Code_Aster

Titre : Opérateur DEFI_CONTACT
Responsable : Thomas DE SOZA

Version 11

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Operator DEFI_CONTACT

1 Drank

To affect conditions of unilateral contact and friction in mechanics or conditions unilateral on the degrees of freedom.

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2   Syntax

```
char_contact = DEFI_CONTACT
(
♦MODELE=mo                        ,
[model]
◊INFO=/1                   ,
[DEFAULT]
                    /2,


♦FORMULATION=/              "DISCRETE"
[DEFAULT]
                    /"CONTINUE"
                    /"XFEM"
                    /"LIAISON_UNIL"
```

\# For the formulations of contact-friction
```
{If FORMULATION  ! = ' LIAISON_UNIL"
    ◊FROTTEMENT=/       "SANS",                          [DEFAULT]
                    /"COULOMB",
```

\# general Parameters for the contact with a grid
```
{If     FORMULATION==' DISCRETE' or      FORMULATION==' CONTINUE'}
    ◊STOP_INTERP=/             "NON",                    [DEFAULT]
                    /"OUI'
    ◊LISSAGE=/                 "NON",                    [DEFAULT]
                    /"OUI',
    ◊VERI_NORM=/               "OUI',                    [DEFAULT]
                    /"NON",
}
```

\# Controls geometrical non-linearity
```
{If FORMULATION == "CONTINUE"
    ◊ALGORITHME_RESO_GEOM=/         "POINT_FIXE",
[DEFAULT]
                    /"NEWTON",
}
{If FORMULATION == "DISCRETE" or (FORMULATION == "CONTINUE" and ALGO_RESO_GEOM
==' POINT_FIXE')
    ◊REAC_GEOM=/               "AUTOMATIQUE",
[DEFAULT]
                    /"CONTROLE",
                    /"SANS"
    {If REAC_GEOM ==' AUTOMATIQUE'
        ◊ITER_GEOM_MAXI=/10         ,                   [DEFAULT]
                    /iter_geom_maxi,                     [I]
        ◊RESI_GEOM=/0.01           ,
[DEFAULT]
                    /resi_geom,                          [R]
    }
    {If REAC_GEOM    ==' CONTRÔLE'
        ◊NB_ITER_GEOM=/2           ,
[DEFAULT]
                    /nb_iter_geom,                       [I]
    }
}
    { If (FORMULATION == "CONTINUE" and ALGO_RESO_GEOM == "NEWTON")
```

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```
        ◊RESI_GEOM=/0.000001                    ,
[DEFAULT]
                                    /resi_geom,                   [R]
    }
    {If FORMULATION == "XFEM"
        ◊REAC_GEOM=/                "SANS",
[DEFAULT]
                                    /"AUTOMATIQUE",
                                    /"CONTROLE",
        {If REAC_GEOM  ==' AUTOMATIQUE'
            ◊ITER_GEOM_MAXI=/10           ,                       [DEFAULT]
                                    /iter_geom_maxi,              [I]
            ◊RESI_GEOM=/0.0001                  ,
[DEFAULT]
                                    /resi_geom,                   [R]
        }
        {If     REAC_GEOM==' CONTRÔLE'
            ◊NB_ITER_GEOM=/2             ,
[DEFAULT]
                                    /nb_iter_geom,                [I]
        }
    }


    # Controls non-linearity of contact
    {If FORMULATION == "DISCRETE"
        ◊ITER_CONT_MULT=/4           ,
[DEFAULT]
                                    /iter_cont_mult,              [I]
    }
    {If FORMULATION == "CONTINUE" or FORMULATION == "XFEM"
        {If FORMULATION == "CONTINUE"
            ◊ALGORITHME_RESO_CONT=/          "NEWTON",
[DEFAULT]
                                        /"POINT_FIXE",
        }
        {If (FORMULATION == "CONTINUE" and ALGO_RESO_CONT == "POINT_FIXE") or
FORMULATION == "XFEM"
            ◊ITER_CONT_TYPE=/            "MAXI",
[DEFAULT]
                                        /"MULT"

            {If    ITER_CONT_TYPE==' MULT'
                ◊ITER_CONT_MULT=/4           ,
[DEFAULT]
                                        /iter_cont_mult,          [I]
            }
            {If    ITER_CONT_TYPE==' MAXI'
                ◊ITER_CONT_MAXI=/30           ,                   [DEFAULT]
                                        /iter_cont_maxi,          [I]
            }
        }
    }


    # Controls non-linearity of threshold of friction
    { If FROTTEMENT    ==' COULOMB'
        {If      FORMULATION==' CONTINUE'
            ◊ALGORITHME_RESO_FROT=/          "NEWTON",
[DEFAULT]
                                        /"POINT_FIXE",
```

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```
         }
      {If (FORMULATION == "CONTINUE" and ALGO_RESO_FROT == "POINT_FIXE") or
FORMULATION == "XFEM"
            ◊ITER_FROT_MAXI=/10            ,                              [DEFAULT]
                                    /iter_frot_maxi,                      [I]
            ◊RESI_FROT=/0.0001              ,
[DEFAULT]
                                    /resi_frot,                          [R]
         }
      {If (FORMULATION == "CONTINUE" and    ALGO_RESO_FROT=='NEWTON')
            ◊RESI_FROT=/0.0001              ,
[DEFAULT]
                                    /resi_frot,                          [R]
         }


      # general Parameters of the discrete formulations
      {If      FORMULATION==' DISCRETE'
         # dualized Methods (FORCED, LAGRANGIAN)
         ◊STOP_SINGULIER=/          "OUI',                               [DEFAULT]
                              /"NON"
         ◊NB_RESOL=/10               ,                                   [DEFAULT]
                              /nb_resol                                  [I]


         # Method "GCP"
         ◊RESI_ABSO=/resi_abso                                          [R]
         ◊ITER_GCP_MAXI=/0            ,
[DEFAULT]
                                    /iter_gcp_maxi
         ◊RECHERCHE_LINEAIRE=/            "ADMISSIBLE",
[DEFAULT]
                                    /"NON_ADMISSIBLE"
         ◊PRE_COND=/          "SANS",
[DEFAULT]
                                    /"DIRICHLET"
         {If PRE_COND == "DIRICHLET"
            ◊ITER_PRE_MAXI=/0             ,
[DEFAULT]
                                    /iter_pre_maxi
            ◊COEF_RESI=/-1                .,
[DEFAULT]
                                    /coef_resi                          [R]
         }
      }

      # Assignment of the DISCRETE case
      {If      FORMULATION==' DISCRETE'
         ZONE = _F (
            ♦/MAILLE_MAIT=l_maille_mait
[l_maille]
               /GROUP_MA_MAIT    =grma_mait
[gr_maille]
            ♦/MAILLE_ESCL=l_maille_escl
[l_maille]
               /GROUP_MA_ESCL    =grma_escl
[gr_maille]

            ◊SANS_NOEUD=l_snoeud
[l_noeud]
```

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```
            ◊SANS_GROUP_NO=l_sgrno
    [l_gr_noeud]
            ◊SANS_MAILLE=l_smaille
    [l_maille]
            ◊SANS_GROUP_MA=l_sgrma
    [l_gr_maille]


       ◊APPARIEMENT=/              "MAIT_ESCL"
[DEFAULT]
                          /"NODAL"


       ◊NORMALE=/                  "MAIT"                    [DEFAULT]
                          /"MAIT_ESCL"
                          /"ESCL"


       ◊VECT_MAIT=/               "AUTO"                    [DEFAULT]
                          /"FIXES"
                          /"VECT_Y"
    {If VECT_MAIT == "FIXES"
       ◆MAIT_FIXE=             (Yx, Yy, Yz)                 [R]
    }
    {If VECT_MAIT == "VECT_Y"
       ◆MAIT_VECT_Y=         (Yx, Yy, Yz)                   [R]
    }


       ◊VECT_ESCL    =  "AUTO"                              [DEFAULT]
                          /"FIXES"
                          /"VECT_Y"
    {If "   FIXED" VECT_ESCL==
       ◆ESCL_FIXE=            (Yx, Yy, Yz)                  [R]
    }
    {If VECT_ESCL== "VECT_Y"
       ◆ESCL_VECT_Y=        (Yx, Yy, Yz)                    [R]
    }


       ◊TYPE_APPA=/              "CLOSE"
[DEFAULT]
                          /"FIXES"
    { If "   FIXED" TYPE_APPA==
       ◆DIRE_APPA=            (Yx, Yy, Yz)                  [R]
    }


       ◊DIST_POUTRE=/           "NON"
[DEFAULT]
                          /"OUI'
       ◊DIST_COQUE=/         "NON"                          [DEFAULT]
                          /"OUI'
    {If DIST_POUTRE    ==' OUI' or DIST_COQUE    ==' OUI'
       ◆CARA_ELEM=carac
[cara_elem]
    }


       ◊DIST_MAIT=dist_mait
[function]
       ◊DIST_ESCL=dist_escl
[function]


       ◊TOLE_APPA=/-1.0
[DEFAULT]
                                /tole_appa                  [R]
```

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◊**TOLE_PROJ_EXT=/**0.50   [DEFAULT]

                                  /tole_proj_ext   [R]

Deactivation of resolution
◊**RESOLUTION=/**   "OUI'   [DEFAULT]
                          /"NON"
{If RESOLUTION == "NON"
    ◊**TOLE_INTERP=/**0   .,   [DEFAULT]
                                  /tole_interp   [R]
}

♦ALGORITHME_CONT=/   "FORCED"   [DEFAULT]

                                  /"LAGRANGIAN"
                                  /"GCP"
                                  /"PENALIZATION"

{If ALGO_CONT ==' CONTRAINTE'
    ◊**GLISSIERE=/**   "NON"   [DEFAULT]

                                  /"OUI'
    {If SLIDE ==' OUI'
        ◊**ALARME_JEU=/**0   [DEFAULT]

                                  /alarme_jeu   [R]
    }
}

{If ALGO_CONT ==' PENALIZATION'
    ♦E_N=e_n   [R]
}

{If FROTTEMENT   ==' COULOMB'
    ♦COULOMB=coulomb   [R]
    ◊**COEF_MATR_FROT=/**0   .   [R]
                                  /coef_matr_frot
    ♦ALGORITHME_FROT=/   "PENALIZATION"   [DEFAULT]

                                  /"LAGRANGIAN"
    {If ALGO_FROT   ==' PENALIZATION'
        ♦E_T=e_t   [R]
    }
}
}

Assignment of case CONTINU
{If   FORMULATION==' CONTINUE'
    ZONE = _F (
        ♦/MAILLE_MAIT=l_maille_mait   [l_maille]
        /GROUP_MA_MAIT   =grma_mait   [gr_maille]
        ♦/MAILLE_ESCL=l_maille_escl   [l_maille]
        /GROUP_MA_ESCL   =grma_escl   [gr_maille]

        ◊**SANS_NOEUD=l_snoeud**   [l_noeud]

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```
          ◊SANS_GROUP_NO=l_sgrno
    [l_gr_noeud]
          ◊SANS_MAILLE=l_smaille
    [l_maille]
          ◊SANS_GROUP_MA=l_sgrma
    [l_gr_maille]


          ◊APPARIEMENT=/              "MAIT_ESCL"
[DEFAULT]


          ◊NORMALE=/                   "MAIT"                      [DEFAULT]
                                      /"MAIT_ESCL"
                                      /"ESCL"


          ◊VECT_MAIT=/                 "AUTO"                      [DEFAULT]
                                      /"FIXES"
                                      /"VECT_Y"
          {If VECT_MAIT == "FIXES"
             ♦MAIT_FIXE=              (Yx, Yy, Yz)                    [R]
          }
          {If VECT_MAIT == "VECT_Y"
             ♦MAIT_VECT_Y=           (Yx, Yy, Yz)                    [R]
          }

          ◊VECT_ESCL   =  "AUTO"                                   [DEFAULT]
                               /"FIXES"
                               /"VECT_Y"
          {If "   FIXED" VECT_ESCL==
             ♦ESCL_FIXE=              (Yx, Yy, Yz)                    [R]
          }
          {If VECT_ESCL== "VECT_Y"
             ♦ESCL_VECT_Y=           (Yx, Yy, Yz)                    [R]
          }

          ◊TYPE_APPA=/              "CLOSE"
[DEFAULT]
                                      /"FIXES"
          {If "   FIXED" TYPE_APPA==
             ♦DIRE_APPA=              (Yx, Yy, Yz)                    [R]
          }


          ◊DIST_POUTRE=/               "NON"
[DEFAULT]
                                      /"YES"
          ◊DIST_COQUE=/            "NON"                           [DEFAULT]
                                      /"OUI'
          {If DIST_POUTRE    ==' OUI' or DIST_COQUE    ==' OUI'
             ♦CARA_ELEM=carac
[cara_elem]
          }


          ◊DIST_MAIT=dist_mait
[function]
          ◊DIST_ESCL=dist_escl
[function]


          ◊TOLE_APPA=/-1.0
[DEFAULT]
                                      /tole_appa                      [R]
```

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◊**TOLE_PROJ_EXT=/0.50**
[DEFAULT]

　　　　　　　　　　　　　　　　　/tole_proj_ext　　　　　　　[R]

　　　# Deactivation of the resolution
◊**RESOLUTION**　　　　=　　"OUI'　　　　　　　[DEFAULT]
　　　　　　　　　　　　　　/"NON"
　　{If RESOLUTION　==' NON'
　　　　◊**TOLE_INTERP=/0**　　　　　　　.,　　　　　[DEFAULT]
　　　　　　　　　　　　　　　/tole_interp　　　　　[R]
　　}

　　◊**GLISSIERE=/**　　　　　　　"NON"
[DEFAULT]

　　　　　　　　　　　　/"OUI'
　　◊**CONTACT_INIT=/**　　　　"INTERPENETRATES"
[DEFAULT]

　　　　　　　　　　　　/"OUI'
　　　　　　　　　　　　/"NON"

　　◊**INTEGRATION=/**　　　　　"AUTO"　　　　　　[DEFAULT]
　　　　　　　　　　　/"GAUSS"
　　　　　　　　　　　/"SIMPSON"
　　　　　　　　　　　/"NCOTES"

　　{If INTEGRATION　==' GAUSS'
　　　◊**ORDRE_INT=/3**
[DEFAULT]

　　　　　　　　　　　/1 ≤ordre_int≤6　　　　　　　[I]
　　}
　　{If INTEGRATION　==' SIMPSON'
　　　◊**ORDRE_INT=/1**
[DEFAULT]

　　　　　　　　　　　/1 ≤ordre_int≤4　　　　　　　[I]
　　}
　　{If INTEGRATION　==' NCOTES'
　　　◊**ORDRE_INT=/3**
[DEFAULT]

　　　　　　　　　　　/3 ≤ordre_int≤8　　　　　　　[I]
　　}
　　◊**ALGORITHME_CONT=/**　　　　　"STANDARD"
[DEFAULT]

　　　　　　　　　　　/"PENALIZATION"

　　{If ALGO_CONT ==' STANDARD'
　　　◊**COEF_CONT=/100**　　　　　.　　　　　　[DEFAULT]
　　　　　　　　　　　/coef_cont　　　　　[R]
　　}
　　{If ALGO_CONT ==' PENALIZATION'
　　　♦COEF_PENA_CONT=coef_pena_cont　　　　　　[R]
　　}

　　{If FROTTEMENT == "COULOMB"
　　　♦COULOMB=coulomb　　　　　　　　　[R]
　　　◊/SANS_NOEUD_FR=l_sfnoeud
[l_noeud]

　　　　　/SANS_GROUP_NO_FR　=l_sgrno　　　　[l_gr_noeud]
　　　{If SANS_NOEUD_FR! =None **or** SANS_GROUP_NO_FR! =None
　　　　◊**DIRE_EXCL_FROT=**　　　　(Yx, Yy, Yz)　　　[R]

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```
                             }

                    ◊SEUIL_INIT=/0                    .                          [DEFAULT]
                                            /seuil_init                [R]

                    ◊ALGORITHME_FROT=/                   "STANDARD"
[DEFAULT]
                                            /"PENALIZATION"

                    {If ALGO_FROT "STANDARD" ==
                         ◊COEF_FROT=/100              .                          [DEFAULT]
                                            /coef_frot                [R]
                    }
                    {If ALGO_FROT ==' PENALIZATION'
                        ♦COEF_PENA_FROT=/coef_pena_frot                        [R]
                    }
                }
            }

        # Assignment of case XFEM
        {If FORMULATION==' XFEM'
            ZONE = _F (
                ♦FISS_MAIT=fiss_mait
[fiss_xfem]
                ◊   INTEGRATION=/       "NOEUD"
                                       /"GAUSS"                          [DEFAULT]
                                       /"SIMPSON"
                                       /"NCOTES"
                {If INTEGRATION   ==' GAUSS'
                    ◊ORDRE_INT=/6
[DEFAULT]
                                       /1 ≤ordre_int≤6                   [I]
                }
                {If INTEGRATION   ==' SIMPSON'
                    ◊ORDRE_INT=/1
[DEFAULT]
                                       /1 ≤ordre_int≤4                   [I]
                }
                {If INTEGRATION   ==' NCOTES'
                    ◊ORDRE_INT=/3
[DEFAULT]
                                       /3 ≤ordre_int≤8                   [I]
                }
                ◊CONTACT_INIT=/           "NON"
[DEFAULT]
                                       /"OUI'
                ◊ALGORITHME_LAGR=/            "VERSION1"
[DEFAULT]
                                       /"VERSION2"
                ◊TOLE_PROJ_EXT=/0.50
[DEFAULT]
                                       /tole_proj_ext                [R]
                ◊ALGORITHME_CONT=/            "STANDARD"
[DEFAULT]
                                       /"PENALIZATION"
                                       /"CZM"

                {If ALGO_CONT ==' STANDARD'
                    ◊COEF_CONT=/100              .                          [DEFAULT]
                                       /coef_cont                [R]
```

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```
                }
                {If ALGO_CONT ==' PENALIZATION'
                   ♦COEF_PENA_CONT=/coef_pena_cont                            [R]
                }
                { If ALGO_CONT ==' CZM'
                   ♦RELATION=/              "CZM_EXP_REG"            [DEFAULT]
                                        /"CZM_LIN_REG"
                                        /"CZM_OUV_MIX"
                                        /"CZM_TAC_MIX"
                }

                ◊GLISSIERE=/              "NON"
[DEFAULT]
                                    /"OUI'

                {If == "COULOMB"
                   ♦COULOMB=coulomb                                      [R]
                   ◊SEUIL_INIT=/0          .                        [DEFAULT]
                                    /seuil_init                        [R]
                   ◊ALGORITHME_FROT=/           "STANDARD"
[DEFAULT]
                                    /"PENALIZATION"

                   {If ALGO_FROT ==' STANDARD'
                      ◊COEF_FROT=/100          .                      [DEFAULT]
                                        /coef_frot                    [R]
                   }
                   {If ALGO_FROT == "PENALIZATION"
                      ♦COEF_PENA_FROT=/coef_pena_frot                      [R]
                   }
                }
            }
        }

    # Assignment of case LIAISON_UNIL
    {If      FORMULATION==' LIAISON_UNIL'
       ZONE=_F (
            ♦/NOEUD=l_noeud
[l_noeud]
            /GROUP_NO          =l_grno
[l_gr_noeud]
            /MAILLE           =l_maille                          [l_maille]
            /GROUP_MA          =l_grma
[l_gr_maille]
            ♦ NOM_CMP=l_cmp                                   [l_TXM]
            ♦ COEF_IMPO=l_c_impo
[function]
            ♦ COEF_MULT=l_c_mult
[l_fonction]
            ◊ SANS_NOEUD=l_snoeud
[l_noeud]
            ◊ SANS_GROUP_NO=l_sgrno                          [l_gr_noeud]
        )
    }
);
```

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3   Principles

This command makes it possible to describe the zones subjected to conditions of unilateral contact with or without friction. Description is done on two levels:

- Total parameters like the choice of the formulation or the parameters of control of the nonlinear algorithm of resolution (loops of fixed point or Newton, parameters specific for the solver);
- Local parameters specific to each contact zone.

The concept resulting from DEFI_CONTACT is then indicated like parameter in keyword simple CONTACT of operators STAT_NON_LINE [U4.51.03] and DYNA_NON_LINE [U4.53.01]. Each zone understands two surfaces being able to make contact which are described by the data of the mesh groups which constitute them.

The sets of meshes potentially in contact are meshes of skin: surface and linear in dimension 3 (QUAD9, QUAD8, QUAD4, TRIA7, TRIA6, TRIA3, SEG3, SEG2), linear and specific in dimension 2 (SEG3, SEG2 and POI1). Meshes of type POI1 must obligatorily be on surface slave. They are not usable with the formulation CONTINUE.

Caution:

 –*For formulation* DISCRETE, *in dimension 3, the processing of the contact with meshes of the edge quadratic ones of type* QUAD8 *requires to bind the nodes mediums to the nodes tops in order to have correct results. This operation is made automatically in the code. Nevertheless, for computations 3D continuums the use of elements* HEXA27 *or* PENTA18 *(with sides* QUAD9*)* **is strongly advised***.*

 –*For the formulation* CONTINUE, *in dimension 3, the use of meshes of edge quadratic of type* QUAD8 *or curved* TRIA6 *(i.e. whose nodes mediums are not aligned with the nodes tops) can involve violations of the model of contact. More precisely the contact is then solved on average on each element. In the presence of contact one can thus observe clearances at the same time slightly positive and negative what can disturb the results close to the contact zone or computations of recovery with initial state. For this reason it* **is advised** *to use elements* HEXA27 *(with sides* QUAD9*) or many linear elements.*

 –*One can transform into* HEXA27 *or* PENTA18 *a mesh made up of meshes* HEXA20 *or* PENTA15 *using operator* CREA_MAILLAGE *[U4.23.02].*

The studied structures can undergo great slidings one compared to the other. There exist four great types of formulations:

1) The discrete formulations (see [R5.03.50]) which correspond to the resolution of the discretized unilateral problem (unknown of displacements and nodal forces). This formulation is accessible *via* FORMULATION=' DISCRETE'. It is usable with or without friction of Coulomb.
2) The formulation continues (see [R5.03.52]) which is a method of Lagrangian increased written using the mixed variational writing "multiplying displacements/contact pressure/of friction". This formulation is accessible *via* FORMULATION=' CONTINUE'. It is usable with or without friction of Coulomb.
3) Formulations on the elements XFEM (see [R7.02.12] for the version small slidings and [R5.03.53] for the version great slidings) which are a variation of the continuous formulation to the case of elements XFEM. These formulations are accessible *via* FORMULATION=' XFEM'. They are usable with or without friction of Coulomb.
4) The formulation of type unilateral connection (FORMULATION=' LIAISON_UNIL'). Near to the discrete formulations, it to impose leans on an algorithm used in contact of the boundary conditions of type inequality on any degree of freedom. This formulation is treated separately in the last part of this document (*cf* §3.63.6).

Before doing a calculation with contact, it is **essential** to have read the note of use of the contact [U2.04.04] which clarifies for examples the role of the majority of the key words described below and described methodologies for various types of studies with taking into account of the contact.

All the methods of resolution of contact-friction known as formulations "with a grid" (discrete formulations [R5.03.50] or formulation continues [R5.03.52]) rest on a strategy in two times:

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- an operation of pairing which consists in finding which meshes and which nodes are potentially in situation of contact;
- an operation of resolution itself which consists in solving the problem of unilateral contact with or without friction.

Paragraphs 3.1 and 3.2 concentrate on the phase of pairing while paragraphs 3.3 and 3.4 treat methods of resolution of the problem.
Finally paragraph 3.5 described data structure of postprocessing produced by a computation of contact.
Formulation "LIAISON_UNIL" is approached in paragraph 3.6.

3.1 Control pairing (methods with a grid except XFEM)

♦ZONE=   _F (*options of pairing*)

the keywords of this paragraph are valid for the formulations with a grid (DISCRETE and CONTINUE).

3.1.1 Operand APPARIEMENT

◊**APPARIEMENT=/**   "MAIT_ESCL"   [DEFAULT]
                      /"NODAL"

In the case as of discrete formulations pairing can be node-facet ("MAIT_ESCL") or nodal ("NODAL"). For nodal pairing one writes a relation of nonpenetration between a master node and a slave node, whereas for pairing node-facet one writes this relation between a slave node and his projection on the master mesh nearest (see [R5.03.50] for details on the algorithm of pairing).

Nodal pairing is reserved for the compatible meshes and is available only in formulation DISCRETE. Master-slave pairing is the only method to make it possible to take into account the great slidings in a precise way.

3.1.2 Operands MAILLE_MAIT/GROUP_MA_MAIT/MAILLE_ESCL/GROUP_MA_ESCL

♦   /GROUP_MA_MAIT   =l_grma_mait   [l_gr_maille]
    /MAILLE_MAIT   =l_maille_mait   [l_maille]
♦   /GROUP_MA_ESCL   =l_grma_escl   [l_gr_maille]
    /MAILLE_ESCL   =l_maille_escl   [l_maille]

For the formulations with a grid the user meshes provides the list of contact potential of surface Master (GROUP_MA_MAIT or MAILLE_MAIT) and of surface slave (GROUP_MA_ESCL or MAILLE_ESCL). These meshes must be surface or linear in dimension 3 (QUAD9, QUAD8, QUAD4, TRIA7, TRIA6, TRIA3, SEG3, SEG2), linear or specific in dimension 2 (SEG3, SEG2 and POI1).

Caution:

–*It is important to check that the connectivity of these meshes is such as **the norm with structure is outgoing** (for this making, use MODI_MAILLAGE key word ORIE_PEAU_2D, ORIE_PEAU_3D, ORIE_NORM_COQUE [U4.23.04]).*
–*The intersection between surface slave and Master of the same zone must be disjoined or the common nodes must be excluded (cf 3.1.3).*
–*Surfaces slaves must be imperatively two to two disjoined in continuous formulation.*

Subsequently, the master-slave concept will be used: the nodes of surface slave cannot "penetrate" in the facets (or the nodes) of surface Master. In the case of the pairing of the type "MAIT_ESCL", surface Master is that defined by "GROUP_MA_MAIT" or "MAILLE_MAIT". In the case of the pairing of the " NODAL" type (available only for the discrete formulations), surface Master is that which must comprise the most nodes. If it is not the case the user is stopped by an error message and guest to invert two surfaces.

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Note:

> • *It is impossible to mix the purely two-dimensional modelizations (plane stresses C_PLAN, plane strains D_PLAN and axisymmetric AXIS) with the three-dimensional modelizations. Surfaces Master and slave must be of comparable nature (2D/2D or 3D/3D). An error message stops the user in the contrary case. Let us note that a beam, a plate or a shell are of dimension 3 and that it is thus possible to make poutre/3D of the contact or beam/plate.*

3.1.3 Operands SANS_NOEUD/SANS_GROUP_NO/SANS_MAILLE/SANS_GROUP_MA

◊**SANS_GROUP_NO=l_sgrno**   [l_gr_noeud]
◊**SANS_NOEUD=l_snoeud**   [l_noeud]
◊**SANS_GROUP_MA=l_sgrma**
[l_gr_maille]
◊**SANS_MAILLE=l_smaille**   [l_maille]

These operands make it possible to exclude from the nodes of surfaces slaves, operation which is recommended when the latter are subjected to boundary conditions in the direction expected of the contact (fixed support for example).

3.1.4 " CLOSE

"   operands TYPE_APPA/DIRE_APPA ◊TYPE_APPA=/
     [DEFAULT]
                    /"FIXES"
◊**DIRE_APPA=**   (Yx, Yy, Yz)   [R]

the choice of the mesh main paired with a slave node is done by an operation of minimization of the distance between this node and the meshes main. With the option by default, TYPE_APPA=' PROCHE', the algorithm used for this orthogonal projection are a classical algorithm of Newton.
In very rare cases this algorithm can fail, for example if projection on a mesh is not single, which can arrive if the master mesh is convex. In this case, the user can inform a fixed direction of pairing to use in the algorithm *via* option TYPE_APPA=' FIXE', the direction being then given by a vector in DIRE_APPA.

3.1.5 Operands TOLE_APPA and TOLE_PROJ_EXT

◊**TOLE_APPA=/-1.0**   [DEFAULT]
                    /tole_appa   [R]
◊**TOLE_PROJ_EXT=/0.50**
[DEFAULT]
                    /tole_proj_ext   [R]

During the pairing of the current slave node, it is possible to restrict the field of search among the meshes main ones with the use of keyword TOLE_APPA. If TOLE_APPA=-1 (value by default), then all meshes main the data in the contact zone are likely to be paired with the slave node. If TOLE_APPA=val with val a positive reality, then only the meshes main ones located, in 3D in the sphere, 2D in the circle of radius val centered (E) on the slave node can be paired.

In certain situations, it can be necessary to extend in a fictitious way meshes of surface Master. Of the contact let us take the case in 2D on 3.1.5-1 (contact surfaces are thus segments), one places itself on edge of contact surface. The projection of a slave node falls apart from surface Master.
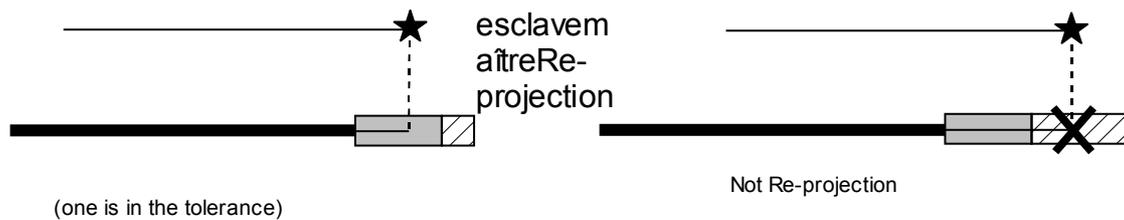
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maîtreescl
aveFigure

**3.1.5-1: Projection of a slave node apart from a
master mesh**
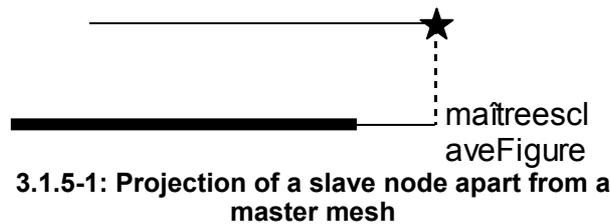
a solution then consists in not pairing the node, which comes down excluding it of the contact:

esclavem
aîtreFigur
e

3.1.5-2: Exclusion of a slave node

However, this solution does not take account of the borderline cases and can cause inopportune
interpenetrations if ever the mesh is not "optimal" (i.e. not fine enough, which is difficult to ensure in the
frame as of great transformations). *A contrario*, one cannot obviously fold back all the nodes projecting
itself apart from surface Master.
One thus chose an intermediate solution by limiting the extension of surface Master likely to involve a
folding back.

esclavem
aîtreRe-
projection

Not Re-projection

(one is in the tolerance)

Figure 3.1.5-3: Operation of `TOLE_PROJ_EXT`

the size of the zone of folding back is fixed by the keyword "`TOLE_PROJ_EXT`" which takes for
argument the value, reported to the element of reference, of the extension of the mesh main. By
default, this value is fixed at 0,50. For example in 2D, that means that any slave node being projected
with more than 25% on the right or on the left length of the mesh main will not be folded back (in the
case of a segment, the element of reference is length 2, cf [R3.01.01]). To prohibit the folding back
completely, it is enough to fix `negative` TOLE_PROJ_EXT. This operator is valid in 2D and 3D (in
this last case, it is the extension of a surface mesh of contact).

Note:

> *It is dangerous to disable the folding back completely. Except edges of contact surfaces, there
> exist indeed situations where points are not projected inside any master mesh (it is the case for
> any surface convex Master). If all the nodes of contact had suddenly been excluded, an alarm is
> emitted. It is then advisable to check that this situation is well that expected by the user.*

3.1.6 Standard choice of

3.1.6.1 the norms of norm (`NORMAL`)

◊**NORMALE=/**   "MAIT"   [DEFAULT]
                              /"MAIT_ESCL"
                              /"ESCL"

It is possible to choose the type of the norm used to write the conditions of NON-interpenetration:

• the norm external with master mesh (NORMALE=' MAIT', by default);
• the interior norm with the mesh slave (NORMALE=' ESCL');
• an average enters the norms Master and slave (NORMALE=' MAIT_ESCL').

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3.1.6.2 Determination of the norms Master or slave (`VECT_MAIT`/`VECT_ESCL`)

```
◊VECT_MAIT=/              "AUTO"                          [DEFAULT]
                         /"FIXES"
                         /"VECT_Y"
♦MAIT_FIXE=               (Yx, Yy, Yz)                        [R]
♦MAIT_VECT_Y=            (Yx, Yy, Yz)                         [R]

◊VECT_ESCL=/              "AUTO"                          [DEFAULT]
                         /"FIXES"
                         /"VECT_Y"
♦ESCL_FIXE        =      (Yx, Yy, Yz)                         [R]
♦ESCL   _VECT_Y=         (Yx, Yy, Yz)                         [R]
```

the determination of the norm (on the slave mesh or on the master mesh) can be made several ways:

- automatically, the norm is then calculated by the use of the shape functions of the element, it is option "AUTO" ;
- fixed and data directly by the user, it is the " FIXED" option. One enters then the norm with keyword MAIT_FIXE or ESCL_FIXE ;
- variable and data indirectly by the tangent, it is option VECT_Y. The user then gives the direction of **the second tangent vector** by keyword MAIT_VECT_Y or ESCL_VECT_Y. The code then reconstitutes the norm starting from the cross product of the first tangent of the mesh and the vector provided by the user.

A fixed direction (option VECT_*=' FIXE') is necessary if one must evaluate the norm on a mesh of the type POI1.

A variable direction given by second tangent (VECT_MAIT=' VECT_Y') is particularly used in the case as of beams which become deformed only in one plane. In this case, the use of the option of the type VECT_Y makes it possible to reactualize the norm continuously while the beam becomes deformed:

$$\vec{N} = \vec{T} \wedge VECT\_Y$$
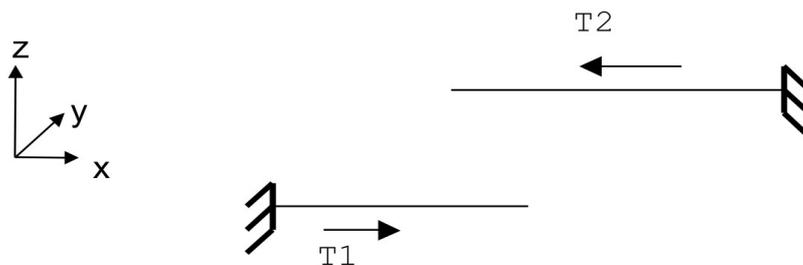
Appear 3.1.6.2-1: Determination of the norm by `VECT_Y`

In the example above, T1= (1,0,0) and T2= (- 1,0,0), with VECT_Y = (0,1,0), one obtains the norm desired for each beam: N1= (0,0,1) and N2= (0,0, - 1).
The directional sense of each beam (i.e. the vectors T1 and T2) is given using key word ORIE_LIGNE of operator MODI_MAILLAGE [U4.23.04].

3.1.6.3 Lissage of norms (`LISSAGE`)

```
◊LISSAGE=/               "NON",                          [DEFAULT]
                        /"OUI',
```

operand LISSAGE makes it possible to smooth the norms at contact surfaces intervening in the computation of the contact matrix. One will note Q an unspecified node of contact surfaces (Master or slave), P a node of surface slave and M the master node obtained by projection of the node P .

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The lissage is done in two stages:

- the first stage of the lissage consists in carrying out an average with the node Q of the norms to meshes which contain Q ;
- the second stage consists in interpolating the norm in P or M starting from the norms in Q and of the shape functions associated with the mesh containing P or M.

The lissage takes into account the options of norms decided by key words VECT_MAIT and VECT_ESCL. Attention, this parameter is total and not zone.

3.1.7 Modification of clearance

clearance is always calculated as being the minimal distance between the slave node and projection on the master mesh nearest, modulo the options of choice of this norm (*cf* 3.1.6). It is however possible to define values of clearance "into tough", for example, to simulate the presence of a hole or a bump not represented by the mesh, or to take into account the geometrical characteristics of the structural elements which use the notion of fiber neutral or mean surface.

3.1.7.1 Operands DIST_MAIT/DIST_ESCL

◊**DIST_MAIT=dist_mait**
[function]
◊**DIST_ESCL=dist_escl**
[function]

These operands make it possible to take into account a fictitious clearance nonwith a grid or the thickness of the shells for example (by defaults the relations of contact are written between the parts with a grid i.e. between the two average averages).
This clearance is taken into account on surfaces Masters (DIST_MAIT) or slaves (DIST_ESCL). One positively counts the distance in the meaning of the outgoing norm to the structure (cf [R5.03.50]). A negative value thus makes it possible "to dig virtually" a surface (Master like slave). Contrary, a positive value makes it possible "to enlarge" a surface.
The well informed quantities are necessarily functions of the variables of space. If the user wishes a fixed value, it must define a constant function (see DEFI_CONSTANTE [U4.31.01]).

3.1.7.2 Operands DIST_POUTRE/DIST_COQUE/CARA_ELEM

◊**DIST_POUTRE=/**   "NON"   [DEFAULT]
                        /"OUI'
◊**DIST_COQUE=/**   "NON"   [DEFAULT]
                        /"OUI'
♦CARA_ELEM=carac   [cara_elem]

Similar to the two preceding key words, keywords DIST_POUTRE/DIST_COQUE make it possible to introduce a fictitious clearance which rests on the description of the structural elements in the product concept by AFFE_CARA_ELEM that the user obligatorily informed:

- for the beam elements (modelization POU_*), keyword DIST_POUTRE stipulates that the code must take account of an additional clearance corresponding to the radius of the circular **section** of the beam.
- for the shell elements or of shell (modelization DKT or COQUE_3D for example), keyword DIST_COQUE stipulates that the code must take account of an additional clearance corresponding to the half-thickness around the average average of a shell.

Attention, when these keywords are used, fictitious clearance is added only on surface slave. If one models a contact between two structural elements, DIST_MAIT will thus have also to be used.

3.2 CONTINUE control pairing specific to the formulation

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3.2.1 Operands SANS_NOEUD_FR/SANS_GROUP_NO_FR

◊/**SANS_NOEUD_FR**=l_sfnoeud   [l_noeud]
     /SANS_GROUP_NO_FR   =l_sgrno   [l_gr_noeud]

◊**DIRE_EXCL_FROT**=   (Yx, Yy, Yz)   [R]

These keywords make it possible to the user to potentially exclude from the processing of the friction of the nodes slaves carrying of the boundary conditions in conflict with the imposition of the conditions of dependancy and sliding. The excluded nodes continue however to check the conditions of contact.
In 2D, no other key word is necessary: the nodes are excluded from friction.
In 3D, if the user informed a vector with 3 components under key word DIRE_EXCL_FROT then the direction indicated by the projection of this vector on the tangent level to the points of contact is excluded. The dependancy or the sliding will not thus occur more but in the perpendicular direction (in the tangent plane).

If the user does not inform key word DIRE_EXCL_FROT in 3D, then that amounts excluding the 2 orthogonal directions from friction and thus more not solving friction on the eliminated nodes.

3.3 Choice and control of the total algorithm of resolution

3.3.1 Control of geometrical non-linearity

Whatever the formulation employed, it is necessary to treat the geometrical non-linearity of the problem of contact-friction. It is possible either to neglect it (REAC_GEOM=' SANS'), or to solve it in an approximate way (REAC_GEOM=' CONTRÔLE') or exactly (REAC_GEOM=' AUTOMATIQUE').
To solve this non-linearity, one employs an algorithm of the type in general "not fixes" (ALGORITHME_RESO_GEOM=' POINT_FIXE'). The formulation CONTINUE is also able to treat geometrical non-linearity with the center even of the algorithm of Newton (ALGORITHME_RESO_GEOM=' NEWTON', to see §3.3.4.4).
In formulation XFEM, the choice to activate the geometrical reactualization or not switches towards two distinct formulations (see [R5.03.53]): X-FEM small slidings or sliding X-FEMs large.

When geometrical non-linearity is solved by a loop of "fixed point", a certain number of adjustments are possible:

◊**REAC_GEOM**=/   "AUTOMATIQUE",   [DEFAULT]
                 /"CONTROLE",
                 /"SANS"
◊**ITER_GEOM_MAXI**=/10   ,   [DEFAULT]
                 /iter_geom_maxi,   [I]
◊**RESI_GEOM**=/0.01   ,   [DEFAULT]
                 /0.0001,   [DEFAULT]
(XFEM)
                 /resi_geom,   [R]
◊**NB_ITER_GEOM**=/2   ,   [DEFAULT]
                 /nb_iter_geom,   [I]

operand REAC_GEOM indicates on which geometrical configuration with the problem of contact is dealt:

*   REAC_GEOM=' AUTOMATIQUE' : the geometry automatically is reactualized i.e. the number of cycles "reactualization geometrical-iterations" until convergence is not fixed by advance but obeys a geometrical convergence criterion. It is the option by default, advised to solve the non-linearity of pairing correctly. It ensures that the conditions of contact were imposed on a configuration (initial) which differs from less resi_geom of the found configuration (1% per default for formulations DISCRETE or CONTINUE, 0.01% per default for formulation XFEM).

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- REAC_GEOM=' SANS' : one works on the initial geometry. This option is valid only on the assumption of small disturbances or when the norm at contact surfaces does not change during computation.

- REAC_GEOM=' CONTRÔLE' : when the automatic criterion does not manage to be satisfied, the user must control itself the geometrical reactualization and for this reason it must inform parameter NB_ITER_GEOM. It is the number of geometrical cycles of reactualizations which will be carried out by step of load. We place at a step of load given:
  - Value 1 indicates that with convergence of Newton, one reactualizes the geometry and one passes to the step of load according to.
  - Value 2 indicates that with convergence of Newton, one reactualizes the geometry and one reiterates until convergence before passing to the step of load according to.
  - The value $n > 2$ indicates that one makes n cycles "reactualization geometrical-convergence" before passing to the step of load according to.

If you selected REAC_GEOM=' AUTOMATIQUE', parameter ITER_GEOM_MAXI is the tolerated maximum number of geometrical cycles of reactualizations. If the bearing criterion on RESI_GEOM is not satisfied at the end of iter_geom_maxi cycles, then one stops in error or one cuts out time step if the user asked it. Documentation [U2.04.04] provides many advice to overcome these problems of convergence (in particular, to activate lissage).

Note:

- *If the user chooses a reactualization controlled with $n > 1$ and that Code_Aster detects the need for a geometrical reactualization, it will emit an alarm. Charge with the user with deciding if the made mistake (necessarily higher than 1%) is acceptable or not. There is indeed a risk of error of pairing (a mesh was paired on a configuration which moved) and thus of interpenetration.*
- *If one solves on the initial geometry or with only one cycle of geometrical reactualization, there is no warning because one cannot calculate error. The user must thus check the validity of his choice in postprocessing.*
- *The value of the geometrical convergence criterion is displayed in the table of the iterations of Newton (column CONTACT CRITERE VALEUR).*

3.3.2 Friction

◊**FROTTEMENT=/**   "SANS",   [DEFAULT]
                    /"COULOMB",

to assign friction of Coulomb to the contact zones, use keyword FROTTEMENT=' COULOMB'. This keyword is **total** (valid for all the zones), but it is possible to affect friction zones by zone while exploiting the value of the coefficient of Coulomb (one puts this coefficient at 0 when one does not wish friction).

3.3.3 Formulation DISCRETE

3.3.3.1 Choice of the "

FORCED   " algorithms ♦ALGORITHME_CONT=/
    [DEFAULT]
                        /"LAGRANGIAN"
                        "GCP"/
                        "PENALIZATION"/
    ♦ALGORITHME_FROT=/   "PENALIZATION"
[DEFAULT]
                        /"LAGRANGIAN"

to select the type of algorithm in formulation DISCRETE, one uses keywords ALGO_CONT and ALGO_FROT. ALGO_FROT is modifiable only if FROTTEMENT=' COULOMB'. All the combinations are not possible:

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	Impossible ALGO_FROT='	PENALIZATION' ALGO_FROT='
LAGRANGIEN' ALGO_CONT='	***CONTRAINTE'***	***Impossible***
ALGO_CONT=' GCP'	***Impossible***	***Impossible***
ALGO_CONT=' PENALIZATION'	***OK***	***Impossible***
ALGO_CONT=' LAGRANGIEN'	***OK***	***OK***

the various methods of resolution is:

- "FORCED" : algorithm by default which deals with the exact problem of the contact unilateral with the method of the active stresses (see [R5.03.50]). **No possible friction**.
- "GCP" : it is an iterative method near of the " FORCED" method but which is particularly adapted to the cases where the number of connections of contact is very high. **No possible friction**.
- "PENALIZATION" : the penalized method makes it possible to deal with problems of contact in an approximate way with or without friction, in 2D or 3D.
- "LAGRANGIAN" : the Lagrangian method makes it possible to treat in an exact way by Lagrange multipliers of the problems of contact with or without friction, in 2D and 3D.

Although the various algorithms are given by zone, it is not possible to mix several combinations of methods in the same DEFI_CONTACT.

3.3.3.2 Dualized methods (FORCED and LAGRANGIAN)

the FORCED method makes it possible to solve problems of contact without friction in an exact way (no interpenetration is tolerated). It is particularly fast and robust, its convergence is proven. The resolution of the system of inequations resulting of the contact leaning on explicit construction from a complement from Schur, its use is restricted to a few hundreds of connections of contact. Beyond the costs report and computation become too important.

The method LAGRANGIAN differs from the method FORCED by the fact that it does not have proof of convergence (the update of the active stresses being made per package) and that it is usable in FROTTEMENT. For more details, to see [R5.03.50].

◊**NB_RESOL=/10**   [DEFAULT]
                    /nb_resol   [I]

NB_RESOL is the number of simultaneous resolutions for construction of the complement of Schur. To carry out several simultaneous resolutions makes it possible to handle matrixes per blocks. To increase nb_resol thus accelerates the construction of the complement of Schur but made lose core memory. nb_resol=10 is a good compromise. This parameter is to be held **to the experts**.

◊**STOP_SINGULIER=/**   "OUI',   [DEFAULT]
                    /"NON"

STOP_SINGULIER makes it possible to disable the fatal error appearing if the complement of Schur is singular following an important loss of decimals in factorization (8 decimals per default). One informs for that STOP_SINGULIER= `NON'. This parameter is to be held **to the experts**.

◊**ITER_CONT_MULT=/4**   ,   [DEFAULT]
                    /iter_cont_mult,   [I]

One can control the loop on the statutes by giving a multiplying coefficient, ITER_CONT_MULT : the maximum number of iterations on the statute of contact will be equal to the product iter_cont_mult by the number of nodes slaves.

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So computation stops because the maximum number of iterations of contact is exceeded, one can then try to refine the mesh, to subdivide time step or in last recourse to increase the value of `ITER_CONT_MULT`.

Note: for the FORCED `method`, convergence being proven, this coefficient is fixed into tough at 2.

3.3.3.3 Method `SLIDE`

◊**GLISSIERE=/**   "NON"   [DEFAULT]
                              /"OUI'
◊**ALARME_JEU=/0**   [DEFAULT]
                              /alarme_jeu   [R]

This option is available only for " the FORCED" `method`. It makes it possible to activate the mode of bilateral contact also called "slide", in which two surfaces being in touch stay "stuck" (i.e. with a null clearance) whatever the evolution of the loading. It authorizes great relative slidings.
The bilateral contact is activated only once surfaces are indeed in contact (one does not stick *a priori* two separate surfaces if the loading does not imply it).
Operand "ALARME_JEU" makes it possible to set off an alarm as soon as the algorithm detects that, without the method slide, there would be separation of two surfaces. Its value is regulated by default with 0, which alarms the user as soon as surfaces should have fallen apart without the activated option.

3.3.3.4 Method `GCP`

This method makes it possible to solve problems of contact without friction. It solves with an adjustable accuracy (possibly very high) the conditions of contact using Lagrange multipliers. It is in any point similar to the method "FORCED" with the difference close which it is of completely iterative nature and thus far from greedy in memory. In other words, the overcost of storage related to the taking into account of the contact is weak. This specificity causes to return it particularly adapted to the case implying a large number of connections of contact.

◊**RESI_ABSO=/resi_abso**   [R]

◊**ITER_GCP_MAXI=/0**
[DEFAULT]
                              /iter_gcp_maxi
◊**RECHERCHE_LINEAIRE=/**   "ADMISSIBLE"
[DEFAULT]
                              /"NON_ADMISSIBLE"

◊**PRE_COND=/**   "SANS",
[DEFAULT]
                              /"DIRICHLET"
◊**ITER_PRE_MAXI=/0**
[DEFAULT]
                              /iter_pre_maxi
◊**COEF_RESI=/-1**   .   [DEFAULT]
                              /coef_resi   [R]

key word `RESI_ABSO` makes it possible to regulate the accuracy of the resolution of the inequations of contact (it is stopping criteria on the value of clearances for the iterative algorithm). `RESI_ABSO` (which it is necessary to understand by "absolute residue") represents the maximum level of interpenetration tolerated for the bodies in contact. From a practical point of view, one will start by choosing a value of the order defois 10^{-3} the size of the elements in the vicinity of contact surfaces then one will decrease this value until stabilization of the results.

The maximum number of authorized iterations of the algorithm of the conjugate gradient project can be regulated with the key word `ITER_GCP_MAXI`. By default this nombre of iterations depends on the size of the problem.

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Like any method of iterative resolution, method "GCP" can be accelerated by the use of a pre-conditioner. Only one is available today and it is about a pre-conditioner of Dirichlet (PRE_COND=' DIRICHLET'). Its use can in certain cases accelerate and decrease appreciably the time of resolution. By default no pre-conditioner is activated (PRE_COND = ' SANS').

The phase of prepacking is carried out by the resolution (also iterative) of an auxiliary problem. Key word COEF_RESI makes it possible to start this pre-conditioner only when the residue sufficiently decreased: more precisely when the initial residue of the algorithm (i.e. initial interpenetration) was multiplied by coef_resi (coef_resi is thus smaller than 1).

ITER_PRE_MAXI makes it possible to fix the maximum number of iterations of the pre-conditioner.

The method of resolution "GCP" requires a phase called linear search. Two alternatives are available: acceptable or NON-acceptable. One chooses them with keyword RECH_LINEAIRE (*cf* [R5.03.50]).

3.3.3.5 Method PENALIZATION

This method is a method of resolution of the contact/friction per regularization. It is nonexact in the meaning where there is always **interpenetration** when the contact is established. If one uses a discrete formulation with penalization, it is thus advisable to inform it (S) coefficient (S) of penalization (cf §3.4.1.1).

3.3.4 Formulation CONTINUE

3.3.4.1 Choice of algorithms

◊**ALGORITHME_RESO_CONT=/**   "NEWTON"   [DEFAULT]
                    /"POINT_FIXE"
◊**ALGORITHME_RESO_FROT=/**   "NEWTON"   [DEFAULT]
                    /"POINT_FIXE"
◊**ALGORITHME_RESO_GEOM=/**   "POINT_FIXE"   [DEFAULT]
                    /"NEWTON"

the formulation continues has two types of algorithms to solve non-linearities of contact-friction: algorithm of point fixed or algorithm of generalized Newton. In addition to geometrical non-linearity (*cf* §3.3.13.3.1), this choice can be also carried out for the non-linearity of contact and friction *via* keywords ALGO_RESO_CONT, ALGO_RESO_FROT and ALGO_RESO_GEOM (all the choices are not possible):

ALGO_RESO_CONT	ALGO_RESO_FROT	ALGO_RESO_GEOM	
POINT_FIXE	POINT_FIXE	POINT_FIXE	**OK**
NEWTON	POINT_FIXE	POINT_FIXE	**OK**
POINT_FIXE	NEWTON	POINT_FIXE	**OK**
NEWTON	NEWTON	POINT_FIXE	**OK (by default)**
POINT_FIXE	POINT_FIXE	NEWTON	**Impossible**
NEWTON	POINT_FIXE	NEWTON	**OK**
POINT_FIXE	NEWTON	NEWTON	**Impossible**
NEWTON	NEWTON	NEWTON	**OK**

When one chooses the method of Newton generalized for friction, the produced tangent matrix becomes NON-symmetric. The method of Newton generalized is much faster and less sensitive to the value of the coefficient of kinetic friction than the method of fixed point. It can in certain cases prove less robust in the processing of geometrical non-linearity, this is why it is not activated by default in this case. In the case of the resolution of a problem of contact-friction in generalized Newton, it is often necessary to increase the nombre of iterations of Newton (built-in by default to 10).

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Whatever the method of resolution used (not fixes or Newton) the got results are identical.

3.3.4.2 Non-linearity of contact

◊**ITER_CONT_TYPE=/**   "MAXI",   [DEFAULT]
                         /"MULT"
◊**ITER_CONT_MULT=/4**   ,   [DEFAULT]
                         /iter_cont_mult,   [I]
◊**ITER_CONT_MAXI=/30**   ,   [DEFAULT]
                         /iter_cont_maxi,   [I]

With the adjustments by default (ALGORITHME_RESO_CONT=' NEWTON'), it has no parameter there required for the resolution of the non-linearity of contact.
When ALGO_RESO_CONT=' POINT_FIXE' is chosen, one can control the loop on the statutes of contact of two ways:

- By giving the maximum **absolute** number of iterations of contact, ITER_CONT_TYPE=' MAXI' then ITER_CONT_MAXI ;
- By giving the maximum **relative** number of iterations of contact by a multiplying coefficient, ITER_CONT_TYPE=' MULT' then ITER_CONT_MULT ; in this case, the nombre of iterations on the statute of contact will be equal to the product iter_cont_mult by the number of nodes slaves.

Into method of point fixed, the statutes are changed per blocks and the maximum number of iterations is thus more logically indicated in absolute value. If the maximum number of iterations of contact is reached, one can then try to refine the mesh, to subdivide time step or as a last resort to increase the value of ITER_CONT_MAXI/ITER_CONT_MULT.

3.3.4.3 Non-linearity of threshold of friction

◊**ITER_FROT_MAXI=/10**   ,   [DEFAULT]
                         /iter_frot_maxi,   [I]
◊**RESI_FROT=/0.0001**   ,   [DEFAULT]
                         /resi_frot,   [R]

By default the problem of Coulomb is solved by an algorithm of generalized Newton (ALGORITHME_RESO_FROT=' NEWTON'), the only key word which one can inform is thus RESI_FROT to define the criterion of stationarity of the threshold (during RESI_GEOM, *cf* 3.3.1). An additional column in the table of convergence makes it possible to follow the value of the criterion (column *CONTACT NEWTON GENE CRIT. FROT.*).

When ALGO_RESO_FROT=' POINT_FIXE' is chosen, the problem of Coulomb is solved by a succession of fixed points on the threshold of Tresca. To control this loop, the mechanism is the same one as on the loop of geometrical reactualization (*cf* 3.3.1, ITER_FROT_MAXI plays the part of ITER_GEOM_MAXI and RESI_FROT plays the part of RESI_GEOM).

3.3.4.4 Geometrical non-linearity

◊**RESI_GEOM=/0.000001**   ,   [DEFAULT]
                         /resi_geom,   [R]

the parameters of the fixed loop of point on the geometry (default setting) are given in the § 3.3.1 .

When one chooses ALGO_RESO_ GEOM = ' NEWTON', one rocks towards the algorithm of generalized Newton. Geometrical non-linearity is then taken into account with each iteration of Newton: one remakes pairing and one recomputes the local base (normal and tangents). In this mode, an additional column appears in the table of convergence, it corresponds to the evaluating of the geometrical criterion (column *CONTACT NEWTON GENE CRIT. GEOM.*).

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It is possible to modify the target value of this criterion, just like in mode `POINT_FIXE` , using parameter `RESI_GEOM` . However its definition in generalized Newton implies that it is generally checked before the criterion of equilibrium of Newton . If one wants really to control it, it is thus necessary to rock in mode `POINT_FIXE` .

3.3.5 Formulation **XFEM**

3.3.5.1 Buckles of fixed point for the statutes of contact

◊**ITER_CONT_TYPE=/**	"MAXI",	[DEFAULT]
	/"MULT"	
◊**ITER_CONT_MULT=/4**	,	[DEFAULT]
	/iter_cont_mult,	[I]
◊**ITER_CONT_MAXI=/30**	,	[DEFAULT]
	/iter_cont_maxi,	[I]

One can control the loop on the statutes of contact of two ways:
* By giving the maximum **absolute** number of iterations of contact, `ITER_CONT_TYPE=' MAXI'` then `ITER_CONT_MAXI` ;
* By giving the maximum **relative** number of iterations of contact by a multiplying coefficient, `ITER_CONT_TYPE=' MULT'` then `ITER_CONT_MULT` ; in this case, the nombre of iterations on the statute of contact will be equal to the product `iter_cont_mult` by the number of nodes slaves.

For the formulation `XFEM`, the statutes are changed per blocks and the maximum nombre of iterations is thus more logically indicated in absolute value. In all the cases, the modification of these parameters is reserved **to the experts** because it can lead to false **results** if friction is activated.

If one exceeds the maximum number of iterations of contact, one can then try to refine the mesh, to subdivide time step or as a last resort to increase the value of `ITER_CONT_MAXI/ITER_CONT_MULT`.

3.3.5.2 Buckle of fixed point for friction

◊**ITER_FROT_MAXI=/10**	,	[DEFAULT]
	/iter_frot_maxi,	[I]
◊**RESI_FROT=/0.0001**	,	[DEFAULT]
	/resi_frot,	[R]

For formulation `XFEM` (in small slidings), the problem of Coulomb is solved by a succession of fixed points on the threshold of Tresca. To control this loop, the mechanism is the same one as on the geometrical loop of reactualization.

For X-FEM in great slidings (`REAC_GEOM! = ' SANS'`), it does not have there a loop on the thresholds of Tresca (algorithm of generalized Newton). Parameter `ITER_FROT_MAXI` does not have any effect then.

3.3.6 Method without resolution

◊**STOP_INTERP=/**	"NON",	[DEFAULT]
	/"OUI'	

In the case of the mode without resolution (see §3.4.43.4.4) the code emits an alarm as soon as it detects an interpenetration. Parameter `STOP_INTERP` makes it possible to stop computation instead of alarming the user.

3.4 Local parameters (zone by zone) of control of local

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3.4.1 the Parameters resolution (zone by zone) of formulation `DISCRETE`

♦ZONE=_F   (*local parameters*)

the keywords of this paragraph are valid for formulation `DISCRETE`. The parameters are defined by zone.

3.4.1.1 Method "`PENALIZATION`"

♦E_N=e_n   [R]
♦E_T=e_t   [R]

e_n is the coefficient of penalization on the interpenetration for the penalized method. It is homogeneous with the stiffness of springs placed between contact surfaces to prevent the interpenetration. A value about the largest Young modulus of solids in contact multiplied by a characteristic length is initially recommended. One will of results increase the value of the coefficient until obtaining stable.
Moreover it is possible to control the distances from interpenetration and thus to refine its choice of coefficient, which is not the case in the presence of friction, since one does not know a priori which are the slipping zones and not slipping whereas in the event of contact one can check that the distances from interpenetration are small in front of dimensions characteristic of the contact zones.
There exists in formulation `DISCRETE` an automatic adaptive mechanism of the coefficient of penalization E_N (*cf* DEFI_LIST_INST [U4.34.03]).

e_t is the coefficient of penalization on the sliding for the penalized method. It is necessary only when friction is active. It is necessary of results to increase the value of this coefficient until obtaining stable.

3.4.1.2 Specific parameters for friction

♦COULOMB=coulomb   [R]
◊**COEF_MATR_FROT=coef_matr_frot**   [R]

parameter COULOMB makes it possible to regulate the coefficient of kinetic friction.
In the case of a formulation penalized or Lagrangian 3D, parameter COEF_MATR_FROT, ranging between 0 and 1, makes it possible to moderate the destabilizing effect of the negative part of the matrix of sliding (which is added to the tangent stiffness, *cf* [R5.03.50]). More this coefficient is large, better is convergence when one is close to the equilibrium and more the resolution is difficult far from the equilibrium. A value of 0.5 is thus a good compromise. The value by default built-in to 0 ensures a better robustness for a longer computing time.

3.4.2 Local parameters (zone by zone) of formulation `CONTINUE`

♦ZONE=_F   (*local parameters*)

the keywords of this paragraph are valid for the formulation `CONTINUE`. The parameters are defined by zone.

3.4.2.1 Operands `CONTACT_INIT`/`SEUIL_INIT`

◊**CONTACT_INIT=/**   "INTERPENETRATES"   [DEFAULT]
                                   /"OUI'
                                   /"NON"
◊**SEUIL_INIT=/0**   .   [DEFAULT]
                                   /seuil_init   [R]

operands CONTACT_INIT and SEUIL_INIT make it possible respectively to fix the statute of contact at the initial state and the threshold of initial sliding.

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By defaults, only connections with null clearance or interpenetrated are activated by algorithm (CONTACT_INIT=' INTERPENETRE'). As regards friction all connections are considered slipping, the threshold of initial sliding is thus null (SEUIL_INIT=0).

It is nevertheless possible to force the algorithm to activate all connections without exception (CONTACT_INIT=' OUI') or to take a threshold of initial sliding different from zero by informing SEUIL_INIT. The threshold of sliding has the dimension of one density surface force. In a point of contact surface, there will be sliding if the contact pressure λ and the coefficient of kinetic friction μ check:

$$\lambda \blacksquare \mu \times SEUIL\_INIT$$

It is also possible to disable any initial contact by CONTACT_INIT=' NON'.

Value CONTACT_INIT=' INTERPENETRE' is compulsory in the event of resumption of computation with an initial state.

3.4.2.2 Coefficients of the formulation CONTINUE

```
  " STANDARD            " ◊ ALGO_CONT=/                          [DEFAULT]
                          /"PENALIZATION"
{If ALGO_CONT   ==' STANDARD'
      ♦COEF_CONT=/100        .                                  [DEFAULT]
                    /coef_cont                      [R]
}
{If ALGO_CONT   ==' PENALIZATION'
      ♦COEF_PENA_CONT=coef_pena_cont                  [R]
}

   ◊ALGORITHME_ FROT=/        "STANDARD"                          [DEFAULT]
                       /"PENALIZATION"
{If ALGO_FROT   ==' STANDARD'
      ♦COEF_FROT=/100        .                                   [DEFAULT]
                   /coef_frot                     [R]
}
{If ALGO_FROT   ==' PENALIZATION'
        ♦COEF_PENA_ FROT=coef_pena_frot                   [R]
}
```

the formulation continues is an increased Lagrangian formulation. There is a penalized version.
If one chooses ALGO_CONT=' STANDARD' and ALGO_FROT=' STANDARD', the formulation continues is then equivalent to a classical increased Lagrangian formulation whose coefficients of increase are given, respectively, by COEF_CONT and COEF_FROT.
If one chooses ALGO_CONT=' PENALIZATION' and ALGO_FROT=' PENALIZATION', the formulation then is purely penalized. One reaches only under terms COEF_PENA_CONT and COEF_PENA_FROT.
The penalized method is described in the case of the discrete method to the §3.3.3.5 and §3.4.1.1, COEF_PENA_CONT corresponds to it to E_N and COEF_PENA_FROT with E_T.

It is not possible to mix a formulation standard for the contact and penalized for friction and *vice versa* .

3.4.2.3 Operand INTEGRATION

```
◊INTEGRATION=/              "AUTO"                             [DEFAULT]
                    /"GAUSS"
                    /"SIMPSON"
                    /"NCOTES"


{If INTEGRATION ==' GAUSS'
```

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```
                ◊ORDRE_INT=/3
[DEFAULT]
                                    /1 ≤ordre_int≤6                          [I]
        }
        {If INTEGRATION ==' SIMPSON'
                ◊ORDRE_INT=/1
[DEFAULT]
                                    /1 ≤ordre_int≤4                          [I]
        }
        {If INTEGRATION ==' NCOTES'
                ◊ORDRE_INT=/3
[DEFAULT]
                                    /3 ≤ordre_int≤8                          [I]
        }
```

the operand "INTEGRATION" makes it possible to select a numerical integration method for the terms of contact and friction. Several methods are implemented:

-"AUTO" to let the code choose the diagram of integration more adapted (of standard trapezoid or Simpson);

-"GAUSS" for a squaring of Gauss with the possibility of choosing the degree of the polynomials which the diagram makes it possible to integrate exactly;

-"SIMPSON" for a diagram of Simpson ($1/3$) with the possibility of choosing the number of subdivisions of the element of reference;

-"NCOTES" for a diagram of Newton-Dimensions with the possibility of choosing the degree of the polynomials interpolaters.

The choice of the degree of the polynomials which one integrates exactly or amongst subdivisions for the diagram of Simpson is made ORDRE_INT with the key word.

Automatic integration (by default choice) is most general and most effective. The choice of a diagram of integration is to be held **to the experts**.

3.4.2.4 Operand SLIDE

```
        ◊GLISSIERE=/              "NON"
[DEFAULT]
                                /"OUI'
```

Contrary to the discrete formulation (see §3.3.3.3), it is possible to activate this option zones by zone.

3.4.3 Local parameters (zone by zone) of formulation XFEM

```
        ♦ZONE=                  _F (local parameters)
```

the keywords of this paragraph are valid for formulation XFEM . The parameters are defined by zone.

3.4.3.1 Operand FISS_MAIT

```
        ♦FISS_MAIT=fiss_mait
[fiss_xfem]
```

For the formulation XFEM , the user provides the crack whose lips potentially will make contact (FISS_MAIT). The expected concept is resulting from operator DEFI_FISS_XFEM [U4.82.08].

3.4.3.2 Operands CONTACT_INIT/SEUIL_INIT

```
        ◊CONTACT_INIT=/          "NON"                          [DEFAULT]
                                /"OUI'
        ◊SEUIL_INIT=/0          .                               [DEFAULT]
```

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```
                                /seuil_init                          [R]
```

cf 3.4.2.1.

3.4.3.3 Coefficients of " STANDARD

```
"                    formulation XFEM ◊ALGORITHME_CONT=/
[DEFAULT]
                          /"PENALIZATION"
                          /"CZM"
    ◊COEF_CONT=/100              .                          [DEFAULT]
                          /coef_cont                    [R]
    ◊COEF_PENA_CONT=/100          .                          [DEFAULT]
                          /coef_pena_cont               [R]
    ◊ALGORITHME_FROT=/          "STANDARD"
[DEFAULT]
                          /"PENALIZATION"
    ◊COEF_FROT=/100              .                          [DEFAULT]
                          /coef_frot                    [R]
    ◊COEF_PENA_FROT=/100          .                          [DEFAULT]
                          /coef_pena_frot               [R]
```

formulation XFEM is writing of a continuous type. The choice of the coefficients is the same one as in the case of the continuous formulation (§3.4.2.2).

The algorithm ALGO_CONT = "CZM" (Cohesive Zone Model) is particular. It is used when one wishes to model cohesive forces between two lips of a crack. The contact is then taken into account by a term of penalization in the cohesive model. The parameters relating to the model of contact-friction should not then be indicated. Indeed, parameter COEF_PENA_CONT is for example useless, the given coefficient of penalization from being materials parameters provided in operator DEFI_MATERIAU [U4.43.01], under key word RUPT_FRAG. The shear stress obeying the cohesive model and not a friction law, no key word relating to friction is used.

3.4.3.4 Operand INTEGRATION

```
   ◊  INTEGRATION=/        "NOEUD"                              [DEFAULT]
                          /"GAUSS"
                          /"SIMPSON"
                          /"NCOTES"


    {If INTEGRATION ==' GAUSS'
         ◊ORDRE_INT=/6
[DEFAULT]
                          /1 ≤ordre_int≤6                      [I]
    }
    {If INTEGRATION ==' SIMPSON'
         ◊ORDRE_INT=/1
[DEFAULT]
                          /1 ≤ordre_int≤4                      [I]
    }
    {If INTEGRATION ==' NCOTES'
         ◊ORDRE_INT=/3
[DEFAULT]
                          /3 ≤ordre_int≤8                      [I]
    }
```

This key word has the same meaning as that of the formulation CONTINUE, *cf* §3.4.2.3. It is a parameter to be held **to the experts**.

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3.4.3.5 Operand SLIDE

◊**GLISSIERE=/**   "NON"   [DEFAULT]

/"OUI'

Contrary to the discrete formulation (see § 3.3.3.3), it is possible to activate this option zones by zone.

3.4.3.6 Operand ALGO_LAGR

◊**ALGORITHME_LAGR=/**   "VERSION1"   [DEFAULT]

/"VERSION2"

This key word determines the choice of the algorithm of elimination of Lagrange of friction to satisfy condition LBB (see [R7.02.12]). This parameter is of a use intended for **the experts**.

3.4.3.7 Operand RELATION

◊   RELATION=/   "CZM_EXP_REG"   [DEFAULT]
/"CZM_LIN_REG"
/"CZM_TAC_MIX"
/"CZM_OUV_MIX"

the key word RELATION makes it possible to activate the taking into account of forces of cohesion at the time of the opening of an interface X-FEM. It is used exclusively with the option ALGO_CONT = "CZM". Cohesion is modelled by the cohesive model of the same name, already existing of finite element method classics (see the note of use [U2.05.07] for abstract, documentation [R7.02.11] for the definition of these models and documentation [R5.03.54] for their extension to X-FEM).
The data necessary of the field material are provided in operator DEFI_MATERIAU [U4.43.01], under key word RUPT_FRAG.

3.4.4 Method without resolution

◊**RESOLUTION=/**   "OUI',   [DEFAULT]
/"NON"

◊**TOLE_INTERP=/**0   .,   [DEFAULT]
/tole_interp   [R]

When RESOLUTION=' NON', one carries out a control of the interpenetration of two surfaces without imposing the conditions of contact (if there is interpenetration, it is not corrected).
The code emits an alarm as soon as an interpenetration is detected at the end of a step of loading. Total parameter STOP_INTERP (§3.3.63.3.6) makes it possible to stop computation instead of alarming the user.

TOLE_INTERP (zone by zone) regulates the value of tolerated interpenetration (homogeneous with a length in the unit of the mesh). The value given is absolute (does not have sign). This method is available in discrete and continuous formulation.

Note:

- *In mode RESOLUTION=' NON', pairing is made only once at the end of each time step , the notion of loop geometrical does not exist more if all the zones are in mode RESOLUTION=' NON'. In this last case, option REAC_GEOM if it is different from "SANS" thus does not have a meaning.*
- *The fact that mode RESOLUTION=' NON' detects interpenetrations in one of the contact zones does not prejudge that real computation (with effective checking of the unilateral condition) gives the same results. Indeed, the activation of the unilateral condition necessarily will change the kinematics of strain compared to mode RESOLUTION=' NON'. It*

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is thus advisable to be careful when one mixes zones with resolution of the contact and others without resolution.

3.5 Data format `VALE_CONT`

All the methods of contact with or without friction produce a data structure of the type `VALE_CONT` with the following components in each slave node:

- `CONT` : indicator of contact rubbing
  - `0` : no contact
  - `1` : adherent contact (only if `FROTTEMENT=' COULOMB'`)
  - `2` : contact slipping
  - `3` : if there is interpenetration (only in mode `RESOLUTION=' NON' );`
- `JEU` : value of clearance
- `RN` : normal reaction of contact RNX
- `normalizes` : component following DX of the normal reaction of contact
- `RNY` : component following DY of the normal reaction of contact
- `RNZ` : component following DZ of the normal reaction of contact
- `GLIX` : component following t_1 of tangential sliding (local coordinate system)
- `GLIY` : component following t_2 of tangential sliding (local coordinate system)
- `GLI` : tangential sliding RTAX
- `normalizes` : component following DX of the tangential force of dependancy
- `RTAY` : component following DY of the tangential force of dependancy
- `RTAZ` : component following DZ of the tangential force of dependancy
- `RTGX` : component following DX of the tangential force of sliding
- `RTGY` : component following DY of the tangential force of sliding
- `RTGZ` : component following DZ of the tangential force of sliding
- `X-ray` : component following DX of the force of contact rubbing (RNX+RTAX+RTGX)
- `RY` : component following DY of the force of contact rubbing (RNY+RTAY+RTGY)
- `RZ` : component following DZ of the force of rubbing contact (RNZ+RTAZ+RTGZ)
- `R` : force of rubbing contact normalizes
- `I` : percussion of the resultant R of the force of contact rubbing
- `IX` : percussion of the component following DX of the force of contact rubbing
- `IY` : percussion of the component following DY of the force of contact rubbing
- `IZ` : percussion of the component following DZ of the force of contact rubbing
- `PT_X` : coordinates according to DX of the point of intersection in formulation XFEM
- `PT_Y` : coordinates according to DY of the point of intersection in formulation XFEM
- `PT_Z` : coordinates according to DZ of the point of intersection in formulation XFEM
- `PROJ_X` : coordinates according to DX of the projection of the slave node on the mesh or master node
- `PROJ_Y` : coordinates according to DY of the projection of the slave node on the mesh or master node
- `PROJ_Z`: coordinated according to DZ of the projection of the slave node on the mesh or the master node

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It is printed as follows in the form of array:

```
MATABLE=POST_RELEVE_T (ACTION=_F (INTITULE=' INFORMATION FROTTEMENT',
                       GROUP_NO=' ESCLAVE',
                       RESULTAT=U,
                       INST=10.,
                       TOUT_CMP=' OUI',
                       NOM_CHAM=' VALE_CONT',
                       OPERATION=' EXTRACTION',),);


IMPR_TABLE (TABLE=MATABLE);
```

It is advisable to notice that the quantities corresponding to the reactions of contact-friction are nodal forces (in unit of force) within the meaning of the finite elements and not of contact pressures. In axisymmetric modelization, just like for the option `FORC_NODA` or `REAC_NODA`, it is thus necessary to multiply the values obtained by 2π obtaining the resultant (*cf* [U4.81.02]). The nodal forces punctually do not have a meaning (they depend on the smoothness of the mesh), only their resultant can be interpreted.

More generally, to have access to contact pressures, two methods are possible according to the formulation (*cf* [U2.04.04]):

*   if one is in the case of a discrete formulation, it is necessary to recover the stresses inside finite elements (`SIEF_ELGA`) and to extrapolate with the nodes on the skin (`SIEF_NOEU`, there is thus approximation);
*   if one is in the case of a continuous formulation, the contact pressure and the density of force of friction are accessible directly like unknowns from the problem (component `LAGS_C`, `LAGS_F1` and `LAGS_F2` of field `DEPL`). Attention the density of surface force tangential is obtained by multiplying the norm of the `LAGS_F*` by `LAGS_C` (*cf* [U2.04.04]).

Caution: in formulation `XFEM`, component `CONT` is not stored.

3.6 Formulation `LIAISON_UNIL`

formulation `LIAISON_UNIL` is usable to define a unilateral condition (inequation) of nodal type on unspecified degrees of freedom such as:

$$\sum \alpha_i(t)\, p_i < r(x,y,z,t)$$

with:

$-p_i$ the value of the degree of freedom of a node (displacement, pressure, temperature, etc...) (§3.6.1.3)

$-\alpha_i(t)$ a real function of time (parameter `INST`) (§3.6.1.4)

$-r(x,y,z,t)$ a real function of time or space (parameters X, Y, Z, INST) (§3.6.1.4)

It will be noticed that the parameter α_i also makes it possible, if its sign is negative, to reverse the meaning of the inequality.

3.6.1 Local parameters (zone by zone) of formulation `LIAISON_UNIL`

    ♦ZONE=_F   (*local parameters*)

the keywords of this paragraph are valid for formulation `LIAISON_UNIL`. The parameters are defined by zone.

3.6.1.1 Operands `MAILLE/GROUP_MA/NOEUD/GROUP_NO`

    ♦   /GROUP_NO   =l_grno   [l_gr_noeud]
        /NOEUD   =l_noeud   [l_noeud]
        /GROUP_MA   =l_grma   [l_gr_maille]

Code_Aster

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```
/MAILLE          =l_maille                              [l_maille]
```

the unilateral condition is expressed on the nodes of the mesh given under keywords GROUP_NO or NOEUD. One can nevertheless give meshes carrying the nodes thanks to keywords GROUP_MA and MESH. Contrary to the "classical" case of the contact, as the conditions are nodal, it is useless meshes to direct the norms with skin in case LIAISON_UNIL.

3.6.1.2 Operands SANS_NOEUD/SANS_GROUP_NO

◊**SANS_GROUP_NO=l_sgrno**   [l_gr_noeud]
◊**SANS_NOEUD=l_snoeud**   [l_noeud]

These operands make it possible to exclude from the nodes of the unilateral condition in the same way as for the formulations CONTINUE or DISCRETE (see §3.1.33.1.3).

3.6.1.3 Operand NOM_CMP

♦NOM_CMP=l_cmp   [l_TXM]

List of the components p_i (degrees of freedom) on which is exerted the unilateral relation. It can be any degree of freedom carried by the node. For example: PRE, PRE1, PRE2, TEMP or DX, DY or DZ.

3.6.1.4 Operands COEF_IMPO and COEF_MULT

♦COEF_IMPO=l_c_impo   [function]
♦COEF_MULT=l_c_mult   [l_fonction]

COEF_IMPO is the specified value $r(t)$ to the member of right of the unilateral relation. COEF_MULT is the list of the multiplying coefficients $\alpha(t)$ used in front of each degree of freedom. The lengths of lists COEF_MULT and NOM_CMP must of course be identical.
The coefficients $r(t)$ and $\alpha(t)$ are inevitably **functions**. To define constant coefficients, it will be advisable to use command DEFI_CONSTANTE.

3.6.2 Example

One wants to impose the condition 1.3*PRE1-5.2*PRE2 < 4.0, one will have then:

```
        coef_i  = DEFI_CONSTANTE (VALE=4.0)
        coef_m1 = DEFI_CONSTANTE (VALE=1.3)
        coef_m2 = DEFI_CONSTANTE (VALE=-5.2)

        NOM_CMP = ("PRE1", "PRE2")
        COEF_IMPO = coef_i
        COEF_MULT = (coef_m1, coef_m2)
```