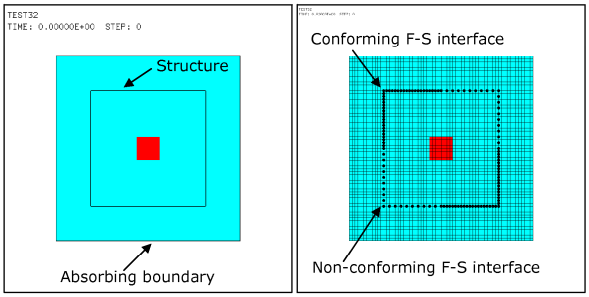
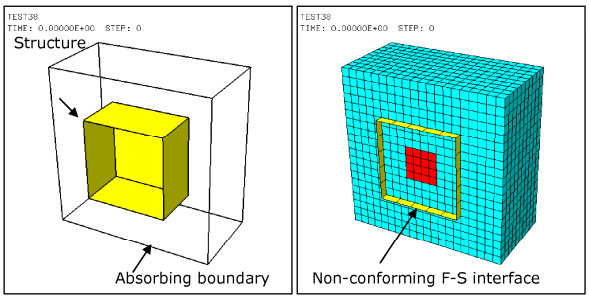
Example 6bis – Non-conforming FSI with CCVF

(Weak coupling, without or with structural failure)



2D case

(the dots indicate the structure nodes)



3D case

(half model shown for clarity)

32

Geometric data and materials:

See picture above for the geometry in 2D and 3D.

The fluids are perfect gases. The structure is steel with an elasto-plastic law.

Numerical Solutions (2D)

TEST32

This model uses conforming and non-conforming FSI together in the same calculation. The structure is deformable but is not allowed to fail. The mesh generation file is:

```
*
opti echo 1;
TITRE 'TEST32' ;
*
* creation du fluide (pour elements VFCC)
* - - - - - - - - - -
*
opti dime 2 elem qua4;
*
* une seule densite pour le maillage fluide
dens1= 0.025;
dens dens1;
*
p1= -0.5 -0.5;
p2= 0.5 -0.5;
p3= 0.5 0.5;
p4= -0.5 0.5;
p5= -0.1 -0.1;
p6= 0.1 -0.1;
p7= 0.1 0.1;
p8= -0.1 0.1;
p9= -0.1 -0.5;
p10= -0.1 0.5;
p11= 0.1 -0.5;
p12= 0.1 0.5;
p13= -0.8 -0.8;
p14= -0.5 -0.8;
p15= 0.5 -0.8;
p16= 0.8 -0.8;
p19= -0.5 0.8;
p17= 0.8 0.8;
p18= 0.5 0.8;
p20= -0.8 0.8;
p22= 0 -0.5;
p24= 0.5 0;
p26= 0 0.5;
p28= -0.5 0;
p33= 0 -0.1;
p34= 0.1 0;
p35= 0 0.1;
p36= -0.1 0;
*
* creation des surfaces
*
s1=dall (p1 d p9) (p9 d p36) (p36 d p28) (p28 d p1);
s2=dall (p11 d p2) (p2 d p24) (p24 d p34) (p34 d p11);
s3=dall (p8 d p35) (p35 d p26) (p26 d p10) (p10 d p8);
s4=dall (p9 d p22) (p22 d p33) (p33 d p5) (p5 d p9);
s6=dall (p13 d p14) (p14 d p19) (p19 d p20) (p20 d p13);
s7=dall (p15 d p16) (p16 d p17) (p17 d p18) (p18 d p15);
s8=dall (p14 d p15) (p15 d p2) (p2 d p1) (p1 d p14);
s9=dall (p4 d p3) (p3 d p18) (p18 d p19) (p19 d p4);
s10=dall (p28 d p36) (p36 d p10) (p10 d p4) (p4 d p28);
s11=dall (p34 d p24) (p24 d p3) (p3 d p12) (p12 d p34);
s12=dall (p35 d p7) (p7 d p12) (p12 d p26) (p26 d p35);
s13=dall (p22 d p11) (p11 d p6) (p6 d p33) (p33 d p22);
cha0=dall (p5 d p6) (p6 d p7) (p7 d p8) (p8 d p5);
*
* assemblage de toutes les surfaces sans la charge
*
a1= s11 et s12 et s1 et s4;
air0= s1 et s2 et s3 et s4 et s10 et s11 et s12 et s13;
air1= s6 et s7 et s8 et s9;
*
* assemblage du fluide par fusion des noeuds communs
*
flu1= cha0 et air0 et air1;
elim (flu1) (dens1/1000);
*
* noeuds pour la declaration de la frontiere externe: eulerienne
*
pflu1=chan 'POI1' flu1;
*trac pflu1;
seg1 = pflu1 POIN 'DROIT' p13 p16;
seg2 = pflu1 POIN 'DROIT' p16 p17;
seg3 = pflu1 POIN 'DROIT' p17 p20;
seg4 = pflu1 POIN 'DROIT' p20 p13;
eul0= seg1 et seg2 et seg3 et seg4;
*
* construction frontiere exterieure absorbante
*
abs0= (p13 d p16) et (p16 d p17) et (p17 d p20) et (p20 d p13);
*
flu0= flu1 et eul0 et abs0;
elim (flu0) (dens1/1000);
*
* creation de la structure
* - - - - - - - - - -
*
* deux densites pour le maillage de la structure
```

```
* correspondant aux cas conforme et non-conforme
*
* dens1 = dens conforme
* dens2 = dens non conforme
*
dens2= 2*dens1;
*
dens dens2;
p21 = -0.5 -0.5;
p25 = 0.5 0.5;
p29 = 0 -0.5;
p30 = 0.5 0;
p31 = 0 0.5;
p32 = -0.5 0;
*
dens dens1;
p23 = 0.5 -0.5;
p27 = -0.5 0.5;
p37 = 0 -0.5;
p38 = 0.5 0;
p39 = 0 0.5;
p40 = -0.5 0;
*
* creation de la structure
* - - - - - - - - - - - - - - - - - - - -
* 3 cas: structure conforme, structure non conforme, cas mixte
* cas mixte: 1 partie de la structure conforme 1 autre non conforme
* - - - - - - - - - - - - - - - - - - - -
*
* partie conforme dans le cas mixte
conf0= (p37 d p23) et (p23 d p38) et (p39 d p27) et (p27 d p40);
elim (conf0) (dens1/1000);
* partie non conforme dans le cas mixte
nconf0= (p21 d p29) et (p25 d p31) et (p32 d p21) et (p30 d p25);
elim (nconf0) (dens1/1000);
*
** cas conforme: on fusionne les noeuds de la structure (entre eux) et avec
** ceux du maillage fluide
*stru0= conf0 et nconf0;
*elim (stru0) (dens1/1000);
*mesh0= stru0 et flu0;
*elim (mesh0) (dens1/1000);
*
** cas non conforme: on fusionne les noeuds de la structure (entre eux) et on
** recupere la liste des noeuds fluide correspondant
*stru0= conf0 et nconf0;
*elim (stru0) (dens1/1000);
** noeuds correspondants a l'ensemble de la structure
*pair0=chan 'POI1' air0;
*seg5 = pair0 POIN 'DROIT' p1 p2;
*seg6 = pair0 POIN 'DROIT' p2 p3;
*seg7 = pair0 POIN 'DROIT' p3 p4;
*seg8 = pair0 POIN 'DROIT' p4 p1;
*noeF0= seg5 et seg6 et seg7 et seg8;
*mesh0= stru0 et flu0 et noeF0;
*elim (mesh0) (dens1/1000);
**
* cas mixte: on fusionne les noeuds des parties conformes avec les noeuds
fluide
* et on recupere la liste des noeuds fluides des parties correspondant aux
* parties non conformes
pa1=chan 'POI1' a1;
seg5 = pa1 POIN 'DROIT' p28 p1;
seg6 = pa1 POIN 'DROIT' p1 p9;
seg7 = pa1 POIN 'DROIT' p24 p3;
seg8 = pa1 POIN 'DROIT' p3 p12;
noeF0= seg5 et seg6 et seg7 et seg8;
mesh0= conf0 et flu0 et noeF0;
elim (mesh0) (dens1/1000);
mesh0= mesh0 et nconf0;
elim (nconf0 et conf0) (dens1/1000);
*
* post-traitement: VF ou l'on regarde la pression
*
e1 = air0 elem cont p1;
e2 = air0 elem cont p2;
e3 = air0 elem cont p3;
e4 = air0 elem cont p4;
e22 = air0 elem cont p22;
e24 = air0 elem cont p24;
e26 = air0 elem cont p26;
e28 = air0 elem cont p28;
ealic = e1 et e2 et e3 et e4 et e22 et e24 et e26 et e28;
mesh = mesh0 et ealic;
*
tass mesh;
opti sauv form 'TEST32.msh';
sauv form mesh;
opti trac psc ftra 'TEST32_mesh.ps';
trac qual mesh;
Fin;
```

The input file is:

```
TEST32
*------------------------------------------------------------------------
ECHO
$VERI
!CONV win
CAST MESH
*-------------------------------------------------------------Problem type
DPLA ALE
*-------------------------------------------------------------Dimensioning
DIME
 NALE 2000 NBLE 3887
TERM
*----------------------------------------------------------------Geometry
GEOM
  Q4VF air0 air1 cha0 ED01 conf0 nconf0 CL2D abs0
TERM
*-----------------------------------------------Geometrical complements
COMP COUL roug LECT cha0 TERM
          turq LECT air0 air1 TERM
     EPAI 0.01 LECT conf0 nconf0 TERM
     NGRO 1 'nstru' LECT conf0 nconf0 TERM
*-------------------------------------------------------------------ALE
GRIL LAGR LECT conf0 nconf0 TERM
     EULE LECT eul0 TERM
     AUTO AUTR
*-----------------------------------------------------------Material data
MATE
$ high-pressure perfect gas (explosive bubble)
          GAZP RO 1.3 GAMMA 1.4 PINI 100.E5 PREF 1.E5
          LECT cha0 TERM
$ air
          GAZP RO 1.3 GAMMA 1.4 PINI 1.E5 PREF 1.E5
          LECT air0 air1 TERM
$ structure
          VM23 RO 7800. YOUNG 1.6E11 NU 0.333 ELAS 1.05E8
          TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
          LECT conf0 nconf0 TERM
$ absorbing boundary
          CLVF absorbant ro 1.4
          lect abs0 term
*----------------------------------------------------------------Outputs
ECRI
     VITE ECRO TFRE 100.E-3
     FICH ALIC TFRE 1.E-4
     FICH ALIC TEMP FREQ 1
          ELEM LECT ealic TERM
*-----------------------------------------------------------------Options
OPTI NOTEST
 csta 0.5e0
 step io
 log 1
 VFCC DUMP NCFS LECT noeF0 TERM
*-----------------------------------------------Transient calculation
CALCUL TINI 0 TEND 0.01E0
*=============================================================POST-TREATMENT
SUIT
Post treatment
ECHO
 conv win
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
PLAY
CAME   1 EYE   0.00000E+00  0.00000E+00  4.50000E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
sler cam1 1 nfra 1
scen geom navi free
     iso  fili fiel ecro 1 scal user prog 0.7E5 pas 0.4E5 5.9E5 term
          SUPP LECT air0 air1 cha0  TERM
     text isca
     vect scco fiel vcvi scal user prog 10 pas 10 140 term
          SUPP LECT air0 air1 cha0 TERM
     text vsca
     colo pape
trac offs fich avi     nocl nfto 101 fps 10 kfre 10 comp -1 rend
freq 1
gotr loop 99 offs fich avi cont nocl rend
go
trac offs fich avi cont rend
ENDPLAY
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC GARD PSCR
SORT GRAP
AXTE 1.0 'Time [s]'
*
COUR  1 'dx_21'  DEPL COMP 1 NOEU LECT p21 TERM
COUR  2 'dx_23'  DEPL COMP 1 NOEU LECT p23 TERM
COUR  3 'dx_25'  DEPL COMP 1 NOEU LECT p25 TERM
COUR  4 'dx_27'  DEPL COMP 1 NOEU LECT p27 TERM
COUR  5 'dx_30'  DEPL COMP 1 NOEU LECT p30 TERM
COUR  6 'dx_32'  DEPL COMP 1 NOEU LECT p32 TERM
COUR  7 'dy_21'  DEPL COMP 2 NOEU LECT p21 TERM
COUR  8 'dy_23'  DEPL COMP 2 NOEU LECT p23 TERM
COUR  9 'dy_25'  DEPL COMP 2 NOEU LECT p25 TERM
COUR  10 'dy_27'  DEPL COMP 2 NOEU LECT p27 TERM
COUR  11 'dy_29'  DEPL COMP 2 NOEU LECT p29 TERM
COUR  12 'dy_31'  DEPL COMP 2 NOEU LECT p31 TERM
*
COUR 20 'pr_1'   ECRO COMP 1 ELEM LECT e1 TERM
COUR 21 'pr_2'   ECRO COMP 1 ELEM LECT e2 TERM
COUR 22 'pr_3'   ECRO COMP 1 ELEM LECT e3 TERM
COUR 23 'pr_4'   ECRO COMP 1 ELEM LECT e4 TERM
COUR 24 'pr_5'   ECRO COMP 1 ELEM LECT e22 TERM
COUR 25 'pr_6'   ECRO COMP 1 ELEM LECT e24 TERM
COUR 26 'pr_7'   ECRO COMP 1 ELEM LECT e26 TERM
COUR 27 'pr_8'   ECRO COMP 1 ELEM LECT e28 TERM
*
TRAC 1 2 3 4 5 6 7 8 9 10 11 12 AXES 1.0 'DISPL. [M]'
TRAC 20 21 22 23 24 25 26 27 AXES 1.0 'PRESS [PA]'
LIST 1 2 3 4 5 6 7 8 9 10 11 12 AXES 1.0 'DISPL. [M]'
LIST 20 21 22 23 24 25 26 27 AXES 1.0 'PRESS [PA]'
*
FIN
```

TEST35

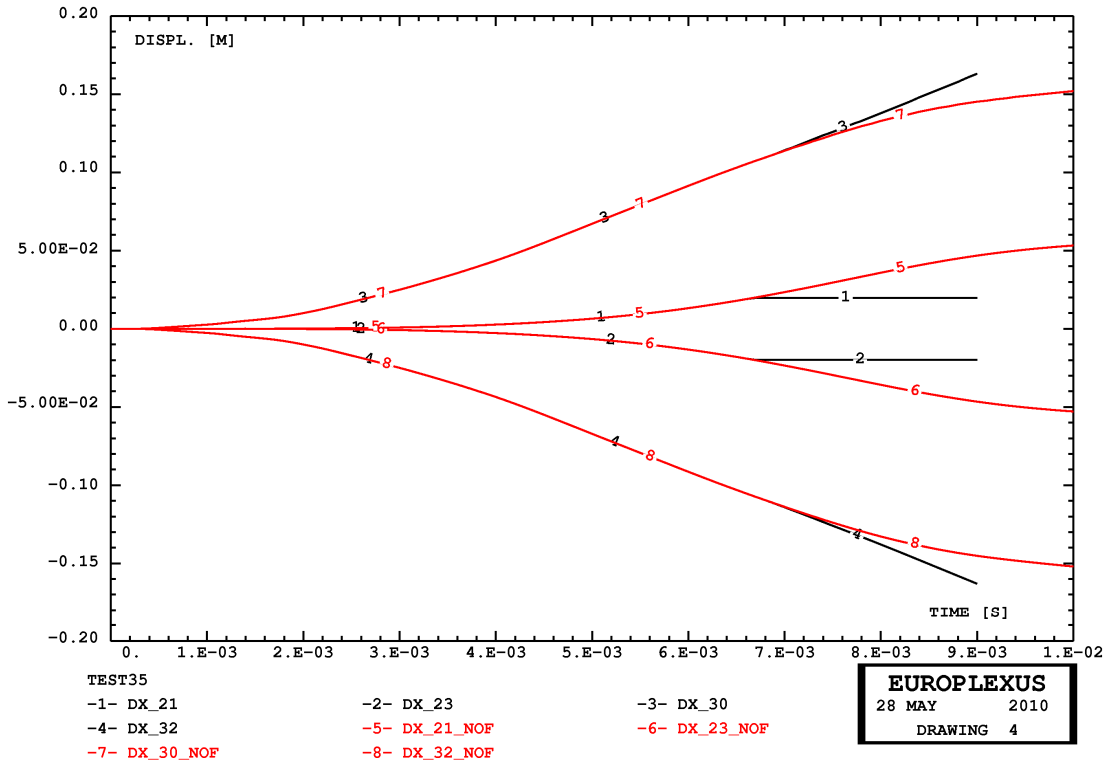
This test is identical to TEST32 but now the structure is allowed to fail. Erosion is applied upon structural failure. The mesh generation file is the same as in the previous case. The input file is:

```
TEST35
*------------------------------------------------------------------------
ECHO
$VERI
!CONV win
CAST MESH
*-------------------------------------------------------------Problem type
DPLA ALE EROS 0.0
*-------------------------------------------------------------Dimensioning
DIME
 NALE 2000 NBLE 3887
TERM
*----------------------------------------------------------------Geometry
GEOM
  Q4VF air0 air1 cha0 ED01 conf0 nconf0 CL2D abs0
TERM
*-----------------------------------------------Geometrical complements
COMP COUL roug LECT cha0 TERM
          turq LECT air0 TERM
     EPAI 0.01 LECT conf0 nconf0 TERM
     NGRO 1 'nstru' LECT conf0 nconf0 TERM
*-------------------------------------------------------------------ALE
GRIL LAGR LECT conf0 nconf0 TERM
     EULE LECT eul0 TERM
     AUTO AUTR
*-----------------------------------------------------------Material data
MATE
$ high-pressure perfect gas (explosive bubble)
          GAZP RO 1.3 GAMMA 1.4 PINI 100.E5 PREF 1.E5
          LECT cha0 TERM
$ air
          GAZP RO 1.3 GAMMA 1.4 PINI 1.E5 PREF 1.E5
          LECT air0 air1 TERM
$ structure
```

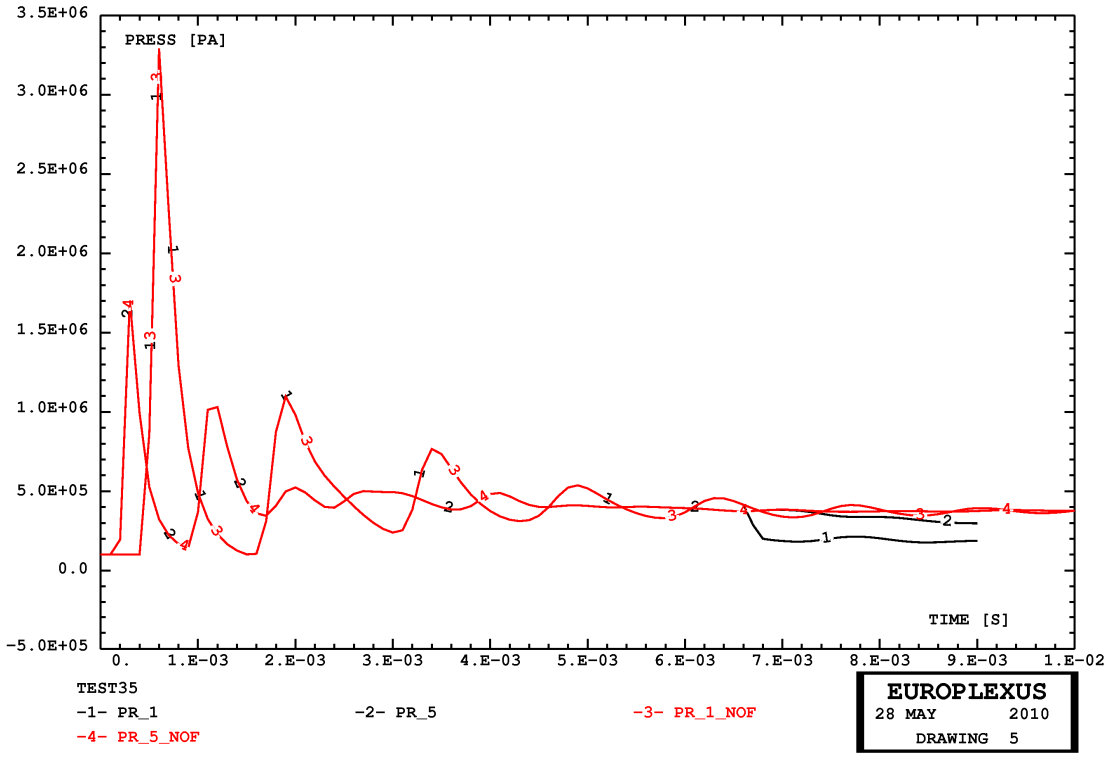
```
          VM23 RO 7800. YOUNG 1.6E11 NU 0.333 ELAS 1.05E8
          FAIL PEPS LIMI 0.038
          TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
          LECT conf0 TERM
          VM23 RO 7800. YOUNG 1.6E11 NU 0.333 ELAS 1.05E8
          FAIL PEPS LIMI 0.035
          TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
          LECT nconf0 TERM
$ absorbing boundary
          CLVF absorbant ro 1.4
          lect abs0 term
*-------------------------------------------------------------------Outputs
ECRI
     VITE ECRO TFRE 100.E-3
     FICH ALIC TFRE 1.E-4
     FICH ALIC TEMP FREQ 1
          ELEM LECT ealic TERM
*-------------------------------------------------------------------Options
OPTI NOTEST
 csta 0.5e0
 step io
 log 1
 VFCC DUMP NCFS LECT noeF0 TERM
*-----------------------------------------------------Transient calculation
CALCUL TINI 0 TEND 0.009E0
*============================================================POST-TREATMENT
SUIT
Post treatment
ECHO
 conv win
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
PLAY
CAME   1 EYE   0.00000E+00  0.00000E+00  4.50000E+00
!        Q     1.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
         VIEW  0.00000E+00  0.00000E+00 -1.00000E+00
         RIGH  1.00000E+00  0.00000E+00  0.00000E+00
         UP    0.00000E+00  1.00000E+00  0.00000E+00
         FOV   2.48819E+01
sler cam1 1 nfra 1
scen geom navi free
     iso  fili fiel ecro 1 scal user prog 0.7E5 pas 0.4E5 5.9E5 term
          SUPP LECT air0 air1 cha0  TERM
     text isca
     vect scco fiel vcvi scal user prog 10 pas 10 140 term
          SUPP LECT air0 air1 cha0 TERM
     text vsca
     colo pape
trac offs fich avi     nocl nfto 91 fps 10 kfre 10 comp -1
     obje nfai lect tous term rend
freq 1
gotr loop 89 offs fich avi cont nocl
     obje nfai lect tous term rend
go
trac offs fich avi cont
     obje nfai lect tous term rend
ENDPLAY
*=================================================================
SUIT
Post-treatment (time curves from alice temps file)
ECHO
RESU ALIC GARD PSCR
```

```
SORT GRAP
AXTE 1.0 'Time [s]'
*
* points structure
COUR  1 'dx_21'  DEPL COMP 1 NOEU LECT p21 TERM
COUR  2 'dx_23'  DEPL COMP 1 NOEU LECT p23 TERM
COUR  3 'dx_25'  DEPL COMP 1 NOEU LECT p25 TERM
COUR  4 'dx_27'  DEPL COMP 1 NOEU LECT p27 TERM
COUR  5 'dx_30'  DEPL COMP 1 NOEU LECT p30 TERM
COUR  6 'dx_32'  DEPL COMP 1 NOEU LECT p32 TERM
COUR  7 'dy_21'  DEPL COMP 2 NOEU LECT p21 TERM
COUR  8 'dy_23'  DEPL COMP 2 NOEU LECT p23 TERM
COUR  9 'dy_25'  DEPL COMP 2 NOEU LECT p25 TERM
COUR  10 'dy_27'  DEPL COMP 2 NOEU LECT p27 TERM
COUR  11 'dy_29'  DEPL COMP 2 NOEU LECT p29 TERM
COUR  12 'dy_31'  DEPL COMP 2 NOEU LECT p31 TERM
*
RCOU 101 'dx_21'  FICH 'test32.pun' RENA 'dx_21_nof'
RCOU 102 'dx_23'  FICH 'test32.pun' RENA 'dx_23_nof'
RCOU 105 'dx_30'  FICH 'test32.pun' RENA 'dx_30_nof'
RCOU 106 'dx_32'  FICH 'test32.pun' RENA 'dx_32_nof'
*
* points fluide
COUR  13 'dx_1'  DEPL COMP 1 NOEU LECT p1 TERM
COUR  14 'dx_2'  DEPL COMP 1 NOEU LECT p2 TERM
COUR  15 'dx_3'  DEPL COMP 1 NOEU LECT p3 TERM
COUR  16 'dx_4'  DEPL COMP 1 NOEU LECT p4 TERM
COUR  17 'dy_1'  DEPL COMP 2 NOEU LECT p1 TERM
COUR  18 'dy_2'  DEPL COMP 2 NOEU LECT p2 TERM
COUR  19 'dy_3'  DEPL COMP 2 NOEU LECT p3 TERM
COUR  20 'dy_4'  DEPL COMP 2 NOEU LECT p4 TERM
*
COUR 21 'pr_1'   ECRO COMP 1 ELEM LECT e1 TERM
COUR 22 'pr_2'   ECRO COMP 1 ELEM LECT e2 TERM
COUR 23 'pr_3'   ECRO COMP 1 ELEM LECT e3 TERM
COUR 24 'pr_4'   ECRO COMP 1 ELEM LECT e4 TERM
COUR 25 'pr_5'   ECRO COMP 1 ELEM LECT e22 TERM
COUR 26 'pr_6'   ECRO COMP 1 ELEM LECT e24 TERM
COUR 27 'pr_7'   ECRO COMP 1 ELEM LECT e26 TERM
COUR 28 'pr_8'   ECRO COMP 1 ELEM LECT e28 TERM
*
RCOU 121 'pr_1'   FICH 'test32.pun' RENA 'pr_1_nof'
RCOU 125 'pr_5'   FICH 'test32.pun' RENA 'pr_5_nof'
*
TRAC 1 2 3 4 5 6 7 8 9 10 11 12 AXES 1.0 'DISPL. [M]'
TRAC 13 14 15 16 17 18 19 20 AXES 1.0 'DISPL. [M]'
TRAC 21 22 23 24 25 26 27 28 AXES 1.0 'PRESS [PA]'
LIST 1 2 3 4 5 6 7 8 9 10 11 12 AXES 1.0 'DISPL. [M]'
LIST 13 14 15 16 17 18 19 20 AXES 1.0 'DISPL. [M]'
LIST 21 22 23 24 25 26 27 28 AXES 1.0 'PRESS [PA]'
TRAC 1 2 5 6 101 102 105 106 AXES 1.0 'DISPL. [M]'
     COLO noir noir noir noir roug roug roug roug
TRAC 21 25 121 125 AXES 1.0 'PRESS [PA]'
     COLO noir noir roug roug
*
*QUAL DEPL COMP 2 LECT 4    TERM REFE  1.77751E-3 TOLE 5.E-3
*     DEPL COMP 2 LECT 5    TERM REFE  1.77751E-3 TOLE 5.E-3
*     DEPL COMP 2 LECT 6    TERM REFE  1.77751E-3 TOLE 5.E-3
*     DEPL COMP 2 LECT 7    TERM REFE  1.77751E-3 TOLE 5.E-3
*     DEPL COMP 2 LECT 8    TERM REFE  1.77751E-3 TOLE 5.E-3
*     ECRO COMP 1 LECT 1    TERM REFE  9.97520E+4 TOLE 5.E-3
*     ECRO COMP 1 LECT 2    TERM REFE  9.97520E+4 TOLE 5.E-3
FIN
```

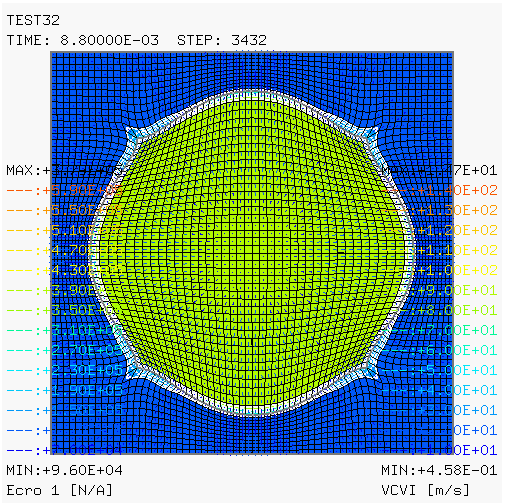
The structural displacements are (in red the case without failure, in black the case with failure):

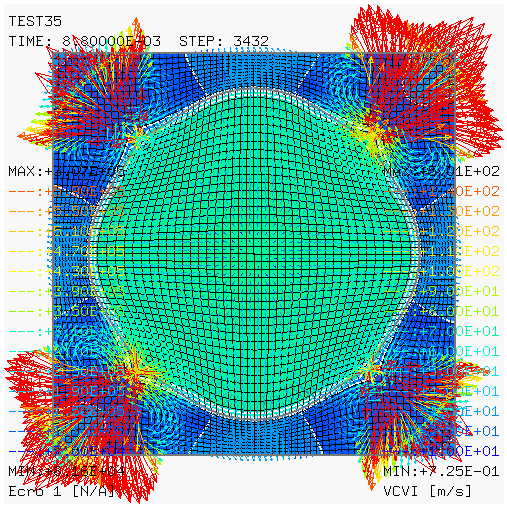


The fluid pressures are (in red the case without failure, in black the case with failure):



The final pressure and velocity maps for the cases without and with failure are:





Numerical Solutions (3D)

TEST38

This model uses non-conforming FSI. The structure is deformable but is not allowed to fail. The mesh generation file is:

```
*$siz 100
opti echo 1;
*
opti titr 'TEST38';
opti dime 3 elem cub8;
opti trac psc;
opti ftra 'TEST38_mesh.ps';
*
dens1= 0.5;
dens2=1.0;
```

```
*
dens dens1;
p0 = 0 0 0;
p1 = -5 -5 -5;
p2 = 5 -5 -5;
p3 = 5 5 -5;
p4 = -5 5 -5;
p5 = -5 -5 5;
p6 = 5 -5 5;
p7 = 5 5 5;
```

```
p8 = -5 5 5;
p91 = -2.5 -2.5 -2.5;
p151= 2.5 2.5 2.5;
tol = 0.01;
*
c1 = p1 d p2;
c2 = p2 d p3;
c3 = p3 d p4;
c4 = p4 d p1;
*
base = dall c1 c2 c3 c4 plan;
flu0 = base volu tran 20 (0 0 10);
abs0 = enve flu0;
elim tol (flu0 et p0 et p5 et p6 et p7 et p8);
expl1 = flu0 elem 'APPU' 'LARG' p0;
air1 = diff flu0 expl1;
expl2 = air1 elem 'APPU' 'LARG' expl1;
expl = expl1 et expl2;
air = diff flu0 expl;
*trak air;
*trak expl;
*
r1 = air elem 'APPU' 'LARG' expl;
r3 = (air elem 'APPU' 'LARG' r1) diff r1;
r2 = air diff (r1 et r3);
r1 = expl et r1;
r5 = air elem 'APPU' 'LARG' r3;
elim tol (p91 et p151 et r5);
r6= r5 et expl;
eflu1=enve r6;
noef0=chan 'POI1' eflu1;
*trak eflu1;
*trac noef0;
*
dens dens2;
p9 = -2.5 -2.5 -2.5;
p10= 2.5 -2.5 -2.5;
p11= 2.5 2.5 -2.5;
p12= -2.5 2.5 -2.5;
p13= -2.5 -2.5 2.5;
p14= 2.5 -2.5 2.5;
p15= 2.5 2.5 2.5;
p16= -2.5 2.5 2.5;
*
p17= 2.5 -0.5 -0.5;
p18= 0.5 2.5 0.5;
p19= 0.5 0.5 2.5;
*
stru1 = dall (p9 d p10) (p10 d p11) (p11 d p12) (p12 d p9)
plan;
stru2 = dall (p13 d p16) (p16 d p15) (p15 d p14) (p14 d p13)
plan;
```

```
stru3 = dall (p9 d p13) (p13 d p14) (p14 d p10) (p10 d p9)
plan;
stru4 = dall (p11 d p10) (p10 d p14) (p14 d p15) (p15 d p11)
plan;
stru5 = dall (p12 d p11) (p11 d p15) (p15 d p16) (p16 d p12)
plan;
stru6 = dall (p9 d p12) (p12 d p16) (p16 d p13) (p13 d p9)
plan;
stru0 = stru1 et stru2 et stru3 et stru4 et stru5 et stru6;
elim tol stru0;
elim tol (stru0 et p17 et p18 et p19);
*
pcx1 = -2.5 0 0;
pcx2 =  2.5 0 0;
pcy1 =  0 -2.5 0;
pcy2 =  0  2.5 0;
pcz1 =  0 0 -2.5;
pcz2 =  0 0  2.5;
elim tol (pcx1 et pcx2 et pcy1 et pcy2 et pcz1 et pcz2 et stru0);
tpln = pcx1 et pcx2 et pcy1 et pcy2 et pcz1 et pcz2;
*
ex1 = r5 elem cont pcx1;
ex2 = r5 elem cont pcx2;
ey1 = r5 elem cont pcy1;
ey2 = r5 elem cont pcy2;
ez1 = r5 elem cont pcz1;
ez2 = r5 elem cont pcz2;
e9 = r5 elem cont p91;
e15 = r5 elem cont p151;
ealic = ex1 et ex2 et ey1 et ey2 et ez1 et ez2 et e9 et e15;
*
mesh0= flu0 et abs0 et noef0 et tpln et ealic;
elim tol mesh0;
mesh=mesh0 et stru0;
*
tass mesh;
trac cach qual mesh;
trac cach (expl et stru0 et abs0);
trac cach (r1 et stru0);
trac cach (r2 et stru0);
trac cach (r3 et stru0);
*
opti sauv form 'TEST38.msh';
sauv form mesh;
*
list (nbel flu0);
list (nbno flu0);
list (nbel abs0);
list (nbno abs0);
list (nbel stru0);
list (nbno stru0);
fin;
```

The input file is:

```
TEST38
*------------------------------------------------------------------------
ECHO
!CONV win
CAST MESH
*-------------------------------------------------------------Problem type
TRID ALE
*-------------------------------------------------------------Dimensioning
DIME
 NALE 2000 NBLE 6859 ZONE 4
TERM
*-----------------------------------------------------------------Geometry
GEOM
  CUVF flu0 Q4GS stru0 CL3D abs0
TERM
*-----------------------------------------------Geometrical complements
COMP EPAI 0.01 LECT stru0 TERM
     GROU 3 'fy_gt_0' LECT flu0 TERM COND YB GT 0
            'sy_gt_0' LECT stru0 TERM COND YB GT -0.01
            'y_gt_0' LECT fy_gt_0 sy_gt_0 TERM
     COUL roug LECT expl TERM
          turq LECT air TERM
          jaun LECT stru0 TERM
          jaun LECT sy_gt_0 TERM
*-------------------------------------------------------------------------ALE
GRIL LAGR LECT stru0 TERM
     EULE LECT abs0 TERM
     AUTO AUTR
*-----------------------------------------------------------------Material data
MATE
$ air
          GAZP RO 1.3 GAMMA 1.4 PINI 1.E5 PREF 1.E5
          LECT air TERM
$ high-pressure perfect gas (explosive bubble)
          GAZP RO 1.3 GAMMA 1.4 PINI 100.E5 PREF 1.E5
          LECT expl TERM
$ structure
          VM23 RO 7800. YOUNG 1.6E11 NU 0.333 ELAS 1.05E8
          TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
          LECT stru0 TERM
$ absorbing boundary
          CLVF absorbant ro 1.4
          lect abs0 term
*-----------------------------------------------------------------Liaison
LINK COUP
 REGI 'r_in' TOUT LECT r1 TERM
      'r_out' TOUT LECT r2 TERM
      'r_mid' TOUT LECT r3 TERM
      'r_abs' TOUT LECT abs0 TERM
*-------------------------------------------------------------------Outputs
ECRI
 DEPL VITE ACCE FINT FEXT TFRE 0.01D0 !FREQ 10
 FICH ALIC FREQ 1
*-----------------------------------------------------------------Options
OPTI NOTE
 csta 0.5 log 1
 VFCC DUMP NCFS LECT noef0 TERM
*-----------------------------------------------Transient calculation
CALCUL TINI 0. TEND 0.02D0
*=====================================================================
SUIT
Post treatment
ECHO
 conv win
```

```
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
PLAY
CAME 1 EYE 2.08771E+01 -2.07253E+01 3.17743E+01
       VIEW -4.82136E-01 4.78631E-01 -7.33796E-01
       RIGH 8.29814E-01 5.18117E-01 -2.07274E-01
       UP -2.80985E-01 7.08849E-01 6.46978E-01
       FOV 2.48819E+01
SCEN GEOM NAVI FREE
FACE SBAC
REFE FRAM
     ISO FELE FIEL ECRO 1
          SCAL USER PROG 0.9E5 PAS 0.5E5 7.4E5 TERM
     SUPP LECT fy_gt_0 TERM
     TEXT ISCA
     VECT SCCO SCAL USER PROG 5. PAS 5. 70. TERM
     TEXT VSCA
     COLO PAPE
LIMA ON
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 15 KFRE 10 COMP -1
OBJE LECT fy_gt_0 sy_gt_0 TERM REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL
OBJE LECT fy_gt_0 sy_gt_0 TERM REND
GO
TRAC OFFS FICH AVI CONT
OBJE LECT fy_gt_0 sy_gt_0 TERM REND
ENDPLAY
*=====================================================================
SUIT
Post-treatment
ECHO
*
RESU ALIC GARD PSCR
*
SORT GRAP
*
AXTE 1.0 'Time [s]'
*
COUR 1 'dx_pcx1' DEPL COMP 1 NOEU LECT pcx1 TERM
COUR 2 'dx_pcx2' DEPL COMP 1 NOEU LECT pcx2 TERM
COUR 3 'dx_pcy1' DEPL COMP 2 NOEU LECT pcy1 TERM
COUR 4 'dx_pcy2' DEPL COMP 2 NOEU LECT pcy2 TERM
COUR 5 'dx_pcz1' DEPL COMP 3 NOEU LECT pcz1 TERM
COUR 6 'dx_pcz2' DEPL COMP 3 NOEU LECT pcz2 TERM
*
COUR 20 'pr_ex1'   ECRO COMP 1 ELEM LECT ex1 TERM
COUR 21 'pr_ex2'   ECRO COMP 1 ELEM LECT ex2 TERM
COUR 22 'pr_ey1'   ECRO COMP 1 ELEM LECT ey1 TERM
COUR 23 'pr_ey2'   ECRO COMP 1 ELEM LECT ey2 TERM
COUR 24 'pr_ez1'   ECRO COMP 1 ELEM LECT ez1 TERM
COUR 25 'pr_ez2'   ECRO COMP 1 ELEM LECT ez2 TERM
COUR 26 'pr_e9'    ECRO COMP 1 ELEM LECT e9  TERM
COUR 27 'pr_e15'   ECRO COMP 1 ELEM LECT e15 TERM
*
TRAC 1 2 3 4 5 6 axes 1.0 'DISPL. [M]' yzer
TRAC 20 21 22 23 24 25 26 27 AXES 1.0 'PRESS [PA]'
LIST 1 2 3 4 5 6 axes 1.0 'DISPL. [M]' yzer
LIST 20 21 22 23 24 25 26 27 AXES 1.0 'PRESS [PA]'
*=====================================================================
FIN
```

TEST40

This test is identical to TEST38 but now the structure is allowed to fail. Erosion is applied upon structural failure. The mesh generation file is the same as in the previous case. The input file is:

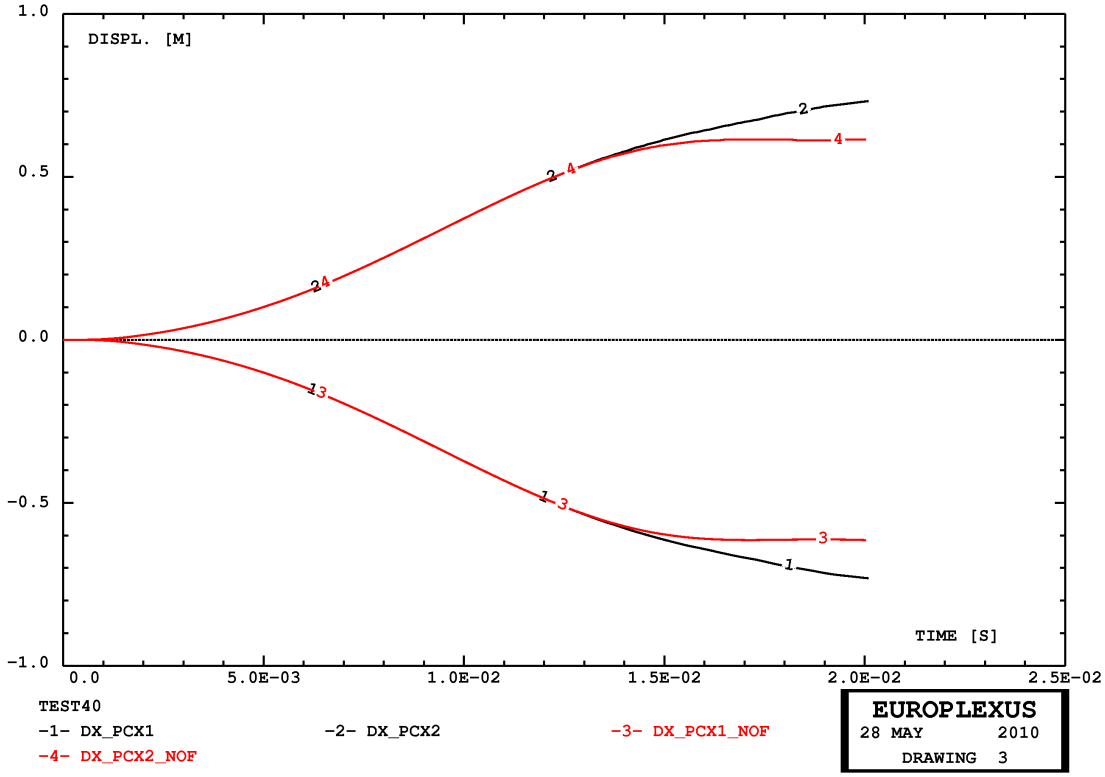
```
TEST40
*------------------------------------------------------------------------
ECHO
!CONV win
CAST MESH
*-------------------------------------------------------------Problem type
TRID ALE EROS 0.0
```

```
*-------------------------------------------------------------Dimensioning
DIME
 NALE 2000 NBLE 6859
TERM
*-----------------------------------------------------------------Geometry
GEOM
  CUVF flu0 Q4GS stru0 CL3D abs0
```

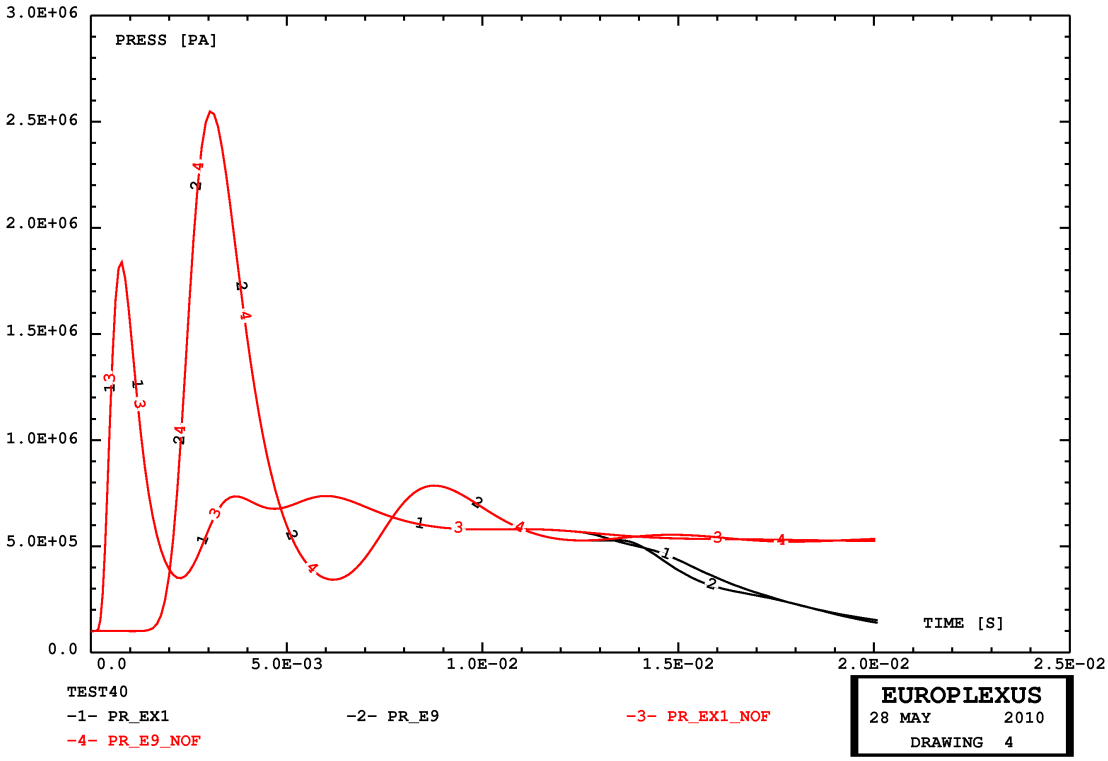
```
TERM
*-------------------------------------------------Geometrical complements
COMP EPAI 0.01 LECT stru0 TERM
     GROU 3 'fy_gt_0' LECT flu0 TERM COND YB GT 0
            'sy_gt_0' LECT stru0 TERM COND YB GT -0.01
            'y_gt_0' LECT fy_gt_0 sy_gt_0 TERM
     COUL roug LECT expl TERM
          turq LECT air TERM
          jaun LECT stru0 TERM
          jaun LECT sy_gt_0 TERM
*-------------------------------------------------------------------------ALE
GRIL LAGR LECT stru0 TERM
     EULE LECT abs0 TERM
     AUTO AUTR
*-----------------------------------------------------------Material data
MATE
$ air
          GAZP RO 1.3 GAMMA 1.4 PINI 1.E5 PREF 1.E5
          LECT air TERM
$ high-pressure perfect gas (explosive bubble)
          GAZP RO 1.3 GAMMA 1.4 PINI 100.E5 PREF 1.E5
          LECT expl TERM
$ structure
          VMZ3 RO 7800. YOUNG 1.6E11 NU 0.333 ELAS 1.05E8
          FAIL PEPS LIMI 0.035
          TRAC 2 1.05E8 .656256E-3 1.6105E10 1.00066
          LECT stru0 TERM
$ absorbing boundary
          CLVF absorbant ro 1.4
          lect abs0 term
*-------------------------------------------------------------------Liaison
LINK COUP
 REGI 'r_in' TOUT LECT r1 TERM
      'r_out' TOUT LECT r2 TERM
      'r_mid' TOUT LECT r3 TERM
      'r_abs' TOUT LECT abs0 TERM
*-------------------------------------------------------------------Outputs
ECRI
 DEPL VITE ACCE FINT FEXT TFRE 0.01D0 !FREQ 10
 FICH ALIC FREQ 1
*-------------------------------------------------------------------Options
OPTI NOTE
 csta 0.5 log 1
 VFCC DUMP NCFS LECT noef0 TERM
*-----------------------------------------------Transient calculation
CALCUL TINI 0. TEND 0.02D0
*=================================================================
SUIT
Post treatment
ECHO
 conv win
RESU ALIC GARD PSCR
OPTI PRIN
SORT VISU NSTO 1
PLAY
CAME 1 EYE 2.08771E+01 -2.07253E+01 3.17743E+01
       VIEW -4.82136E-01 4.78631E-01 -7.33796E-01
       RIGH 8.29814E-01 5.18117E-01 -2.07274E-01
       UP -2.80985E-01 7.08849E-01 6.46978E-01
       FOV 2.48819E+01
SCEN GEOM NAVI FREE
```

```
FACE SBAC
REFE FRAM
     ISO FELE FIEL ECRO 1
          SCAL USER PROG 0.9E5 PAS 0.5E5 7.4E5 TERM
     SUPP LECT fy_gt_0 TERM
     TEXT ISCA
     VECT SCCO SCAL USER PROG 5. PAS 5. 70. TERM
     TEXT VSCA
     COLO PAPE
LIMA ON
SLER CAM1 1 NFRA 1
TRAC OFFS FICH AVI NOCL NFTO 201 FPS 15 KFRE 10 COMP -1
OBJE nfai LECT fy_gt_0 sy_gt_0 TERM REND
FREQ 1
GOTR LOOP 199 OFFS FICH AVI CONT NOCL
OBJE nfai LECT fy_gt_0 sy_gt_0 TERM REND
GO
TRAC OFFS FICH AVI CONT
OBJE nfai LECT fy_gt_0 sy_gt_0 TERM REND
ENDPLAY
*=================================================================
SUIT
Post-treatment
ECHO
*
RESU ALIC GARD PSCR
*
SORT GRAP
*
AXTE 1.0 'Time [s]'
*
COUR 1 'dx_pcx1' DEPL COMP 1 NOEU LECT pcx1 TERM
COUR 2 'dx_pcx2' DEPL COMP 1 NOEU LECT pcx2 TERM
COUR 3 'dx_pcy1' DEPL COMP 2 NOEU LECT pcy1 TERM
COUR 4 'dx_pcy2' DEPL COMP 2 NOEU LECT pcy2 TERM
COUR 5 'dx_pcz1' DEPL COMP 3 NOEU LECT pcz1 TERM
COUR 6 'dx_pcz2' DEPL COMP 3 NOEU LECT pcz2 TERM
RCOU 101 'dx_pcx1' FICH 'test38.pun' RENA 'dx_pcx1_nof'
RCOU 102 'dx_pcx2' FICH 'test38.pun' RENA 'dx_pcx2_nof'
*
COUR 20 'pr_ex1'   ECRO COMP 1 ELEM LECT ex1 TERM
COUR 21 'pr_ex2'   ECRO COMP 1 ELEM LECT ex2 TERM
COUR 22 'pr_ey1'   ECRO COMP 1 ELEM LECT ey1 TERM
COUR 23 'pr_ey2'   ECRO COMP 1 ELEM LECT ey2 TERM
COUR 24 'pr_ez1'   ECRO COMP 1 ELEM LECT ez1 TERM
COUR 25 'pr_ez2'   ECRO COMP 1 ELEM LECT ez2 TERM
COUR 26 'pr_e9'    ECRO COMP 1 ELEM LECT e9  TERM
COUR 27 'pr_e15'   ECRO COMP 1 ELEM LECT e15 TERM
RCOU 120 'pr_ex1' FICH 'test38.pun' RENA 'pr_ex1_nof'
RCOU 126 'pr_e9'  FICH 'test38.pun' RENA 'pr_e9_nof'
*
TRAC 1 2 3 4 5 6 axes 1.0 'DISPL. [M]' yzer
TRAC 20 21 22 23 24 25 26 27 AXES 1.0 'PRESS [PA]'
LIST 1 2 3 4 5 6 axes 1.0 'DISPL. [M]' yzer
LIST 20 21 22 23 24 25 26 27 AXES 1.0 'PRESS [PA]'
TRAC 1 2 101 102 axes 1.0 'DISPL. [M]' yzer
     COLO noir noir roug roug
TRAC 20 26 120 126 AXES 1.0 'PRESS [PA]'
     COLO noir noir roug roug
*=================================================================
FIN
```

The structural displacements are (in red the case without failure, in black the case with failure):



The fluid pressures are (in red the case without failure, in black the case with failure):



The final pressure and velocity maps and the structural failure (for the case with failure) are: