

# Contact Modeling in LSDYNA®

## Part 4: Airbag, Edge to Edge, and Rigidbody Contacts

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### 8.0 Airbag Contact

Simulation of airbag deployment and interaction of an airbag with other components may require special contact treatment. Some of the challenges associated with airbag contact are as follows:

- High Airbag Nodal Velocity ( $> 100$  m/s)
- Soft Tissue Properties ( $E < 50$  MPa)
- Small Tissue Thickness ( $< 0.5$  mm)
- Frequent Initial Penetrations in Folded Bag
- Treatment of Airbag Fabric Layers

To promote stability and accuracy in simulating airbag contact, the following contact types and contact parameters are recommended.

### 8.1 Airbag Self-Contact

When treating airbag self-contact (fabric-to-fabric contact), the use of `*CONTACT_AIRBAG_SINGLE_SURFACE` is highly recommended. This contact type is based on `*CONTACT_AUTOMATIC_SINGLE_SURFACE` but has significant modifications to account for the difficulties associated with deployment of a folded airbag.

`SOFT=2` is generally recommended (SMP only) to better deal with the many initial penetrations present in a folded airbag and to invoke a segment-to-segment contact search which is often advantageous in dealing with the complex geometry of a folded or partially unfolded airbag. Airbag contact with `SOFT=2` is expensive relative to other contact options so to improve CPU performance when using `SOFT=2`, an additional contact with `SOFT=0` or `1` can be implemented as shown in Figure 8.1. By defining two separate contacts and employing contact birthtime and deathtime to switch from the `SOFT=2` contact to the `SOFT=1` contact when the bag has unfolded, a good combination of contact reliability and efficiency can be achieved.

If the airbag simulation is run using an MPP executable, note that `SOFT=2` is not yet available and so `SOFT=0` or `1` must be used. For a folded airbag, this will likely mean that a load curve defining the fabric contact thickness versus time will be necessary to transition from a very small thickness in the folded state to a larger thickness as the bag unfolds. This is done to prevent initial penetrations in the folded state and still have good contact behavior during the unfolding process. The contact thickness vs. time curve is identified by `LCIDAB` on Optional Card A of `*CONTACT`. As a possible alternative to a time-dependent contact thickness, the user may try invoking the option for tracking of initial penetrations by setting `IGNORE=1` on Optional Card C. This latter option is new in version 960 and has not been thoroughly checked out for airbag applications.

### 8.2 Airbag-to-Structure Contact

During and after airbag deployment, the airbag fabric comes into contact with other parts of the model such as the steering wheel, occupant, instrument panel, door trim components and, in the case of side curtain deployment, the seat. For these contact conditions, a two-way contact such as `*CONTACT_AUTOMATIC_SURFACE_TO_SURFACE` is generally recommended. In instances when the airbag nodes comprise the slave side in a one-way type contact such as `*CONTACT_AUTOMATIC_NODES_TO_SURFACE`, the structural nodes are not checked for penetration through the airbag segments. This may result in noticeable penetration of finely-meshed structural components into airbag segments. Single surface contacts such as `*CONTACT_AUTOMATIC_SINGLE_SURFACE` for airbag-to-structure interaction may be ill-advised as this would result in duplication of self-contact treatment for the fabric.

Difficulties in airbag-to-structure contact are largely associated with significant differences in material bulk moduli (up to  $1000\times$ ) and very low thickness of the fabric. To avoid premature nodal release triggered by a small fabric thickness, it is recommended that the contact thickness of the fabric be set to a minimum value of  $1.0$  mm. Since a wide range of

materials are involved, the use of SOFT=1 is highly recommended as it eliminates the need to fine-tune penalty scale factors. An example of the overall setup for airbag-related contact is shown in Figure 8.2.

## 9.0 Edge-to-Edge Contact

Most contact types do not check for edge-to-edge penetrations as the search entails only nodal penetration through a segment. This may be adequate in many cases; however, in some unique shell contact conditions, the treatment of edge-to-edge contact becomes very important. There are several ways to handle edge-to-edge contact; the merits/demerits of each one of these methods are discussed below.

### 9.1 \*CONTACT\_AUTOMATIC\_GENERAL Excluding Interior Edges

By default, \*CONTACT\_AUTOMATIC\_GENERAL considers only exterior edges in its edge-to-edge treatment as indicated by Figure 9.1. An exterior edge is defined as belonging to only a single element or segment whereas interior edges are shared by two or more elements or segments. The entire length of each exterior edge, as opposed to only the nodes along the edge, is checked for contact. As with other penalty-based contact types, SOFT=1 can be activated to effectively treat contact of dissimilar materials.

### 9.2 \*CONTACT\_AUTOMATIC\_GENERAL Including Interior Edges

Edge-to-edge contact which *includes* consideration of interior edges may be invoked in one of two ways. One method takes advantage of the beam-to-beam contact capability of \*CONTACT\_AUTOMATIC\_GENERAL. This labor-intensive approach involves creating null beam elements (\*ELEMENT\_BEAM, \*MAT\_NULL) approximately 1 mm in diameter (elform=1, ts1=ts2=1,2mm, tt1=tt2=0 in \*SECTION\_BEAM) along every interior edge wished to be considered for edge-to-edge contact and including these null beams in a separate AUTOMATIC\_GENERAL contact. This is illustrated in Figure 9.2. The elastic constants in \*MAT\_NULL are used in determining the contact stiffness so reasonable values should be given. Null beams do *not* provide any structural stiffness.

A preferred alternative to the null beam approach, available in version 960, is to invoke the interior edge option by using \*CONTACT\_AUTOMATIC\_GENERAL\_INTERIOR. A certain cost penalty is associated with this option.

### 9.3 \*CONTACT\_SINGLE\_EDGE

This contact type treats edge-to-edge contact but, unlike the other options above, it treats *only* edge-to-edge contact. This contact type is defined via a part ID, part set ID, or a node set on the slave side. The master side is omitted.

## 10.0 Rigid Body Contact

Components for which deformation is negligible and stress is unimportant may be modeled as rigid bodies using \*MAT\_RIGID or \*CONSTRAINED\_NODAL\_RIGID\_BODY. The elastic constants defined in \*MAT\_RIGID are used for contact stiffness calculations. Thus the constants should be reasonable (properties of steel are often used).

Though there are several contact types in LS-DYNA which are applicable specifically to rigid bodies (RIGID appears in the contact name), these types are seldom used. Any of the penalty-based contacts applicable to deformable bodies may also be used with rigid bodies, and in fact, are generally preferred over the RIGID contact types. Rigid bodies and deformable materials may be included in the same penalty-based contact definition. Constraints and constraint-based contacts may not be used for rigid bodies.

Rigid bodies should have a reasonably fine mesh so as to capture the true geometry of the rigid part. An overly coarse mesh may result in contact instability. Another meshing guideline is that the node spacing on the contact surface of a rigid body should be no coarser than the mesh of any deformable part which comes into contact with the rigid body. This promotes proper distribution of contact forces. As there are no stress or strain calculations for a rigid body, mesh refinement of a rigid body has little effect on CPU requirements. In short, the user should not try to economize in the meshing of rigid bodies.

\*CONTACT\_ENTITY is an altogether different way of defining an analytic, rigid contact surface which interacts with nodes of deformable bodies. For more information

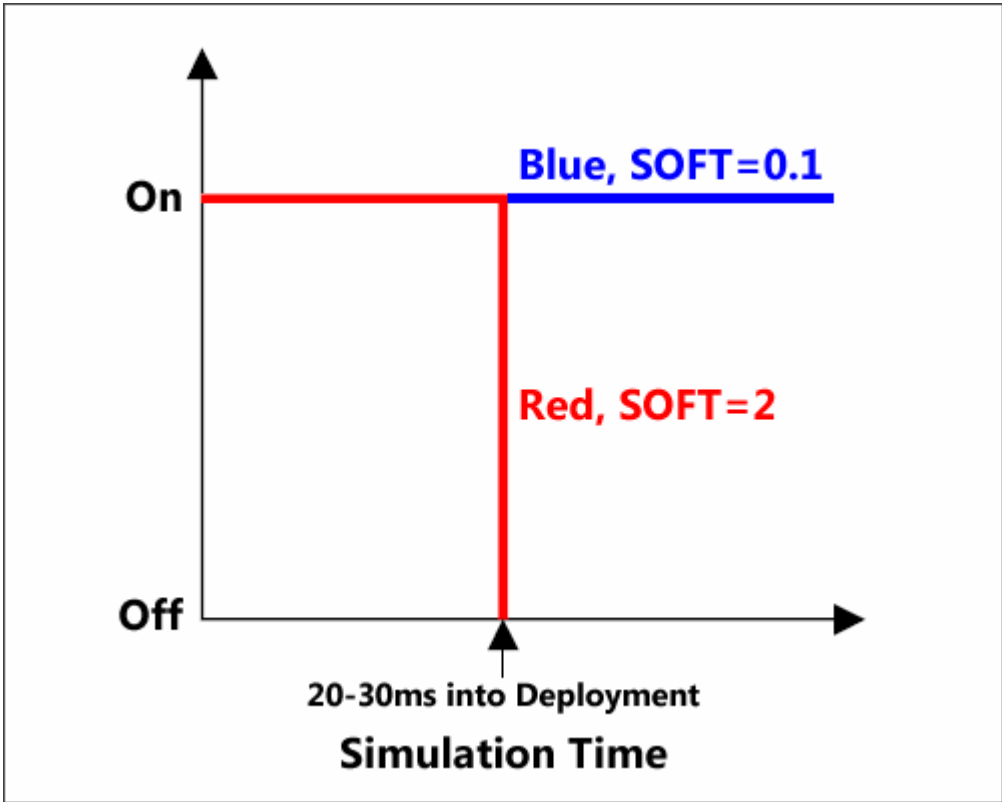


Figure 8.1: Airbag Self Contact Algorithm Switch

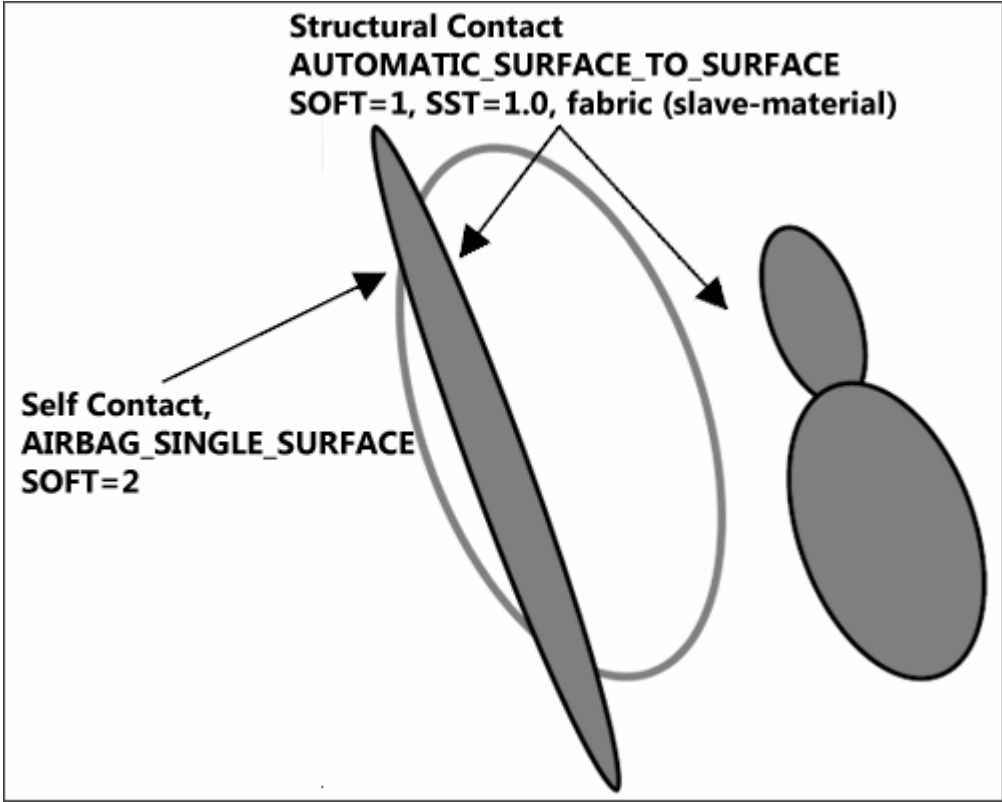


Figure 8.2: Airbag Contact Definition

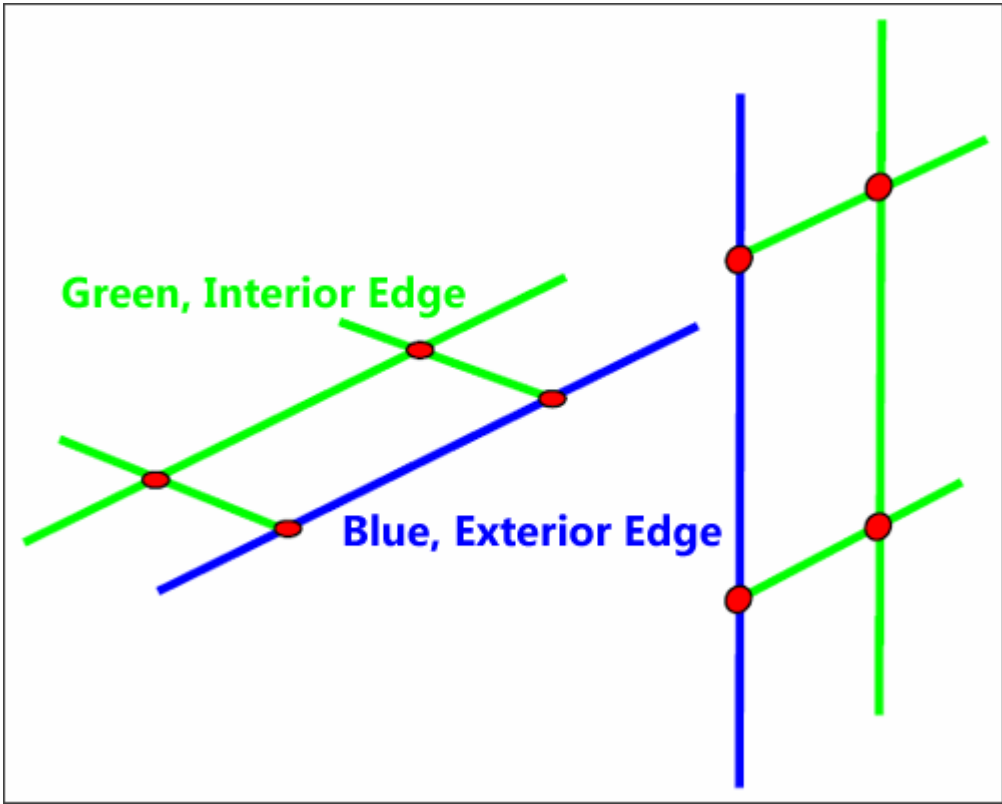


Figure 9.1: Interior and Exterior Shell Edges

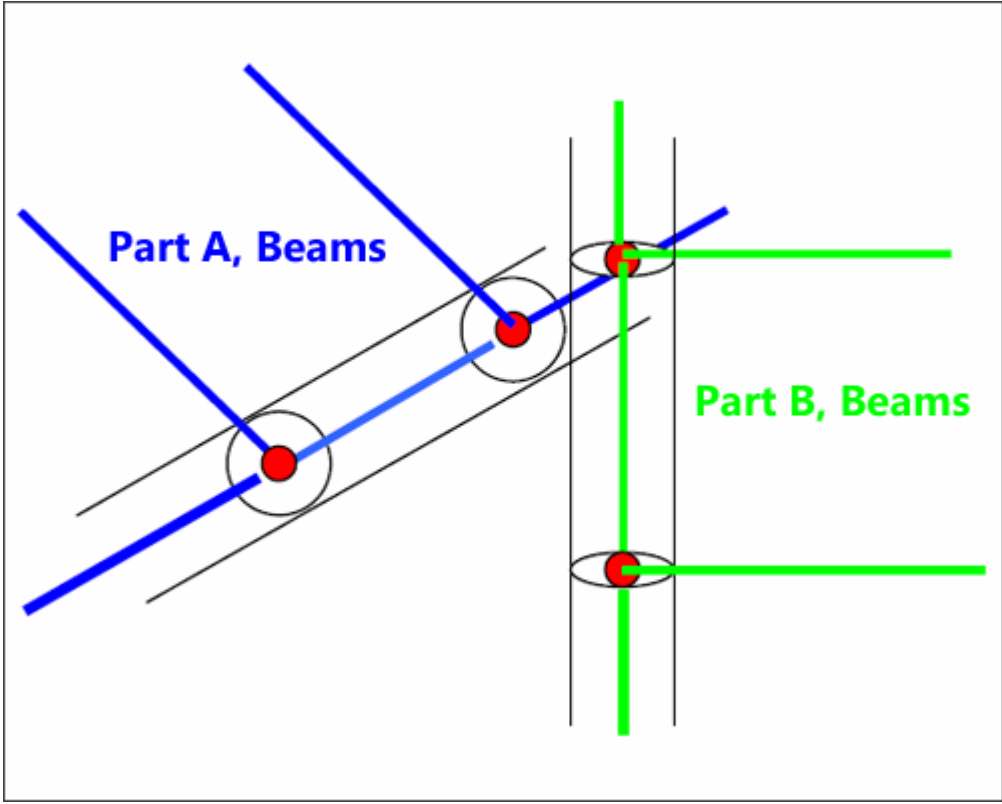


Figure 9.2: Null Beams for Edge-to-Edge Treatment