 3.3 tested and results Criterion

• **"MATAKE_MODI_AC " and associated criterion in formula: For the results with the node formulates $N1$ the mesh formulates $M60$ Gauss 3) the option** COURBE_GRD_VIE = "WOHLER " and the option COURBE_GRD_VIE = "FORM_VIE " and FORMULE_VIE = WHOL: Standard

| identification | of reference Value of reference | Tolerance | formulates |
|---|---|---|---|
| $\Delta\tau(n_1)$ | " 1. 500000 | E + 02 *1.0* E | 10 component |
| formulate $x$ $n_1$ | " – 7.071068 | E – 01.1.0 E | 10 component |
| formulates $y$ $n_1$ | " 7.071068 | E – 01.1.0 E | 10 component |
| formulate $z$ $n_1$ | " 0.0.1.0 | E | 10 formulates |
| $N_{max}(n_1)$ | " 5.000000 | E+01 1.0E- | 10 formula |
| $N_m(n_1)$ | " 0.0.1.0 | E | 10 formulates |
| $\varepsilon_{max}(n_1)$ | " 1.750000 | E – 04.1.0 E | 10 formulates |
| $\varepsilon_m(n_1)$ | " 0.0.1.0 | E | 10 E |
| $\sigma_{eq}(n_1)$ | ANALYTIQUE" | 3.000000 E+02 | 1.0E- 10 |
| $Nb_{cr}(n_1)$ | ANALYTIQUE" | 1.094600 E+04 | 1.0E- 10 |
| $ENDO(n_1)$ | ANALYTIQUE" | 9.135647 – 05.1.0 E | 10 formulate |
| $\Delta\tau(n_2)$ | " 1. 500000 | E + 02 *1.0* E | 10 component |
| formulate $x$ $n_2$ | " 7.071068 | E – 01.1.0 E | 10 component |
| formulate $y$ $n_2$ | " 7.071068 | E – 01.1.0 E | 10 component |
| formulates $z$ $n_2$ | " 0.0.1.0 | E | 10 formulates |
| $N_{max}(n_2)$ | " 5.000000 | E+01 1.0E- | 10 formula |
| $N_m(n_2)$ | " 0.0.1.0 | E | 10 formulates |
| $\varepsilon_{max}(n_2)$ | " 1.750000 | E – 04.1.0 E | 10 formulate |
| $\varepsilon_m(n_2)$ | " 0.0.1.0 | E | 10 E |
| $\sigma_{eq}(n_2)$ | ANALYTIQUE" | 3.000000 E+02 | 1.0E- 10 |
| $Nb_{cr}(n_2)$ | ANALYTIQUE" | 1.094600 E+04 | 1.0E- 10 |
| $ENDO(n_2)$ | ANALYTIQUE" | 9.135647 – 05.1.0 E | 10 the option |

COURBE_GRD_VIE = "FORM_VIE " and FORMULE_VIE = WHOL_F: Standard

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

| identification | of reference Value of reference | Tolerance | formulates |
|---|---|---|---|
| $\Delta\tau(n_1)$ | ″ 1. 500000 | E + 02 *1.0* E | 10 component |
| formulate $x$ $n_1$ | ″ – 7.071068 | E – 01.1.0 E | 10 component |
| formulates $y$ $n_1$ | ″ 7.071068 | E – 01.1.0 E | 10 component |
| formulate $z$ $n_1$ | ″ 0.0.1.0 | E | 10 formulates |
| $N_{max}(n_1)$ | ″ 5.000000 | E+01 1.0E- | 10 formula |
| $N_m(n_1)$ | ″ 0.0.1.0 | E | 10 formulates |
| $\varepsilon_{max}(n_1)$ | ″ 1.750000 | E – 04.1.0 E | 10 formulates |
| $\varepsilon_m(n_1)$ | ″ 0.0.1.0 | E | 10 formulates |
| $\sigma_{eq}(n_1)$ | ″ 3.000000 | E+02 1.0E- | 10 formula |
| $Nb_{cr}(n_1)$ | ″ 1.094600 | E+04 4.0E- | 03 formula |
| $ENDO(n_1)$ | ″ 1.6519 | E+04 4.0E- | 03 formula |
| $\Delta\tau(n_2)$ | ″ 6.05356 | E-05 1.0E- | 10 component |
| formulates $x$ $n_2$ | ″ 7.071068 | E – 01.1.0 E | 10 component |
| formulates $y$ $n_2$ | ″ 7.071068 | E – 01.1.0 E | 10 component |
| formulate $z$ $n_2$ | ″ 0.0.1.0 | E | 10 formulates |
| $N_{max}(n_2)$ | ″ 5.000000 | E+01 1.0E- | 10 formula |
| $N_m(n_2)$ | ″ 0.0.1.0 | E | 10 formulates |
| $\varepsilon_{max}(n_2)$ | ″ 1.750000 | E – 04.1.0 E | 10 formulates |
| $\varepsilon_m(n_2)$ | ″ 0.0.1.0 | E | 10 formulates |
| $\sigma_{eq}(n_2)$ | ″ 3.000000 | E+02 1.0E- | 10 formula |
| $Nb_{cr}(n_2)$ | ″ 1.6519 | E+04 4.0E- | 03 formula |
| $ENDO(n_2)$ | ″ 6.05356 | E-05 4.0E- | 03 Criterion |

• **"DANG_VAN_MODI_AC ″ and associated criterion in formula: For**
the results with the node **formulates** *N1* the mesh **formulates** *M60* **Gauss 3) the option**
COURBE_GRD_VIE = "WOHLER ″ and the option
COURBE_GRD_VIE = "FORM_VIE ″ and FORMULE_VIE = "WHOL": Standard

| identification | of reference Value of reference | Tolerance | formulates |
|---|---|---|---|
| $\Delta\tau(n_1)$ | ″ 1. 500000 | E + 02 *1.0* E | 10 component |

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

| | | | |
|---|---|---|---|
| | | | |
| formulate $x$ $n_1$ | " 7.071068 | E – 01.1.0 E | 10 component |
| formulate $y$ $n_1$ | " 7.071068 | E – 01.1.0 E | 10 component |
| formulates $z$ $n_1$ | " 0.0.1.0 | E | 10 formulates |
| $N_{max}(n_1)$ | " 5.000000 | E+01 1.0E- | 10 formula |
| $N_m(n_1)$ | " 0.0.1.0 | E | 10 formulates |
| $\varepsilon_{max}(n_1)$ | " 1.750000 | E – 04.1.0 E | 10 formulate |
| $\varepsilon_m(n_1)$ | " 0.0.1.0 | E | 10 E |
| $\sigma_{eq}(n_1)$ | ANALYTIQUE" | 2.750000 E+02 | 1.0E- 10 |
| $Nb_{cr}(n_1)$ | ANALYTIQUE" | 1.490300 E+04 | 1.0E- 10 |
| $ENDO(n_1)$ | ANALYTIQUE" | 6.709959 – 05.1.0 E | 10 formulates |
| $\Delta\tau(n_2)$ | " 1. 500000 | E + 02 *1.0* E | 10 component |
| formulate $x$ $n_2$ | " – 7.071068 | E – 01.1.0 E | 10 component |
| formulates $y$ $n_2$ | " 7.071068 | E – 01.1.0 E | 10 component |
| formulate $z$ $n_2$ | " 0.0.1.0 | E | 10 formulates |
| $N_{max}(n_2)$ | " 5.000000 | E+01 1.0E- | 10 formula |
| $N_m(n_2)$ | " 0.0.1.0 | E | 10 formulates |
| $\varepsilon_{max}(n_2)$ | " 1.750000 | E – 04.1.0 E | 10 formulates |
| $\varepsilon_m(n_2)$ | " 0.0.1.0 | E | 10 E |
| $\sigma_{eq}(n_2)$ | ANALYTIQUE" | 2.750000 E+02 | 1.0E- 10 |
| $Nb_{cr}(n_2)$ | ANALYTIQUE" | 1.490300 E+04 | 1.0E- 10 |
| $ENDO(n_2)$ | ANALYTIQUE" | 6.709959 – 05.1.0 E | 10 the option |

COURBE_GRD_VIE = "FORM_VIE " and FORMULE_VIE = WHOL_F: Standard

| identification | of reference Value of reference | Tolerance | formulates |
|---|---|---|---|
| $\Delta\tau(n_1)$ | " 1. 500000 | E + 02 *1.0* E | 10 component |
| formulate $x$ $n_1$ | " 7.071068 | E – 01.1.0 E | 10 component |
| formulate $y$ $n_1$ | " 7.071068 | E – 01.1.0 E | 10 component |
| formulates $z$ $n_1$ | " 0.0.1.0 | E | 10 formulates |

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

| | | | |
|---|---|---|---|
| $N_{max}(n_1)$ | ″ 5.000000 | E+01 1.0E- | 10 formula |
| $N_m(n_1)$ | ″ 0.0.1.0 | E | 10 formulates |
| $\varepsilon_{max}(n_1)$ | ″ 1.750000 | E – 04.1.0 E | 10 formulate |
| $\varepsilon_m(n_1)$ | ″ 0.0.1.0 | E | 10 formulates |
| $\sigma_{eq}(n_1)$ | ″ 2.750000 | E+02 1.0E- | 10 formula |
| $Nb_{cr}(n_1)$ | ″ 2.2822 | E+04 5.0E- | 03 formula |
| $ENDO(n_1)$ | ″ 4.381737 | E-05 5.0E- | 03 formula |
| $\Delta\tau(n_2)$ | ″ 1. 500000 | E + 02 *1.0* E | 10 component |
| formulate $x$ $n_2$ | ″ – 7.071068 | E – 01.1.0 E | 10 component |
| formulates $y$ $n_2$ | ″ 7.071068 | E – 01.1.0 E | 10 component |
| formulate $z$ $n_2$ | ″ 0.0.1.0 | E | 10 formulates |
| $N_{max}(n_2)$ | ″ 5.000000 | E+01 1.0E- | 10 formula |
| $N_m(n_2)$ | ″ 0.0.1.0 | E | 10 formulates |
| $\varepsilon_{max}(n_2)$ | ″ 1.750000 | E – 04.1.0 E | 10 formulates |
| $\varepsilon_m(n_2)$ | ″ 0.0.1.0 | E | 10 formulates |
| $\sigma_{eq}(n_2)$ | ″ 2.750000 | E+02 1.0E- | 10 formula |
| $Nb_{cr}(n_2)$ | ″ 2.2822 | E+04 5.0E- | 03 formula |
| $ENDO(n_2)$ | ″ 4.381737 | E-05 5.0E- | 03 Criterion |

- **” VMIS_TRESCA “For**

nodes: N1; N206; Net : M60 (Gauss point : 3) Standard

| Identification | of reference Value of reference | Tolerance | (Time |
|---|---|---|---|
| $\sigma_{xx}$ : 3) “ANALYTIQUE | ″ – 1.00000 | E+02 1.0E- | 10 (Time |
| $\sigma_{yy}$ : 3) “ANALYTIQUE | ″ 2.00000 | E+02 1.0E- | 10 formula |
| $\sigma_s$ ) “ANALYTIQUE | ″ 529.15026 | E+02 1.0E- | 10 formula |
| $\sigma_s$ ) “ANALYTIQUE | ″ 600.00000 | E+02 1.0E- | 10 For |

nodes: N1; N206; Net: M60 (Gauss point: 7) Standard

| Identification | of reference Value of reference | Tolerance | formulates |
|---|---|---|---|
| $\sigma_{xx}$ : 3) “ANALYTIQUE | ″ – 1.00000 | E+02 1.0E- | 10 formula |

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

| | | | |
|---|---|---|---|
| | | | |
| $\sigma_{yy}$ : 3) “ANALYTIQUE | ” 2.00000 | E+02 1.0E- | 10 formula |
| $\sigma_s$ ) “ANALYTIQUE | ” 529.15026 | E+02 1.0E- | 10 formula |
| $\sigma_s$ ) “ANALYTIQUE | ” 600.00000 | E+02 1.0E- | 10 Criterion |

- **formulate some finding” VMIS_TRESCA** “**`Results`**
  with the node **formulates** $N1$ the mesh **formulates** $M60$ **Gauss 3 and 7) Standard**

| Identification | of reference Value of reference | Tolerance | formulates |
|---|---|---|---|
| $\sigma_s$ ) “ANALYTIQUE | ” 529.15026 | E+02 1.0E- | 10 Modelization |

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

# 4 B Characteristic

## 4.1 of the modelization This case

- tests test of criteria MATAKE_MODI_AV , `DANG_VAN_MODI_AV` , `FATESOCI_MODI_AV` , `criterion` formulates some for the loading NON-periodical and biaxial and proportional; Characteristics

## 4.2 of the mesh Identical

to modelization A. Grandeurs

## 4.3 tested and results Criterion

• **"MATAKE_MODI_AV " and criterion in formula associated For**
the results with the node **and** $N206$ the mesh **(not** $M60$ **Gauss 3) option**
COURBE `_GRD_VIE=' WOHLER" and L` the option
COURBE_GRD_VIE `= "FORM_VIE " and FORMULE_VIE = WHOL: Standard`

| identification | of reference component | Value of reference |
|---|---|---|
| formulates $x$ $n_1$ $n_2$ | " -0.38268343236509 | 0.38268343236509 component |
| formulates $y$ $n_1$ AUTRE_ASTER $n_2$ | " 0.92718385456679 | 0.92387953251129 component |
| formulates $z$ $n_1$ AUTRE_ASTER $n_2$ | " 0.0000000000000 | E+00 formulates |
| $ENDO(n_1)$ | " 7.0532362250863 | E-04 In |

the table above, the components formulates $x$ $y$ $n_1$ $n_2$ values because there exist two vectors which correspond to the same value of damage formulates $ENDO(n_1)$ $ENDO(n_2)$

COURBE `_GRD_VIE= "FORM_VIE" and FORMULE_VIE = WHOL_F: Standard`

| identification | of reference component | Value of reference |
|---|---|---|
| of and $x$ formulates $n_1$ $n_2$ | " -0.38268343236509 | 0.38268343236509 component |
| of and $y$ formulates $n_1$ $n_2$ | " 0.92718385456679 | 0.92387953251129 component |
| formulates $z$ $n_1$ $n_2$ | " 0.0000000000000 | E+00 formulates |
| $ENDO(n_1)$ | " 3.3180845213285 | E-04 In |

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

the table above, the components formulates $x$ $y$ $n_1$ $n_2$ values because there exist two vectors which correspond to the same value of damage formulates $ENDO(n_1)$ $ENDO(n_2)$

• **"DANG_VAN_MODI_AV " and criterion in formula associated For**
the results with the node **and** $N206$ the mesh **(not** $M60$ **Gauss 3) option**
COURBE _GRD_VIE=' WOHLER' and option
COURBE _GRD_VIE=' FORM_VIE" and FORMULE_VIE = WHOL: Standard

| identification | of reference component | Value of reference |
|---|---|---|
| formulates $x$ $n_1$ $n_2$ | " -7.0710678118655 | E-01 7.0710678118655 E-01 component |
| formulates $y$ $n_1$ $n_2$ | " 7.0710678118655 | E-01 component |
| formulates $z$ $n_1$ $n_2$ | " 0.0000000000000 | E+00 formulates |
| $ENDO(n_1)$ | " 1.3419917535855 | E-04 In |

the table above, the components formulates $x$ $y$ $n_1$ $n_2$ values because there exist two vectors which correspond to the same value of damage formulates $ENDO(n_1)$ $ENDO(n_2)$

COURBE _GRD_VIE= "FORM_VIE" and FORMULE_VIE = WHOL_F: Standard

| identification | of reference component | Value of reference |
|---|---|---|
| formulates $x$ $n_1$ $n_2$ | " -7.0710678118655 | E-01 7.0710678118655 E-01 component |
| formulates $y$ $n_1$ $n_2$ | " 7.0710678118655 | E-01 component |
| formulates $z$ $n_1$ $n_2$ | " 0.0000000000000 | E+00 formulates |
| $ENDO(n_1)$ | " 8.7960237413997 | E-05 In |

the table above, the components formulates $x$ $y$ $n_1$ $n_2$ values because there exist two vectors which correspond to the same value of damage formulates $ENDO(n_1)$ $ENDO(n_2)$

• **"FATESOCI_MODI_AV " and associated criterion in formula: For**
the results with the node **and** $N1$ the mesh **(not** $M60$ **Gauss 3) option**
COURBE _GRD_VIE=' WOHLER' and option
COURBE _GRD_VIE=' FORM_VIE" and FORMULE_VIE = MANCO1: Standard

| identification | of reference component | Value of reference |
|---|---|---|
| formulates $x$ $n_1$ $n_2$ | " -0.43051109680829 | 0.43051109680830 component |


Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

| | | |
|---|---|---|
| formulates $y$ $n_1$ $n_2$ | ″ 0.90258528434986 | component |
| formulates $z$ $n_1$ $n_2$ | ″ 0 formulates | |
| $ENDO(n_1)$ | ″ 0.16830578997527 | In |

the table above, the component formulates $x$ $n_1$ $n_2$ values because there exist two vectors which correspond to the same value of damage formulates $ENDO(n_1)$ $ENDO(n_2)$

COURBE _GRD_VIE= "FORM_VIE" and FORMULE_VIE = MANCO2: Standard

| identification | of reference component | Value of reference |
|---|---|---|
| formulates $x$ $n_1$ $n_2$ | ″ -0.43051109680829 | 0.43051109680830 component |
| formulates $y$ $n_1$ $n_2$ | ″ 0.90258528434986 | component |
| formulates $z$ $n_1$ $n_2$ | ″ 6.1232339957368 | E-17 formulates |
| $ENDO(n_1)$ | ″ 0.61539334669938 | In |

the table above, the component formulates $x$ $n_1$ $n_2$ values because there exist two vectors which correspond to the same value of damage formulates $ENDO(n_1)$ $ENDO(n_2)$

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

# 5 C Characteristic

## 5.1 of the modelization the criterion

in formula makes it possible to find associated criteria " MATAKE_MODI_AC" and " DANG_VAN_MODI_AV" and of the criterion in formula for the loading multiaxial. Characteristics

## 5.2 of the mesh The mesh

is identical to that of modelization A. Grandeurs

## 5.3 tested and results For

periodic loading: For
the results with the mesh **(not** $M60$ **Gauss 3) for the option** COURBE_GRD_VIE = "WOHLER " and for the option COURBE_GRD_VIE = "FORM_VIE " and FORMULE_VIE = WHOL: Standard

| identification | of reference Value of reference | "NON_REGRESSION |
|---|---|---|
| $\Delta\tau(n_1)$ | " 1. 330171 | E + 02 *component* |
| of " $x$ NON_REGRESSION $n_1$ | " 6.972459 | E – 02 component |
| of " $y$ NON_REGRESSION $n_1$ | " 9.969556 | E – 01 component |
| of " $z$ NON_REGRESSION $n_1$ | " – 3.489950 | E – 02 "NON_REGRESSION |
| $N_{max}(n_1)$ | " 2.357226 | E+00 "NON_REGRESSION |
| $N_m(n_1)$ | " 2.220625 | E – 14 "NON_REGRESSION |
| $\varepsilon_{max}(n_1)$ | " 0.000000 | E + 00 "NON_REGRESSION |
| $\varepsilon_m(n_1)$ | " – 3.627373 | E – 05 "NON_REGRESSION |
| $\sigma_{eq}(n_1)$ | " 2.348841 | E+02 "NON_REGRESSION |
| $Nb_{cr}(n_1)$ | " 2.583800 | E+04 "NON_REGRESSION |
| $ENDO(n_1)$ | " 3.870305 | E – 05 "NON_REGRESSION |
| $\Delta\tau(n_2)$ | " 1.330158 | E + 02 *component* |
| of " $x$ NON_REGRESSION $n_2$ | " – 9.901402 | E – 01 component |
| of " $y$ NON_REGRESSION $n_2$ | " 6.906669 | E – 02 component |

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

| | | |
|---|---|---|
| of " $z$ NON_REGRESSION $n_2$ | " 1.218693 | E – 01 "NON_REGRESSION |
| $N_{\max}(n_2)$ | " 1.264927 | E+02 "NON_REGRESSION |
| $N_m(n_2)$ | " 1.581158 | E +0 1 "NON_REGRESSION |
| $\varepsilon_{\max}(n_2)$ | " 6.474850 | E – 04 "NON_REGRESSION |
| $\varepsilon_m(n_2)$ | " 8.093563 | E – 05 "NON_REGRESSION |
| $\sigma_{eq}(n_2)$ | " 3.892627 | E+02 "NON_REGRESSION |
| $Nb_{cr}(n_2)$ | " 3.323100 | E+04 "NON_REGRESSION |
| $ENDO(n_2)$ | " 3.009210 | E – 05 For |

the results with the mesh **(not** $M60$ **Gauss 3) for the option** COURBE_GRD_VIE = "FORM_VIE " and FORMULE_VIE = WHOL_F: Standard

| identification | of reference Value of reference | "NON_REGRESSION |
|---|---|---|
| $\Delta\tau(n_1)$ | " 1. 330171 | E + 02 *component* |
| of " $x$ NON_REGRESSION $n_1$ | " 6.972459 | E – 02 component |
| of " $y$ NON_REGRESSION $n_1$ | " 9.969556 | E – 01 component |
| of " $z$ NON_REGRESSION $n_1$ | " – 3.489950 | E – 02 "NON_REGRESSION |
| $N_{\max}(n_1)$ | " 2.357226 | E+00 "NON_REGRESSION |
| $N_m(n_1)$ | " 2.220625 | E – 14 "NON_REGRESSION |
| $\varepsilon_{\max}(n_1)$ | " 0.000000 | E + 00 "NON_REGRESSION |
| $\varepsilon_m(n_1)$ | " – 3.627373 | E – 05 "NON_REGRESSION |
| $\sigma_{eq}(n_1)$ | " 2.348841 | E+02 "NON_REGRESSION |
| $Nb_{cr}(n_1)$ | " 5.1477 | E+04 "NON_REGRESSION |
| $ENDO(n_1)$ | " 1.9426163934314 | E-05 "NON_REGRESSION |
| $\Delta\tau(n_2)$ | " 1.330158 | E + 02 *component* |
| of " $x$ NON_REGRESSION $n_2$ | " – 9.901402 | E – 01 component |
| of " $y$ | " 6.906669 | E – 02 component |



*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

| | | |
|---|---|---|
| NON_REGRESSION $n_2$ | | |
| of " $z$ NON_REGRESSION $n_2$ | " 1.218693 | E – 01 "NON_REGRESSION |
| $N_{max}(n_2)$ | " 1.264927 | E+02 "NON_REGRESSION |
| $N_m(n_2)$ | " 1.581158 | E +0 1 "NON_REGRESSION |
| $\varepsilon_{max}(n_2)$ | " 6.474850 | E – 04 "NON_REGRESSION |
| $\varepsilon_m(n_2)$ | " 8.093563 | E – 05 "NON_REGRESSION |
| $\sigma_{eq}(n_2)$ | " 3.892627 | E+02 "NON_REGRESSION |
| $Nb_{cr}(n_2)$ | " 5.1477 | E+04 "NON_REGRESSION |
| $ENDO(n_2)$ | " 1.9426163934314 | E-05 For |

the results with node **for the option** $N214$ COURBE _GRD_VIE=' WOHLER' and for the option COURBE_GRD_VIE = "FORM_VIE " and FORMULE_VIE = WHOL: Standard

| **identification** | **of reference Value of reference** | **"NON_REGRESSION** |
|---|---|---|
| $\Delta\tau(n_1)$ | " 1.1557902030140 | E+02 component |
| of " $x$ NON_REGRESSION $n_1$ | " 3.8280107156988 | E-01 component |
| of " $y$ NON_REGRESSION $n_1$ | " 8.4447216637038 | E-01 component |
| of " $z$ NON_REGRESSION $n_1$ | " 3.7460659341591 | E-01 "NON_REGRESSION |
| $N_{max}(n_1)$ | " 7.3701737537055 | E+01 "NON_REGRESSION |
| $N_m(n_1)$ | " -6.6290480086559 | E+00 "NON_REGRESSION |
| $\varepsilon_{max}(n_1)$ | " 0. "NON_REGRESSION | |
| $\varepsilon_m(n_1)$ | " -4.2254262706848 | E-05 "NON_REGRESSION |
| $\sigma_{eq}(n_1)$ | " 2.8392113675768 | E+02 "NON_REGRESSION |
| $Nb_{cr}(n_1)$ | " 1.3505000000000 | E+04 "NON_REGRESSION |
| $ENDO(n_1)$ | " 7.4047664409136 | E-05 "NON_REGRESSION |
| $\Delta\tau(n_2)$ | " 1.1520977056656 | E+02 component |
| of " $x$ | " -9.1924333354254 | E-01 component |

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

| | | |
|---|---|---|
| NON_REGRESSION $n_2$ | | |
| of " $y$ NON_REGRESSION $n_2$ | ″ 3.9019564505737 | E-01 component |
| of " $z$ NON_REGRESSION $n_2$ | ″ 5.2335956242944 | E-02 "NON_REGRESSION |
| $N_{\max}(n_2)$ | ″ 1.1296755026397 | E+02 "NON_REGRESSION |
| $N_m(n_2)$ | ″ 6.8110853707598 | E+00 "NON_REGRESSION |
| $\varepsilon_{\max}(n_2)$ | ″ 3.6085283407484 | E-04 "NON_REGRESSION |
| $\varepsilon_m(n_2)$ | ″ 4.5106604259354 | E-05 "NON_REGRESSION |
| $\sigma_{eq}(n_2)$ | ″ 3.4226598124581 | E+02 "NON_REGRESSION |
| $Nb_{cr}(n_2)$ | ″ 4.8720000000000 | E+03 "NON_REGRESSION |
| $ENDO(n_2)$ | ″ 2.0525129321838 | E-04 For |

the results with node **for the option** $N214$ COURBE `_GRD_VIE=' FORMES_VIE' and FORMULE_VIE = WHOL_F: Standard`

| identification | of reference Value of reference | "NON_REGRESSION |
|---|---|---|
| $\Delta\tau(n_1)$ | ″ 1.1557902030140 | E+02 component |
| of " $x$ NON_REGRESSION $n_1$ | ″ 3.8280107156988 | E-01 component |
| of " $y$ NON_REGRESSION $n_1$ | ″ 8.4447216637038 | E-01 component |
| of " $z$ NON_REGRESSION $n_1$ | ″ 3.7460659341591 | E-01 "NON_REGRESSION |
| $N_{\max}(n_1)$ | ″ 7.3701737537055 | E+01 "NON_REGRESSION |
| $N_m(n_1)$ | ″ -6.6290480086559 | E+00 "NON_REGRESSION |
| $\varepsilon_{\max}(n_1)$ | ″ 0. "NON_REGRESSION | |
| $\varepsilon_m(n_1)$ | ″ -4.2254262706848 | E-05 "NON_REGRESSION |
| $\sigma_{eq}(n_1)$ | ″ 2.8392113675768 | E+02 "NON_REGRESSION |
| $Nb_{cr}(n_1)$ | ″ 2.0270 | E+04 "NON_REGRESSION |
| $ENDO(n_1)$ | ″ 4.933357265479 | E-05 "NON_REGRESSION |

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

| | | |
|---|---|---|
| $\Delta\tau(n_2)$ | ″ 1.1520977056656 | E+02 component |
| of “ $x$ NON_REGRESSION $n_2$ | ″ -9.1924333354254 | E-01 component |
| of “ $y$ NON_REGRESSION $n_2$ | ″ 3.9019564505737 | E-01 component |
| of “ $z$ NON_REGRESSION $n_2$ | ″ 5.2335956242944 | E-02 “NON_REGRESSION |
| $N_{\max}(n_2)$ | ″ 1.1296755026397 | E+02 “NON_REGRESSION |
| $N_m(n_2)$ | ″ 6.8110853707598 | E+00 “NON_REGRESSION |
| $\varepsilon_{\max}(n_2)$ | ″ 3.6085283407484 | E-04 “NON_REGRESSION |
| $\varepsilon_m(n_2)$ | ″ 4.5106604259354 | E-05 “NON_REGRESSION |
| $\sigma_{eq}(n_2)$ | ″ 3.4226598124581 | E+02 “NON_REGRESSION |
| $Nb_{cr}(n_2)$ | ″ 1.01240 | E+04 “NON_REGRESSION |
| $ENDO(n_2)$ | ″ 9.8775850589871 | E-05 For |

loading NON-periodical: For
the results with node **for the option** $N214$ COURBE `_GRD_VIE=' WOHLER' and for the option` COURBE `_GRD_VIE=' FORMES_VIE' and FORMULE_VIE = WHOL: Standard`

| identification | of reference component | Value of reference |
|---|---|---|
| of “ $x$ NON_REGRESSION $n_1$ | ″ 3.8280107156988 | E-01 component |
| of “ $y$ NON_REGRESSION $n_1$ | ″ 8.4447216637038 | E-01 component |
| of “ $z$ NON_REGRESSION $n_1$ | ″ 3.7460659341591 | E-01 “NON_REGRESSION |
| $ENDO(n_1)$ | ″ 9.2779623136707 | E-05 For |

the results to the node **and** $N206$ the mesh **(not** $M60$ **Gauss 3) for the option** COURBE `_GRD_VIE= “FORM_VIE” and FORMULE_VIE = WHOL_F: Standard`

| identification | of reference component | Value of reference |
|---|---|---|
| of “ $x$ NON_REGRESSION $n_1$ | ″ 3.8280107156988 | E-01 component |

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

| | | |
|---|---|---|
| of " $y$ NON_REGRESSION $n_1$ | " 8.4447216637038 | E-01 component |
| of " $z$ NON_REGRESSION $n_1$ | " 3.7460659341591 | E-01 "NON_REGRESSION |
| $ENDO(n_1)$ | " 6.1692384350833 | E-05 Modelization |

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

# 6 D Characteristic

## 6.1 of the modelization the functionalities

tested are new quantities (which are not part of the criteria existing already tested in the other modelizations). Only the option CRITERE = ' FORMULE_CRITERE' of the command CALC_ TIRES and the curve of life called by name "WOHLER″ are used. It is noted

that the behavior is elastoplastic and the loading is uniaxial and periodic. Characteristics

## 6.2 of the mesh The mesh

is identical to that of modelization A. Grandeurs

## 6.3 tested and results For

the results with the node **formulates** $N1$ the mesh **formulates** $M60$

| identification | of reference Value of reference | "DEPSPE |
|---|---|---|
| ″ "ANALYTIQUE | ″ 7.5E- | 4 "EPSPR |
| 1″ "ANALYTIQUE | ″ 7.625 | E-4 "SIGNM |
| 1″ "ANALYTIQUE | ″ 200 " | 200 |
| ″ "ANALYTIQUE | ″ 66.6666 | "DENDIS |
| ″ "ANALYTIQUE | ″ 0.45 | "DENDIE |
| ″ "ANALYTIQUE | ″ 0.173333 | "DSIGEQ |
| ″ "ANALYTIQUE | ″ 200 " | 200 |
| 1″ "ANALYTIQUE | ″ 1.75E | - 3 "INVA |
| 2S″ "ANALYTIQUE | ″ 1.616666 | E-3 "DSITRE |
| ″ "ANALYTIQUE | ″ 50 "DEPTRE | 50 |
| ″ "ANALYTIQUE | ″ 6.0625 | E-4 "DEPTRE |
| ″ "ANALYTIQUE | ″ 3.67423 | E-3 Modelization |

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

# 7 E Characteristic

## 7.1 of the modelization the functionalities

tested are new quantities. It is noted
that the behavior is elastoplastic and the loading is biaxial and NON-periodical. Characteristics

## 7.2 of the mesh The mesh

is identical to that of modelization A. Grandeurs

## 7.3 tested and results the value of reference

corresponds to damage (ENDO1) and the results were obtained with the node **formulates** $N1$ the mesh **formulates** $M60$ the formula **of Basquin: Standard**

| identification | of reference Value of reference | Criteria |
|---|---|---|
| **“ANALYTIQUE** | | |
| $\frac{\lvert SIPR1-SIPR2\rvert}{2}$ | ″ 1.0707149 | E-03 “ANALYTIQUE |
| $\frac{\lvert SITN1-SITN2\rvert}{2}$ | ″ 1.0707149 | E-03 “ANALYTIQUE |
| $\frac{SIPN1-SIPN2}{2}$ | ″ 1.0707149 | E-03 “ANALYTIQUE |
| $\frac{SIGEQ1-SIGEQ2}{2}$ | ″ 4.287285 | E-03 the value of reference |

always corresponds to damage (ENDO 1) and the results were obtained with the node **formulates** $N1$ the mesh **formulates** $M60$ an interpolation **of** the curve of Wöhler: Standard

| identification | of reference Value of reference | Criteria |
|---|---|---|
| **formulates** | | |
| $\frac{\lvert SIPR1-SIPR2\rvert}{2}$ | ″ 1.9212572 | E-03 formulates |
| $\frac{\lvert SITN1-SITN2\rvert}{2}$ | ″ 1.9212572 | E-03 formulates |
| $\frac{SIPN1-SIPN2}{2}$ | ″ 1.9212572 | E-03 formulates |
| $\frac{SIGEQ1-SIGEQ2}{2}$ | ″ 5.8175699 | E-03 Modelization |

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

# 8 F Characteristic

## 8.1 of the modelization the functionalities

tested are new quantities. It is noted
that various behaviors and loading are tested: elastic, biaxial and elastoplastic, uniaxial NON-periodical then and NON-periodical. Characteristics

## 8.2 of the mesh The mesh

is identical to that of modelization A. Grandeurs

## 8.3 tested and results Result

- got with first loading (SOL_NL **) :** The value of reference

corresponds to damage (ENDO 1) `and the` results were obtained with the node **and** $N1$ the mesh **via** $M60$ the formula **of Basquin: Standard**

| identification | of reference Value of reference | Criteria |
|---|---|---|
| formulates | | |
| $\frac{\lvert EPSN1-EPSN2 \rvert}{2}$ | ″ 1.08363973 | E-05 formulates |
| $\frac{\lvert ETPR1-ETPR2 \rvert}{2}$ | ″ 1.0 8363973 | E-0 5 formulates |
| $\frac{\lvert ETEQ1-ETEQ2 \rvert}{2}$ | ″ 1.06338423 | E-05 the value of reference |

always corresponds to damage (ENDO 1) `and the` results were obtained with the node **formulates** $N1$ the mesh **formulates** $M60$ an interpolation **of** the curve of Wöhler: Standard

| identification | of reference Value of reference | Criteria |
|---|---|---|
| formulates | | |
| $\frac{\lvert EPSN1-EPSN2 \rvert}{2}$ | ″ 3.26558686 | E-05 formulates |
| $\frac{\lvert ETPR1-ETPR2 \rvert}{2}$ | ″ 3.26558686 | E-05 formulates |
| $\frac{\lvert ETEQ1-ETEQ2 \rvert}{2}$ | ″ 3.21404432 | E-05 Result |

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

- obtained with the second loading (SOIL _NL 2) : The value of reference corresponds to damage (ENDO 1) and the results were obtained with the node **formulates** $N1$ the mesh **formulates** $M60$ the formula **of Basquin: Standard**

| **identification** | **of reference Value of reference** | **Criteria** |
|---|---|---|
| **formulates** | | |
| $\frac{\|EPSN1-EPSN2\|}{2}$ | ″ 1.449229 | E-04 formulates |
| $\frac{\|ETPR1-ETPR2\|}{2}$ | ″ 1. 449229 | E-0 4 formulates |
| $\frac{\|ETEQ1-ETEQ2\|}{2}$ | ″ 6.5320499 | E-05 the value of reference |

always corresponds to damage (ENDO 1) and the results were obtained with the node **formulates** $N1$ the mesh **formulates** $M60$ an interpolation **of** the curve of Wöhler: Standard

| **identification** | **of reference Value of reference** | **Criteria** |
|---|---|---|
| **formulates** | | |
| $\frac{\|EPSN1-EPSN2\|}{2}$ | ″ 2.408735 | E-04 formulates |
| $\frac{\|ETPR1-ETPR2\|}{2}$ | ″ 2.408735 | E-0 4 formulates |
| $\frac{\|ETEQ1-ETEQ2\|}{2}$ | ″ 1.322816 | E-04 Result |

- obtained with the third loading (SOIL _NL 3) : The value of reference corresponds to damage (ENDO 1) and the results were obtained with the node **formulates** $N1$ the mesh **formulates** $M60$ the formula **of Basquin: Standard**

| **identification** | **of reference Value of reference** | **Criteria** |
|---|---|---|
| **formulates** | | |
| $\frac{\|EPPR1-EPPR2\|}{2}$ | ″ 1.377855 | E-02 the value of reference |

always corresponds to damage (ENDO 1) and the results were obtained with the node **formulates** $N1$ the mesh **formulates** $M60$ an interpolation **of** the curve of Wöhler: Standard

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

| identification | of reference Value of reference | Criteria |
|---|---|---|
| **“ANALYTIQUE** | | |
| $\frac{\lvert EPPR1-EPPR2 \rvert}{2}$ | ″ 2.1858445 | E-03 Modelization |



Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

# 9 G Characteristic

## 9.1 of the modelization the functionalities

tested are new quantities. It is noted
that various behaviors and loading are tested: an elastic material and an elastoplastic material. Characteristics

## 9.2 of the mesh The mesh

is identical to that of modelization A. Grandeurs

## 9.3 tested and Criteria results

• **of DANG_VAN_MODI_AC , MATAKE_MODI_AC , DANG_VAN_MODI_AV For**

the results of formula $\phi_z$ formulates $N1$ an elastic material. Value

| **of the Type** $\alpha$ | **of reference Value of reference** | **−1,** |
|---|---|---|
| -0.5,0..10 “ANALYTIQUE | ″ 45 For | 45 |

the results of formula $\phi_z$ formulates $N1$ an elastoplastic material. Standard

| **value of** $\alpha$ | **of reference Value of reference** | |
|---|---|---|
| 0,1,2,3,4 “ANALYTIQUE | ″ 45 Criterion | 45 |

• of MATAKE_MODI_AV **Value**

| **of the Type** $\alpha$ | **of reference Value of reference** | **−1** |
|---|---|---|
| “ANALYTIQUE | ″ 45 – | 45 |
| “ANALYTIQUE | ″ 45,72 | 45.72 |
| | ″ 46,43 | 46.43 |
| 0.5 | ″ 47,14 | 47.14 |
| 1 | ″ 47,86 | 47.86 |
| 1.5 | ″ 48,56 | 48.56 |
| 2 | ″ 49,27 | 49.27 |
| 2.5 | ″ 49,96 | 49.96 |
| 3 | ″ 50,65 | 50.65 |
| 3.5 | ″ 51,34 | 51.34 |
| 4 | ″ 52,02 | 52.02 |
| 4.5 | ″ 52,69 | 52.69 |
| 5 | ″ 53,35 | 53.35 |
| 5.5 | ″ 54 6 | 54 |

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

| | | |
|---|---|---|
| 6 | ″ 54,65 | 54.65 |
| 6.5 | ″ 55,28 | 55.28 |
| 7 | ″ 55,9 | 55.9 |
| 7.5 | ″ 56,51 | 56.51 |
| 8 | ″ 57,11 | 57.11 |
| 8.5 | ″ 57,7 | 57.7 |
| 9 | ″ 58,28 | 58.28 |
| 9.5 | ″ 58,85 | 58.85 |
| 10 | ″ 59,41 | 59.41 |

the results of formula $\phi_z$ **formulate** $N1$ an elastoplastic material. Value

| **of formulated** $\alpha$ | **reference Value of reference** | **0 “ANALYTIQUE** |
|---|---|---|
| | ″ 46,43 | 46.43 |
| 1 | ″ 47,86 | 47.86 |
| 2 | ″ 49,27 | 49.27 |
| 3 | ″ 50,65 | 50.65 |
| 4 | ″ 52,02 | 52.02 |

- **of FATESOCI_MODI_AV For**

the results of formula $\phi_z$ **formulates** $N1$ an elastic material. Value

| **of 0.5** $\alpha$ | **Standard reference** | **Value of reference** |
|---|---|---|
| −1 “ | ANALYTIQUE″ 45 | 45 |
| “ANALYTIQUE | ″ 45,34 | 45.34 |
| | ″ 45,67 | 45.67 |
| 0.5 | ″ 45,99 | 45.99 |
| 1 | ″ 46,31 | 46.31 |
| 1.5 | ″ 46,61 | 46.61 |
| 2 | ″ 46,91 | 46.91 |
| 2.5 | ″ 47,2 | 47.2 |
| 3 | ″ 47,48 | 47.48 |
| 3.5 | ″ 47,75 | 47.75 |
| 4 | ″ 48,01 | 48.01 |
| 4.5 | ″ 48,27 | 48.27 |
| 5 | ″ 48,51 | 48.51 |
| 5.5 | ″ 48,75 | 48.75 |
| 6 | ″ 48,98 | 48.98 |

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

*Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)*

| | | |
|---|---|---|
| 6.5 | ″ 49,2 | 49.2 |
| 7 | ″ 49,42 | 49.42 |
| 7.5 | ″ 49,63 | 49.63 |
| 8 | ″ 49,83 | 49.83 |
| 8.5 | ″ 50,03 | 50.03 |
| 9 | ″ 50,22 | 50.22 |
| 9.5 | ″ 50,4 | 50.4 |
| 10 | ″ 50,58 | 50.58 |

the results of formula $\phi_z$ **formulate** $N1$ an elastoplastic material. Value

| **of formulated** $\alpha$ | **reference Value of reference** | **0 “ANALYTIQUE** |
|---|---|---|
| | ″ 45,67 | 45.67 |
| 1 | ″ 46,31 | 46.31 |
| 2 | ″ 46,91 | 46.91 |
| 3 | ″ 47,48 | 47.48 |
| 4 | ″ 48,01 | 48.01 |

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)

# 10 of the results the got

results are in perfect agreement with the reference solution for modelization A. The modelization B does not have reference solutions associated with the criteria. The modelization C does not have reference solution, it acts of a test of non regression. The results

of the modelizations D, E, F and G agree with the analytical results.

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

Licensed under the terms of the GNU FDL (http://www.gnu.org/copyleft/fdl.html)