DEFINE_CURVE_COMPENSATION_CONSTRAINT_*OPTION

Purpose: This keyword with the two options allows for the definition of a localized die face region for springback compensation of stamping tools.

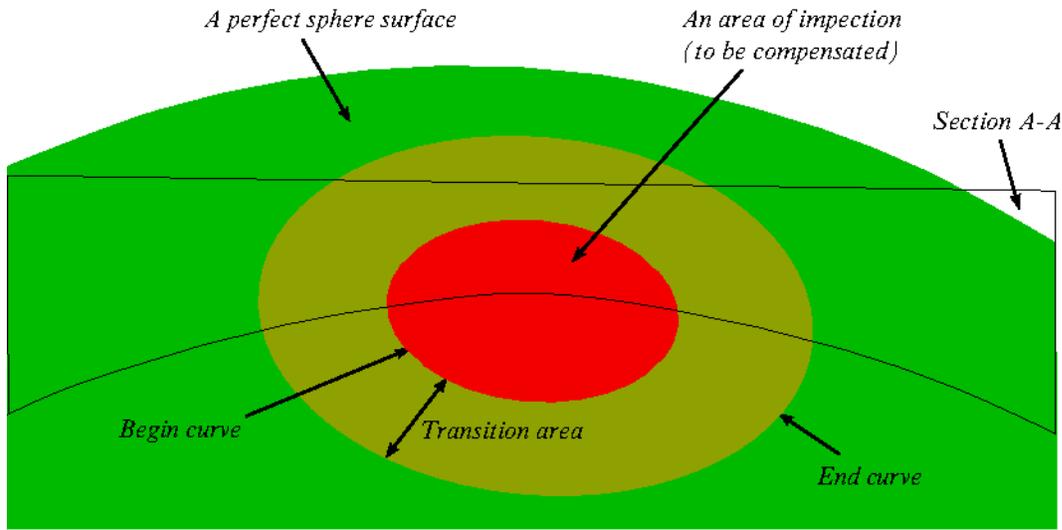Options available include:

BEGIN

END

NOTE:	*DEFINE_CURVE_COMPENSATION_CONSTRAINT_BEGIN and *DEFINE_CURVE_COMPENSATION_CONSTRAINT_END are not valid in the context of a general keyword input deck. Instead, they may only be used inside of an *INCLUDE_COMPENSATION_CURVE include file.

The required option, which must be either BEGIN or END, distinguishes between two different closed curves, which, when taken together identify a portion of the die wherein springback compensation is applied, and a transition region for which compensation smoothly tapers off.

Card 1	1	2	3	4	5	6	7	8
Variable	CRVID	INOUT	TYPE					
Type	I	I	I					
Default	0	0	none					

Point Cards. Include as many as necessary. This input ends at the next keyword ("*") card. Only the projection of this curve onto the x-y plane is used.

Card 2	1	2	3	4	5	6	7	8
Variable	X	Y	Z					
Type	F	F	F					
Default	0.0	0.0	0.0					

Figure 0-1. Local area compensation.

VARIABLE	DESCRIPTION
CRVID	Curve ID; must be unique. The curve must be closed: its first and last point *must* coincide.
INOUT	Flag to indicate local area to be compensated:

      EQ.0: For this option, the compensated region of the die consists of all points for which the projection onto the x-y plane is exterior to the projection of the BEGIN curve. The projection of the END curve is assumed exterior to the BEGIN curve. The transition region, then, consists of all die points for which the projection is between the BEGIN and END curves. All other points on the die are uncompensated.

      EQ.1: For this option, the compensated region of the die consists of all points for which the projection onto the x-y plane is interior to the projection of the BEGIN curve. The projection of the END curve is assumed exterior to the BEGIN curve. The transition region, then, consists of all die points for which the projection is between the BEGIN and END curves. All other points on the die are uncompensated. See Figure **0-1**.

VARIABLE	DESCRIPTION
TYPE	Type code - must be "0".
X	X-coordinate of a point on the curve.
Y	Y-coordinate of a point on the curve.
Z	Z-coordinate of a point on the curve.

Motivation:

Sometimes springback occurs in a localized region of the die face. Since other parts of the die face are better left undisturbed, a localized compensation makes the most sense to bring the part shape back to the design intent. A typical such example will be the front portion along the grill and headlamp, or the rear portion along the windshield of a trimmed hood inner panel. A decklid (or trunk lid) inner also exhibits the similar needs. Once the localized areas are identified, iterative compensation scheme may be employed within this localized region to bring the springback panel back to design shape.

Modeling details:

Referring to Figure **0-1**, the keywords 'COMPENSATION_CONSTRAINT_BEGIN' and 'COMPENSATION_CONSTRAINT_END' must be used together in a file, which in turn will be included in keyword *INCLUDE_COMPENSATION_CURVE. The keyword 'BEGIN' precedes the keyword 'END', each is defined by discrete points. In addition, each curve must form a closed loop. The area formed between the two curves is a transition area, and will be affected in the compensated tooling. LS-PrePost4.0 under *Curve/Merge/Multiple Method*, multiple disconnected curves can be joined together, and output in '.xyz' format required here.

The curve can be a 3-D piecewise linear curve with coordinates in X, Y and Z. However, Z-coordinates are ignored; meaning the tooling to be compensated must be positioned so draw direction is in global Z; otherwise error will occur. In addition, it is assumed that both "blank before springback" and "blank after springback" will be smaller than rigid tools in dimension. It is further noted the rigid tool meshes should be discretized fine enough to provide enough degrees of freedom for the compensation.

Application example – single region:

A complete input deck is provided below for a local compensation simulation. The keyword files *state1.k* and *state2.k* consist model (nodes and elements) information of the blank before and after springback, respectively. It is noted here that if the blank is adaptively refined, the adaptive constraints must be included in the keyword files. The keyword file *tools.k* consists the stamping tools (with PID 1, 2, 3 and 4) all positioned in home position. The keyword file *curvesxy.xyz* consists keywords 'BEGIN' and 'END' defining the two closed-loop curves used to define a localized area.

```
*KEYWORD
*TITLE
LS-Dyna971 Compensation Job
$---+----1----+----2----+----3----+----4----+----5----+----6----+----7----+----8
*INTERFACE_COMPENSATION_NEW
$   METHOD       SL       SF     ELREF     PSIDm     UNDCT     ANGLE   NOLINEAR
         6   10.000    0.700         0         1         0         0          1
*INCLUDE_COMPENSATION_BLANK_BEFORE_SPRINGBACK
state1.k
*INCLUDE_COMPENSATION_BLANK_AFTER_SPRINGBACK
state2.k
*INCLUDE_COMPENSATION_DESIRED_BLANK_SHAPE
state1.k
```
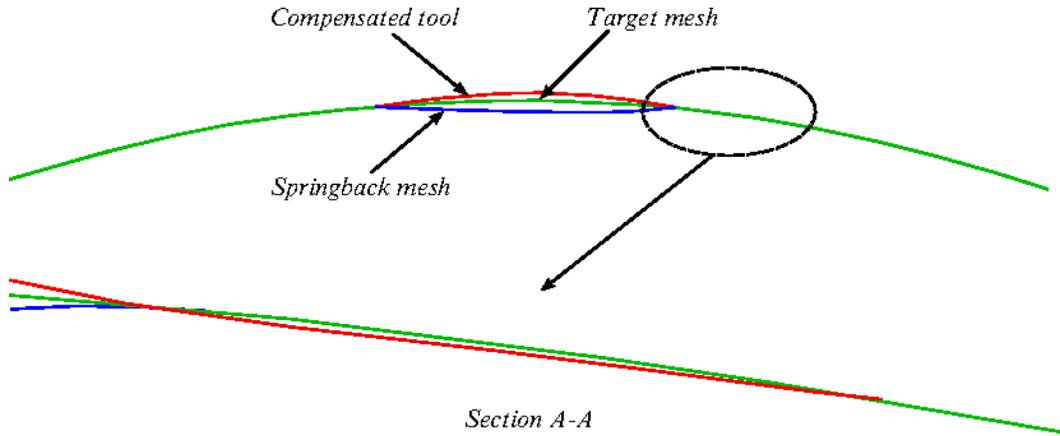
Figure 0-2. Local compensation details.

```
*INCLUDE_COMPENSATION_COMPENSATED_SHAPE
state1.k
*INCLUDE_COMPENSATION_CURRENT_TOOLS
tools.k
*INCLUDE_COMPENSATION_CURVE
curvesxy.xyz
*SET_PART_LIST
        1
1,2,3,4
*END
```

A portion of the file *curvesxy.xyz* is shown below,

```
*KEYWORD
*DEFINE_CURVE_COMPENSATION_CONSTRAINT_BEGIN
$      CID    IN/OUT      TYPE
        1        1          0
   -1.86925e+02    1.83338e+03    -1.55520e+01
   -1.83545e+02    1.83003e+03    -1.55469e+01
   -1.80162e+02    1.82668e+03    -1.55428e+01
   -1.91811e+02    1.83884e+03    -1.56014e+01
   -1.90187e+02    1.83701e+03    -1.55852e+01
   -1.88560e+02    1.83519e+03    -1.55688e+01
   -1.86925e+02    1.83338e+03    -1.55520e+01
*DEFINE_CURVE_COMPENSATION_CONSTRAINT_END
$      CID    IN/OUT      TYPE
        2        1          0
   -4.07730e+02    1.61371e+03    -8.04858e+01
   -3.84480e+02    1.59890e+03    -7.99169e+01
   -3.61193e+02    1.58423e+03    -7.93471e+01
   -3.37832e+02    1.56984e+03    -7.87756e+01
   -4.49289e+02    1.67556e+03    -8.04582e+01
   -4.35672e+02    1.65473e+03    -8.05162e+01
   -4.21764e+02    1.63396e+03    -8.05530e+01
   -4.07730e+02    1.61371e+03    -8.04858e+01
*END
```

It is noted the first point and last point are exactly the same, forming a closed loop. In Figure **0-1**, local area compensation is to be performed in the center portion of a rigid sphere. Based on springback and target meshes, the compensated tool mesh is obtained and smooth transition areas are achieved, Figure **0-2**. Here the compensation scale factor of 0.7 is used.

Application example – multiple regions:

Multi-region localized compensation is also possible by defining multiple pairs of the **_BEGIN** and **_ END** keywords, each forming a localized region. For example, for localized compensation of two regions, the file *curvesxy.xyz* will read as follows,

```
*KEYWORD
*DEFINE_CURVE_COMPENSATION_CONSTRAINT_BEGIN
$      CID    IN/OUT     TYPE
         1         1        0
     3.67967e+02    1.63423e+03    -6.98532e+01
     3.60669e+02    1.62992e+03    -6.92921e+01
     3.53586e+02    1.62525e+03    -6.88777e+01
...
*DEFINE_CURVE_COMPENSATION_CONSTRAINT_END
$      CID    IN/OUT     TYPE
         2         1        0
     4.12534e+02    1.75537e+03    -5.83975e+01
     3.98853e+02    1.75264e+03    -5.58860e+01
     3.85292e+02    1.74921e+03    -5.35915e+01
...
*DEFINE_CURVE_COMPENSATION_CONSTRAINT_BEGIN
$      CID    IN/OUT     TYPE
         3         1        0
    -4.37478e+02    2.67393e+03    -1.70421e+02
    -4.45605e+02    2.67209e+03    -1.71724e+02
    -4.53649e+02    2.66985e+03    -1.72894e+02
...
*DEFINE_CURVE_COMPENSATION_CONSTRAINT_END
$      CID    IN/OUT     TYPE
         4         1        0
    -4.49426e+02    2.79057e+03    -2.18740e+02
    -4.63394e+02    2.78749e+03    -2.20955e+02
    -4.77223e+02    2.78370e+03    -2.22938e+02
...
*END
```
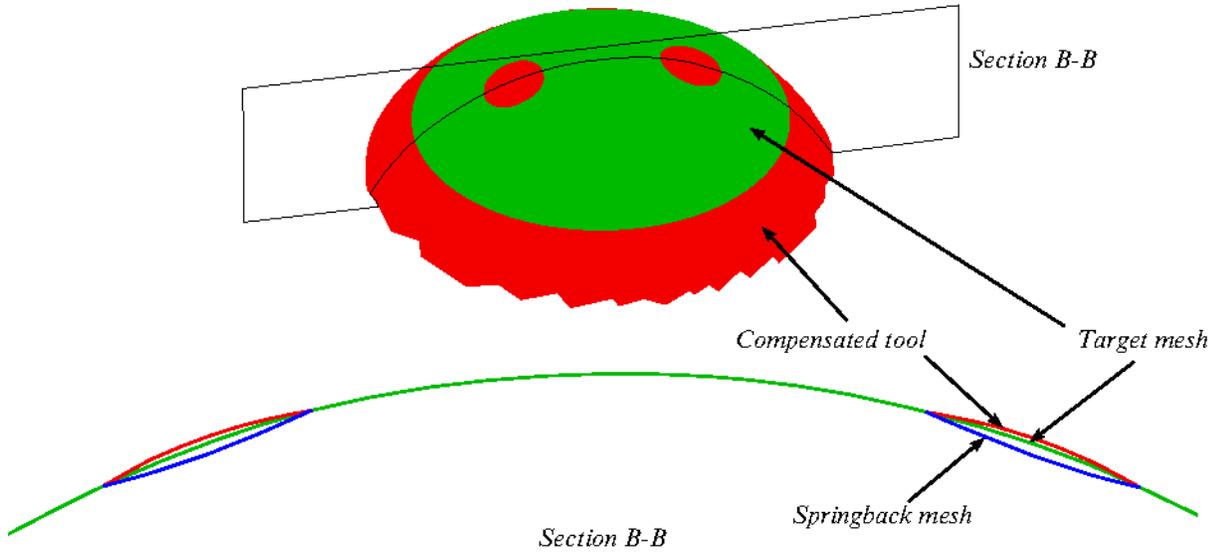
Figure 0-3. Multi-region local compensation.

Figure **0-3** (top) shows an example of two localized areas of the sphere to be compensated. The compensation results are shown in Figure **0-3** (bottom). Again, a compensation scale factor of 0.7 was used and smooth transition areas are achieved.

Revision information:

This feature is available in LS-DYNA Revision 62038 and later releases. Multi-region localized compensation is available in Revision 66129 and later releases. In addition, prior to Revision 66129, all keywords must be capitalized.