/INTER/TYPE2

Block Format Keyword

Defines a TYPE2 tied interface that connects a set of slave nodes to a master surface. It can be used to connect coarse and fine meshes, model spotwelds, rivets, and so on.

Format

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
/INTER/TYPE2/*inter_ID*/*unit_ID*									
inter_title									
$grnd\_ID_s$	$surf\_ID_m$	*Ignore*	$Spot_{flag}$	*Level*	I_{search}	I_{del2}		d_{search}	

Read this input, if $Spot_{flag}$ = 20, 21, or 22:

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rupt	I_{filtr}	fct_ID_{sr}	fct_ID_{sn}	fct_ID_{st}	I_{sym}	*Max_N_Dist*		*Max_T_Dist*	
$Fscale_{stress}$		$Fscale_{str\_rate}$		$Fscale_{dist}$		*Alpha*		*Area*	

Read this input, if $Spot_{flag}$ = 25, 27 or 28:

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Stfac		*Visc*				I_{stf}			

Optional

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
I_{the}	K_{the}								I_{proj}

Definitions

Field	Contents	SI Unit Example

inter_ID	Interface identifier (Integer, maximum 10 digits)	
unit_ID	Unit Identifier (Integer, maximum 10 digits)	
inter_title	Interface title (Character, maximum 100 characters)	
$grnd\_ID_s$	Slave node group identifier (Integer)	
$surf\_ID_m$	Master surface identifier (Integer)	
Ignore	Flag to ignore slave nodes if no master segment found. (Integer) 12 13 **= 0 (Default)** Set to the value defined in /DEFAULT/INTER/TYPE2. **= 1** Slave nodes with no master segment found during the Starter are deleted from the interface **= 2** Slave nodes with no master segment found during the Starter are deleted from the interface, new calculation for d_{search}, if d_{search} = 0 14 **= 3** Slave nodes with no master segment found during the Starter are deleted from the interface, new calculation for d_{search}, if d_{search} = 0 14 **= 1000** No deletion of slave nodes (default, if `/DEFAULT/INTER/TYPE2` is not defined).	

$Spot_{flag}$	Spotweld formulation flag 3 4 5 6 7 11 **= 0 (Default)** Set to the value defined in /DEFAULT/INTER/TYPE2. **= 1** Formulation is optimized for spot welds or rivets **= 2** Same formulation as standard formulation. Required when using hierarchy levels. Not compatible with nodal time step /DT/NODA/CST **= 4** Rotational DOF are not transmitted, if shells are used. Default when /CAA is activated. Not compatible with nodal time step /DT/NODA/CTS. **= 5** Standard formulation (default when /CAA is activated). **= 20, 21, 22** Formulation with failure. Not compatible with nodal time step /DT/NODA/CST. The stress is computed for each slave node according to the "equivalent" surface around the node. The equivalent surface is defined accordingly: **= 20** Surface computed using shell and brick faces attached to the node. **= 21** Surface computed using only the shell attached to the node. **= 22** Surface computed using only the brick faces attached to the node. **= 25** Penalty formulation (not recommended) 19 **= 27** Kinematic formulation similar to the $Spot_{flag}$ =5 with an automatic switch to penalty formulation when incompatible kinematic conditions occur. 20 **= 28** Kinematic formulation similar to $Spot_{flag}$ =1 with an automatic switch to penalty formulation when incompatible kinematic conditions occur. 20 **= 30** Formulation with cubic curvature of master segment. Not compatible with nodal time step /DT/NODA/CST (Integer)	
Level	Hierarchy level of the interface (Integer)	

I_{search}	Search formulation flag for the closest master segment **= 0 (Default)** Set to the value defined in */DEFAULT/INTER/TYPE2*. **= 1** Old formulation (only used for previous version) **= 2** New improved formulation (default, if /DEFAULT/INTER/TYPE2 is not defined). (Integer)	
I_{del2}	Node deletion flag 9 10 16 **= 0 (Default)** Set to the value defined in /DEFAULT/INTER/TYPE2. **= 1** The kinematic condition is suppressed on the slave node, when all elements linked to the master segment are deleted. (The slave node is removed from the interface). **= 2** The kinematic condition is suppressed on the slave node, if the master element is deleted. (The slave node is removed from the interface). **= 1000** No deletion (default, if /DEFAULT/INTER/TYPE2 is not defined). (Integer)	
d_{search}	Distance for searching closest master segment Default value is the average size of the master segments 13 (Real)	$[\mathrm{m}]$
Rupt	Failure model (only available with $Spot_{flag}$ 20, 21 or 22) **= 0 (Default)** Set to value defined in /DEFAULT/INTER/TYPE2. **= 1** Failure when $\sqrt{\left(\frac{N\_Dist}{Max\_N\_Dist}\right)^2+\left(\frac{T\_Dist}{Max\_T\_Dist}\right)^2}>1$ **= 2** Failure when *Max_N_Dist* or *Max_T_Dist* are reached (default) (Integer)	

I_{filtr}	Filter flag 10 **= 0:** No filtering **= 1** Filtering (alpha filter) (Integer)	
fct_ID_{sr}	Stress factor vs stress rate function identifier 6 (Integer)	
fct_ID_{sn}	Max normal stress vs normal relative displacement function identifier (*N_Dist*.) This function must be defined 6 (Integer)	
fct_ID_{st}	Max tangential stress vs tangential relative displacement function identifier (*T_Dist*.) This function must be defined. 6 (Integer)	
I_{sym}	Asymmetric rupture flag 6 **= 0 (Default)** Symmetric rupture (traction and compression) **= 1** Asymmetric rupture (traction only, not in compression) (Integer)	
Max_N_Dist	Maximum normal relative displacement Default = 1e+20 (Real)	$[\mathrm{m}]$
Max_T_Dist	Maximum tangential relative displacement Default = 1e+20 (Real)	$[\mathrm{m}]$
$Fscale_{stress}$	Stress scale factor 6 Default = 1.00 (Real)	$[\mathrm{Pa}]$
$Fscale_{str\_rate}$	Stress rate scale factor 6 Default = 1.00 (Real)	$\left[\frac{\mathrm{Pa}}{\mathrm{s}}\right]$
$Fscale_{dist}$	Distance scale factor 6 Default = 1.00 (Real)	$[\mathrm{m}]$
Alpha	Stress filter alpha value Default = 1 (Real)	

Area	Area of surface which used when the area computed from slave node side is null or when slave node is connected only to 1D element. Default = 0.0 (Real)	$[\mathrm{m}^2]$
Stfac	Stiffness factor (used only with $Spot_{flag}$ 25, 27 or 28) Default = 1.0 (Real)	
Visc	Critical damping coefficient on interface stiffness (used only with $Spot_{flag}$ =25, 27 or 28) Default = 0.05 (Real)	
I_{stf}	Interface stiffness definition flag 16 Only used with penalty formulations ($Spot_{flag}$=25, 27 or 28) **= 0 (Default)** Set to 2 **= 1** Penalty stiffness is only based on master segment stiffness. **= 2, 3, 4 and 5** Penalty stiffness is computed from both master and slave characteristics. (Integer)	
I_{the}	(Optional) Heat transfer flag **= 0** No heat transfer **= 1** Heat transfer between pieces in contact is activated (Integer)	
K_{the}	(Optional) Heat exchange coefficient Default = 0.0	$\left[\frac{\mathrm{W}}{\mathrm{m}^2 \cdot \mathrm{K}}\right]$
I_{proj}	(Optional)Slave node projection flag 18 (not available for $Spot_{flag}$ = 1, 28 and 30). **= 0 (Default)** Set to 1 **= 1** Force slave projection position to master edge **= 2** Slave projection is not modified (Integer)	

Comments

1. Interface TYPE2 is a kinematic condition; no other kinematic condition should be set on any node of the slave surface, except when $Spot_{flag}$ =25, 27 or 28.
2. The d_{search} is computed as (see Tied Interface (TYPE2) in the *Altair Radioss Theory Manual*):

   EQ. 1.

   $$d_{search} = \frac{1}{n} \cdot \sum_{i=1}^{n} d_i$$

   with, n being the number of master segments, and d_i is the total length of all the master side segments.
3. Master nodes of an interface TYPE2 may be slave nodes of another interface TYPE2 only if the hierarchy level of the first interface is lower than the hierarchy level of the second interface. Hierarchy levels are only available with $Spot_{flag}$ =2. It does not work if $Spot_{flag}$ =0 or $Spot_{flag}$ =1.

   A possible workaround is using $Spot_{flag}$=2, which corresponds to the default formulation ($Spot_{flag}$=0); except that it is not compatible with `/DT/NODA/CST`.
4. $Spot_{flag}$ =2 is equivalent to formulation 0; except that it is not compatible with nodal time step `/DT/NODA/CST`.
5. $Spot_{flag}$ =4 is recommended to connect SPH particles to a surface (refer to Smooth Particle Hydrodynamics (SPH)).

6. For failure (*Spot*$_{flag}$ = 20, 21 or 22), it could model, for example, glue connection. In this case, the force in slave node will be scaled by reduced force coefficient *Fac_N* (*Fac_T*), which is computed as:

EQ. 1.

$$Fac\_N = \min\left\{\sqrt{\frac{{\sigma_{N\_\max}}^2}{\max\left[(\sigma_N(t))^2,\ \ 10^{-20}\right]}},\ 1\right\}$$

EQ. 1.

$$Fac\_T = \min\left\{\sqrt{\frac{{\sigma_{T\_\max}}^2}{\max\left[(\sigma_T(t))^2,\ \ 10^{-20}\right]}},\ 1\right\}$$

The reduced force is compared to the max value:

if $\sigma_N < \sigma_{N\_\max}$, then *Fac_N* =1, which means the force will not be reduced.

if $\sigma_N > \sigma_{N\_\max}$, then $Fac\_N = \sqrt{\frac{\sigma_{N\_\max}^2}{\max\left[(\sigma_N(t))^2, 10^{-20}\right]}}$ which means the force will then be reduced.

Here the max value will be defined by the user with:

EQ. 1.

$$\sigma_{N_{\max}} = \mathrm{Fscale}\,(\dot{\sigma}) \cdot \mathrm{f}_{sn}\left(\frac{\Delta X_N}{Fscale_{dist}}\right)$$

EQ. 1.

$$\sigma_{T_{\max}} = \mathrm{Fscale}\,(\dot{\sigma}) \cdot \mathrm{f}_{st}\left(\frac{\Delta X_T}{Fscale_{dist}}\right)$$

EQ. 1.

$$\mathrm{Fscale}\,(\dot{\sigma}) = Fscale_{stress} \cdot \mathrm{f}_{sr}\left(\frac{\dot{\sigma}}{Fscale_{str\_rate}}\right)$$

While, f_{sn} , f_{st} and f_{sr} are functions of *fct_ID*$_{sn}$, *fct_ID*$_{st}$ and *fct_ID*$_{sr}$.

Once the rupture criterion (defined by *Rupt*) is reached, the contact will be deleted.

Here:

- $\sigma_{N\_\max}$ is the maximum normal stress value defined by *fct_ID*$_{sn}$
- $\sigma_N(t)$ is the normal stress
- σ *T_max* is the maximum tangential stress value defined by *fct_ID*$_{st}$
- $\sigma_T(t)$ is the tangential stress
- *Fscale*$_{stress}$ is the input constant stress factor
- *fct_ID*$_{sr}$ is the input variable coefficient
- *fct_ID*$_{sn}$ and *fct_ID*$_{s}$ are the input stress-displacement functions
- *I*$_{sym}$ permits to choose between symmetric or asymmetric rupture (traction/compression). The initial direction from master surface to the slave node defines the positive side (traction). If the distance is zero (slave node lies on the master surface), the rupture will be symmetric, even with *I*$_{sym}$ =1.

This failure option (*Spot*$_{flag}$ = 20, 21 or 22) can not be used in implicit.

7. $Spot_{flag}$ =30: Slave mass/inertia/stiffness distribution to the master node is based on the Kirschoff model: bi-cubic form functions are used instead of linear (standard formulation). It allows a softer contact behavior since the element shape curvature is taken into account in the force/moment transmission.

   Warning: This formulation is not compatible with solid elements, as it requires rotational DOF.

8. If flag I_{del2} =2, then when a 4-node shell, a 3-node shell or a solid element is deleted, it is also removed from the master side of the interface (the kinematic condition is suppressed on relative slave nodes).
9. The options I_{del2} =1 and I_{del2} =2 act if the master element is deleted using explicit deletion in Altair Radioss Engine (using the keyword /DEL in Altair Radioss Engine Input (`/DEL/SHELL`, `/DEL/BRICK`, ...)).
10. If I_{filtr} is set to 1, the normal and tangential stresses are filtered with an alpha filter, as:

$$\sigma_N(t) = Alpha \cdot \sigma_N(t) + (1 - Alpha) \cdot \sigma_N(t-1) \quad \textit{EQ. 1.}$$

$$\sigma_T(t) = Alpha \cdot \sigma_T(t) + (1 - Alpha) \cdot \sigma_T(t-1) \quad \textit{EQ. 1.}$$

11. $Spot_{flag}$ =25 (penalty formulation) will keep the penalty formulation during the whole run. The slave node (of this contact) could also be the slave node of another kinematic option, like rigid body.

    The penalty stiffness is constant, calculated by default as the mean nodal stiffness of master and slave side. The stiffness factor, *Stfac*, may be used to modify it, if needed. The penalty stiffness will be multiplied by *Stfac*.

    A critical viscous damping coefficient (*Visc*) allows damping to be applied to the interface stiffness.

12. If *Ignore* = 1, 2, or 3, the slave nodes without a master segment found during the Starter, are deleted from the interface.

13. If *Ignore* ≠ 1000, d_{search} is used.

    If *Ignore* = 2 or 3 and d_{search} = 0, d_{search} is computed, for each slave node as:

    $$\delta_1 = 0.6\left(thickness\_slave\_node + thickness\_master\_segment\right)$$ *EQ. 1.*

    $$\delta_2 = 0.05\left(master\_segment\_diagonal\right)$$ *EQ. 1.*

    $d_{search} = \max\left(\delta_1, \delta_2\right)$

    For shells:

    - *thickness_slave_node* = shell thickness of slave
    - *thickness_master_segment* = shell thickness of master

    For solids:

    - *thickness_slave_node* = 0

    If *Ignore* = 2:

    - *thickness_master_segment* = $\frac{Element\_volume}{Segment\_area}$

    If *Ignore* = 3:

    - *thickness_master_segment* = 0

    If *Ignore* = 2 or = 3:

    - Thickness is retained in the following order: first from /PART definition, from /SHELL or /SH3N definition, then from /PROP definition.

14. The contact is compatible with 2D-plane and -axisymmetrical simulations only for $Spot_{flag}$=0 and in case of connecting to solid elements with $Spot_{flag}$=0, then moments are not transferred.
15. If flag I_{del2} =1, then when all 4-node shells, all 3-node shells and all solid elements belonging to a master segment are deleted, this segment is also removed from the master side of the interface (the kinematic condition is suppressed on relative slave nodes).
16. $Spot_{flag}$ = 25, 27 or 28: Interface penalty stiffness is computed from both master segment stiffness K_m and slave node stiffness K_s, depending on I_{stf} flag:

    I_{stf} = 1: $K_n = Stfac \cdot K_m$

    I_{stf} = 2 (default): $K_n = Stfac \cdot \frac{K_m + K_s}{2}$

    I_{stf} = 3: $K_n = Stfac \cdot \max\left(K_m, K_s\right)$

    I_{stf} = 4: $K_n = Stfac \cdot \min\left(K_m, K_s\right)$

    I_{stf} = 5: $K_n = Stfac \cdot \frac{K_m \cdot K_s}{K_m + K_s}$

17. If I_{the} >1, the material of the slave side and master need to be a thermal material, using finite element formulation for heat transfer (/HEAT/MAT).

    Thermal conduction is computed when the slave node falls into contact.

    The heat exchange is computed from master to slave and from slave to master:

    $$\phi_{cond} = K_{the}\left(T_s - T_m\right)$$ *EQ. 1.*

18. I_{proj} =1, if a slave node projection is outside of the master element, it is moved to the closest edge of the master element (in order to avoid using negative values for shape functions). This flag is activated by default. In order to ensure consistency with Altair Radioss versions prior to V14.0 and avoid numerical differences, this option can be deactivated (I_{proj} =2).

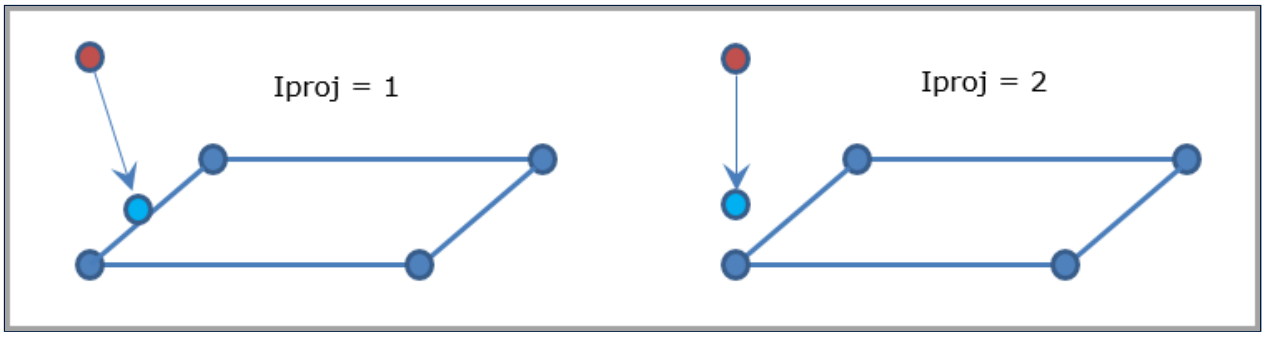

Figure 1.

19. When using the penalty formulation $Spot_{flag}$=25, moments cannot be transmitted from the slave nodes to a master segment. Therefore, it is not recommended to use it for any connection where the slave nodes have rotational degrees of freedom. This would include: shell to shell, spring to shell, shell to solid where the shell is slave and solid is master. Due to this limitation and the lower robustness compared to kinematic formulations, it is recommended to use the mixed kinematic and penalty formulation, $Spot_{flag}$ =27 and 28.
20. $Spot_{flag}$ =27 and 28 are a mixed kinematic and penalty formulation tied contact. By default, the kinematic formulation is used. Any slave nodes with incompatible kinematic conditions are automatically switched to the penalty formulation. Incompatible kinematic conditions with rigid bodies, imposed displacements, imposed velocities, imposed accelerations, other tied contact slave nodes, or boundary conditions will cause the switch to penalty formulation. A WARNING message is printed in the starter output file when slave nodes are switched to penalty formulation.

    The penalty formulation stiffness is constant and calculated using I_{stf} and $Stfac$. A critical viscous damping coefficient ($Visc$) allows damping to be applied to the interface stiffness. The penalty formulation can transfer moments from the slave nodes to the master segment.

21. Unlike $Spot_{flag}$ =1, $Spot_{flag}$ =28 does not add any mass at time=0 when the master surface of the tied contact is a shell element. If the master surface is a solid element there could be some mass added. No mass is added when $Spot_{flag}$ =27 is used.

See Also

Tied Contact (/INTER/TYPE2)

Tied Interface (TYPE2)

RD-E: 1401 VPG with a Complete Finite Element Model

RD-E: 4500 Multi-Domain

RD-E: 4800 Solid Spotweld

RD-E: 4900 Bird Strike on Windshield

Contact Interfaces

Kinematic Conditions