

***INCLUDE_COMPENSATION_{OPTION}**

Purpose: This group of keywords allow for the inclusion of stamping die geometry information for springback compensation. In addition, trim curves from the target geometry can be included for mapping onto the intermediate compensated tool geometry, which can be used for the next compensation iteration. Furthermore, compensation can be done for a localized tool region. These keywords must be used together with *INTERFACE_COMPENSATION_NEW.

Options available include:

- BLANK_BEFORE_SPRINGBACK
- BLANK_AFTER_SPRINGBACK
- DESIRED_BLANK_SHAPE
- COMPENSATED_SHAPE
- CURRENT_TOOLS
- TRIM_CURVE
- CURVE
- ORIGINAL_DYNAIN
- SPRINGBACK_INPUT
- COMPENSATED_SHAPE_NEXT_STEP
- SYMMETRIC_LINES
- ORIGINAL_RIGID_TOOL
- NEW_RIGID_TOOL
- ORIGINAL_TOOL
- UPDATED_BLANK_SHAPE
- UPDATED_RIGID_TOOL

Blank Before Springback Card. Additional card for BLANK_BEFORE_SPRINGBACK keyword option.

Card 1	1	2	3	4	5	6	7	8
Variable	FILENAME							
Type	C							
Default	blank0.tmp							

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Blank After Springback Card. Additional card for BLANK_AFTER_SPRINGBACK keyword option.

Card 1	1	2	3	4	5	6	7	8
Variable	FILENAME							
Type	C							
Default	spbk.tmp							

Desired Blank Shape Card. Additional card for DESIRED_BLANK_SHAPE keyword option.

Card 1	1	2	3	4	5	6	7	8
Variable	FILENAME							
Type	C							
Default	reference0.dat							

Compensated Shape Card. Additional card for COMPENSATED_SHAPE keyword option.

Card 1	1	2	3	4	5	6	7	8
Variable	FILENAME							
Type	C							
Default	reference1.dat							

Current Tools Card. Additional card for CURRENT_TOOLS keyword option.

Card 1	1	2	3	4	5	6	7	8
Variable	FILENAME							
Type	C							
Default	rigid.tmp							

Generic Filename Card. Additional Card for TRIM_CURVE, CURVE, ORIGINAL_DYNAIN, SPRINGBACK_INPUT, COMPENSATED_SHAPE_NEXT_STEP, ORIGINAL_RIGID_TOOL, NEW_RIGID_TOOL, ORIGINAL_TOOL, UPDATED_BLANK_SHAPE, and UPDATED_RIGID_TOOL keyword options.

Card 1	1	2	3	4	5	6	7	8
Variable	FILENAME							
Type	C							
Default	rigid.new for updatedpart.tmp for UPDATED_BLANK_SHAPE; newrigid.tmp for UPDATED_RIGID_TOOL.							

Symmetric Lines Cards. Additional card for SYMMETRIC_LINES keyword option.

Card 1	1	2	3	4	5	6	7	8
Variable	SYMID	SYMXY	X0	Y0				
Type	I	I	F	F				
Default	1	none	0.0	0.0				

VARIABLE	DESCRIPTION
FILENAME	<p>For options below, input the name of the keyword files containing nodes and elements information, with adaptive constraints if exist. Currently all sheet blanks must have the same numbers of nodes and elements.</p> <p>BLANK_BEFORE_SPRINGBACK, BLANK_AFTER_SPRINGBACK, DESIRED_BLANK_SHAPE, COMPENSATED_SHAPE, CURRENT_TOOLS, COMPENSATED_SHAPE_NEXT_STEP</p> <p>For option ORIGINAL_DYNAIN, input the dynain file name from LS-DYNA simulation (for example, trimmed panel from ITER0 baseline simulation) which contains model information, adaptive constraints, stress and strain tensor information. This keyword is to be used in conjunction with *INTERFACE_COMPENSATION_NEW_ACCELERATOR.</p> <p>For option SPRINGBACK_INPUT, give the file name of springback simulation input deck for the baseline ITER0 simulation. This keyword is to be used in conjunction with *INTERFACE_COMPENSATION_NEW_ACCELERATOR.</p> <p>For option TRIM_CURVE, input the name of the keyword file containing X, Y, Z coordinates as defined using keyword *DEFINE_CURVE_TRIM_3D (only TCTYPE=0, or 1 is supported). This option is used to map the trim curve to the new, compensated tooling mesh for next iterative simulation.</p> <p>For option CURVE, input the name of the keyword file containing X, Y, Z coordinates of two curves defining the compensation zone, using keywords: *DEFINE_CURVE_COMPENSATION_BEGIN, and, *DEFINE_CURVE_COMPENSATION_END. This option is for compensation of localized tooling areas.</p> <p>All foregoing keyword options are used together with *INTERFACE_COMPENSATION_NEW.</p> <p>For options ORIGINAL_RIGID_TOOL and NEW_RIGID_TOOL, input the file names of the keyword file containing meshes of the rigid tools. This option is used to smooth distorted meshes of localized tool surfaces. These keyword options are used together with *INTERFACE_COMPENSATION_NEW_LOCAL_SMOOTH.</p>

VARIABLE	DESCRIPTION
FILENAME (continued)	<p>For option ORIGINAL_TOOL, input the file name of the original tool (without any compensation) mesh containing nodes and elements information in keyword format. This option allow the use of the original tool mesh, which is of higher quality, in the iterative compensation runs, to minimize the tool surface mesh distortion in the addendum and binder areas of the compensated tool (see Remarks). These keyword options are used together with *INTERFACE_COMPENSATION_NEW.</p> <p>For options UPDATED_BLANK_SHAPE, and UPDATED_RIGID_TOOL, input the respective mesh information in keyword format. The updated blank shape is the blank formed (or trimmed) shape based on the new tool (die) geometry. These options allow for updating of compensated tool shape for small part shape changes, without the need to go through a full-blown iterative compensation loop again (see Remarks). The options are used together with *INTERFACE_COMPENSATION_NEW_PART_CHANGE, among others.</p>
SYMID	ID of the symmetric condition being defined.
SYMXY	Code defining symmetric boundary conditions: EQ.1: symmetric about Y-axis. EQ.2: symmetric about X-axis:
X0, Y0	Coordinates of a point on the symmetric plane.

About various options:

This group of keywords is used in conjunction with *INTERFACE_COMPENSATION_NEW, to compensate stamping tool shapes for springback with an iterative method. The method approaches the final target design intent from two opposite directions from iteration to iteration. A typical successful compensation requires about 3~4 iterations.

When the option BLANK_BEFORE_SPRINGBACK is used, the included file is the mesh information in keyword format in the first state (from D3PLOT) of the springback simulation, or the 'dynain' file after trimming (before springback and with no mesh coarsening. The default file name is 'blank0.tmp'.

When the option BLANK_AFTER_SPRINBACK is used, the included file is the 'dynain' file after springback, or the last state mesh (from D3PLOT) of the springback. The default file name is 'spbk.tmp'.

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When the option DESIRED_BLANK_SHAPE is used, the included file is the 'dynain' file after trimming in the first iteration. This file never changes in all subsequent iterative compensation. The file name default is 'reference0.dat'.

When the option COMPENSATED_SHAPE is used, the included file for the first iteration, is a 'dynain' file, same as in the option DESIRED_BLANK_SHAPE; and for the following compensation iterations, this file is obtained from the file 'disp.tmp' generated as an output file during the previous compensation iteration. The default file name is 'reference1.dat'.

When the option CURRENT_TOOLS is used, the included file is the file containing the tool mesh in the keyword format. This is the tool mesh from the last compensation run and used for the current forming simulation. The draw bead nodes have to be included in this file so that they will be modified together with the rigid tools. The default file name is 'rigid.tmp', and if the file is named as 'rigid0.tmp' the elements of the tools get refined along the outline of the part.

When the option TRIM_CURVE is used, trim curves off the current tools are mapped onto the compensated tools for the trimming operation in the next iteration. If the trimming simulation uses the IGES format trim curves, a new file 'geocur.trm' will be generated at the end of the trimming simulation. The file basically contains XYZ data of the trim curves in keyword *DEFINE_CURVE_TRIM_{OPTIONS}, which is used for the compensation run. It is noted that the variable TCTYPE in the keyword must be set to '0' (or '1') for the compensation. Length of lines everywhere in the compensated part is calculated according to springback amounts (including the die expansion factors, therefore no die expansion needs to be included in the NC machining of the compensated tooling). These mapped trim curves can be used for die development on the compensated tools and for laser trimming of stamped panels. Procedures outline in keyword manual pages *INTERFACE_BLANKSIZE can be followed to convert in LS-PrePost IGES file of the trim curves to XYZ format (and vice versa) used in this keyword.

In an example keyword input shown below, the file name for this option is *trimcurves.k*. The format is in XYZ format, written with LS-PrePost:

```
*DEFINE_CURVE_TRIM_3D
$#   tcid   tctype   tflg   tdir   tctol   toln   nseed
      1116     1       1       1       0.100     1
$#           cx           cy           cz
      178.05170      -326.24771      51.924496
      177.77397      -301.90869      50.288792
      177.29764      -265.39716      48.594341
...

```

When the option CURVE is used, it allows for die face compensation of a local region in a stamping die. This option is used in conjunction with two more keywords defining two enclosed curves that form the compensation zone in position coordinates X, Y, Z:

*DEFINE_CURVE_COMPENSATION_CONSTRAINT_BEGIN, *DEFINE_CURVE_COMPENSATION_CONSTRAINT_END. Detailed usage of these two keywords is available in the related manual pages. In a complete keyword example shown below, the file name for this option is *curves.k* containing these two keywords. The format is in XYZ format, written in LS-PrePost4.0. A detailed explanation of each keyword is given in the manual pages related to *INTERFACE_COMPENSATION_NEW.

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```
*INCLUDE_COMPENSATION_COMPENSATED_SHAPE_NEXT_STEP
Reference1_flanging.tmp
*INCLUDE_COMPENSATION_CURRENT_TOOLS
rigid.tmp
*SET_PART_LIST
$   PSID
    1
$   PID
    2
*END
```

The option `SYMMTRIC_LINES` applies to compensation Method 7 and 8, as discussed in `*INTERFACE_COMPENSATION_NEW`. In a complete keyword input example below, part set ID 1 is being compensated with symmetric boundary condition about X-axis. The symmetric plane passes a point with coordinates of $x=101.5$, and $y=0.0$.

```
*KEYWORD
$---+---1---+---2---+---3---+---4---+---5---+---6---+---7---+---8
$*INTERFACE_COMPENSATION_NEW
$ Method=8 changes the binder; Method=7 binder/P.O. no changes.
*INTERFACE_COMPENSATION_NEW
$   METHOD      SL      SF      ELREF      PSID      UNDRCT      ANGLE      NLINEAR
      7      10.000      1.000      2      1      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
*INCLUDE_COMPENSATION_COMPENSATED_SHAPE
./state1.k
*INCLUDE_COMPENSATION_CURRENT_TOOLS
./currenttools.k
*INCLUDE_COMPENSATION_SYMMTRIC_LINES
$   SYMID      SYMXY      X0      Y0
      1      2      101.5      0.0
$ SYMXY=2: symmetric about X-axis
*SET_PART_LIST
$   PSID
    1
$   PID
    1
*END
```

The options `ORIGINAL_RIGID_TOOL` and `NEW_RIGID_TOOL` are used together with `*INTERFACE_COMPENSATION_NEW_LOCAL_SMOOTH`, and `*SET_NODE_LIST_SMOOTH`, to smooth local areas of distorted meshes of a tooling surface. Details can be found in manual pages for `*INTERFACE_COMPENSATION_NEW_LOCAL_SMOOTH`.

The option `ORIGINAL_TOOL` is used to obtain a smoother mesh for the addendum and binder region for the current compensation, using the original tool mesh (of better quality) instead of the last compensated tool mesh (maybe distorted). This reduces the accumulative error in mesh extrapolation outside of the trim lines. Details can be found in manual pages for `*INTERFACE_COMPENSATION_NEW`.

The options `UPDATED_BLANK_SHAPE`, and `UPDATED_RIGID_TOOL` calculate a new compensated tool shape according to the updated blank shape. This eliminates the need to go

through a full-blown iterative compensation loop again (see **Remarks**). It is noted that these options should apply only to small part change, which does not affect the springback calculation significantly. Details can be found in manual pages for *INTERFACE_COMPENSATION_NEW_PART_CHANGE.

Revision information:

The option TRIM_CURVE is available starting in Revision 60398. The options ORIGINAL_DYNAIN, and SPRINGBACK_INPUT are available starting in Revision 61264. The option COMPENSATED_SHAPE_NEXT_STEP is available starting in Revision 61406. The option CURVE is available starting in Revision 62038. The option SYMMETRIC_LINES is available starting in Revision 63618. The options of ORIGINAL_RIGID_TOOL and NEW_RIGID_TOOL are available starting in Revision 73850. The option ORIGINAL_TOOL is available starting in Revision 82701. The options UPDATED_BLANK_SHAPE, and UPDATED_RIGID_TOOL are available starting in Revision 82698.

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