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## 1. INTRODUCTION

LS-DYNA 971 release 3.2.1 is an enhanced and bug-fixed release built on LS-DYNA 971 release 2.

This release is not being issued to clients on CD. The software can be downloaded from the Oasys Ltd website at: [www.oasys-software.com/dyna](http://www.oasys-software.com/dyna).

The version, revision (build) number and date of the LS-DYNA code are as follows:

Version ls971s R3.2.1  
Revision 47756

The revision number, precision and version type can be checked in the test box printed at the top of the .OTF and MESSAG files as per the example below.

Livermore Software Technology Corporation	
7374 Las Positas Road Livermore, CA 94551 Tel: (925) 449-2500 Fax: (925) 449-2507 www.lstc.com	
LS-DYNA, A Program for Nonlinear Dynamic Analysis of Structures in Three Dimensions Version : ls971s R3.2.1 Date: 09/18/2008 Revision: 47756 Time: 14:57:19	
- version	
- revision (build) number	
Features enabled in this version:	
- SMP / MPP	Shared Memory Parallel ANSYS Database format ANSYS License (ans110)
Licensed to: ATG OVE ARUP Issued by : arup	
Platform : PC WIN32 OS Level : Windows XP Pro SP2 B2600 Compiler : Intel Fortran Compiler 10.1 Hostname : MCCPC063220 Precision : Single precision (I4R4) Product ID : 47821	
- precision	
Unauthorized use infringes LSTC copyrights	

## 2. ENHANCEMENTS AND MODIFICATIONS MADE TO VERSION 971 RELEASE 3.2.1

**Please note; some definitions have been included in multiple sections for convenience.**

### 2.1 AIRBAGS

- Add new decomposition option based on airbag reference geometry instead of folded geometry. It gives better load balancing while the bag is fully deployed.
- Added pressure limit to airbag LINEAR\_FLUID option.
- Added \*AIRBAG\_PARTICLE.
- Added flag on \*AIRBAG\_HYBRID\_CHEMKIN to turn on/off digitized load curves.
- Enable particle database in *d3plot* file.
- Fixed bug for \*AIRBAG\_WANG\_NEFSKE/HYBRID: Negative parameter A23 with Part-ID > 9999999 was not working in single precision.
- Use local rigid body accelerations for airbag pop option. Previously the global accelerations were used which is in conflict with the users manual's instructions.

### 2.2 ALE

- Bug fix in ale tracer.
- Bug fix for ALE edge coupling.
- Remove the limitation on number of geometry definitions in \*INITIAL\_VOLUME\_FRACTION\_GEOMETRY.
- Support more than 10 AMMGs in ALE.
- Fix for ALE mass scaling.
- Fix for calculating new velocities and temperature after advection for ALE single material with void.
- Bug fix in \*AMBIENT\_HYDROSTATIC\_ALE. For the uppermost AMMG there is no need to determine mixed element or not.
- Bug fix in \*INITIAL\_HYDROSTATIC\_ALE. E0 in \*EOS was calculated wrong.
- Fixed segment based eroding contact when used with an ALE solution. The contact either crashed or failed to detect some contact after erosion.
- Fix time step drop for ALE problems (MPP only).
- Fix memory problem while using ALE coupling ctype=5 (MPP only).
- Fix for multiple ALE elform 5 parts.
- Fix in MPP for certain SPC condition non properly enforced in ALE constrain and penalty coupling.

## 2.3 BEAM ELEMENTS

- PID in \*INTEGRATION\_BEAM allows mixing of different materials in a beam element.
- Fixed bug that caused the wrong beam stresses to be written to *dynain* file (\*INITIAL\_STRESS\_BEAM).
- Fixed bug in \*INITIAL\_STRESS\_BEAM - did not work if the beam had 2 x 2 integration points.
- Fix for beam elements whose internal energy was not kept as eroded internal energy when the beam fails.
- Fix for zero length discrete beams with SCOR set to 2.

## 2.4 BOUNDARY

- New feature \*BOUNDARY\_PRESCRIBED\_ORIENTATION\_RIGID. Input sequence of rigid body rotations about 3 unique axes
- New feature \*BOUNDARY\_PRESCRIBED\_ACCELEROMETER\_RIGID. Input accelerometer data to drive rigid bodies
- Angle shift variable was being converted to a load curve in \*BOUNDARY\_PRESCRIBED\_ORIENTATION\_RIGID\_ANGLES.
- Retain more digits for birth and death times of \*BOUNDARY\_PRESCRIBED\_MOTION\_RIGID to avoid truncation error.
- New \_VECTOR option for PRESCRIBED\_ORIENTATION.
- Allow more than one PRESCRIBED\_MOTION\_RIGID to be applied to the same rigid material if at least one of them is initially turned off by sensors.
- Fix a load curve check for \*BOUNDARY\_PRESCRIBED\_ORIENTATION\_RIGID\_DIRCOS. Add load curve check (consistent number of points) for \_ANGLES and \_EULERP.
- Fix roundoff problem in \*BOUNDARY\_PRESCRIBED\_MOTION\_RIGID.
- Fix for prescribed acceleration problem with scale factor being applied twice - (MPP only).
- Add use of \*DEFINE\_CURVE\_FUNCTION for prescribed motion and implicit.
- Added implicit treatment of boundary prescribed orientation.

## 2.5 CONSTRAINTS & SPOTWELDS

- Fixed the effective strain rate calc in spot weld assemblies that use DaimlerChrysler failure.
- Fixed bug where ELEMENT\_INERTIA is ignored by \*CONSTRAINED\_INTERPOLATION

- Added an error check for spot weld material that is used by both individual hex spot welds and also hex weld assemblies. The individual welds are not checked for failure if the material is shared.
- Added spot weld failure to thermal.
- Fix for \*MAT\_100\_DA with spotweld assemblies. The "no failure" option (negative con\_id) was not working before.
- Added the IFLAG option in \*CONSTRAINED\_EXTRA\_NODES.
- Added damage type DG\_TYP=3 to \*DEFINE\_CONNECTION\_PROPERTIES.
- Fix SPC force reporting error for implicit when mass scaling is active.
- Check for redundant tied constraints (implicit).
- Implement \*CONSTRAINED\_SHELL\_TO\_SOLID - (MPP only).
- Added MPP code so that solid weld elements will be deleted if any of their nodes are attached to a shell that erodes. This matches the SMP behaviour.
- If a segment fails which is also attached to one node of a spotweld brick then the brick element is deleted.
- Change MPP handling of \*CONSTRAINED\_JOINT\_TRACTION\_TRANSLATIONAL, which was not working correctly.
- Fix computation of separation distance for tied contact after an adaptive step.
- Fix for KE calculation with \*CONSTRAINED\_INTERPOLATION.
- Fix for initialization of one noded beam/spotwelds, to better handle the case where there are parallel layers of material.
- Added damage type DG\_TYP=4 to DEFINE\_CONNECTION\_PROPERTIES.
- Added MPP support for IFLAG=1 in CONSTRAINED\_EXTRA\_NODES.
- Correct Implicit handling of tied nodes with failure constraints.
- Fixed MPP brick weld initialization so that it will not hang.
- Fix for \*CONSTRAINED\_JOINT\_TRANSLATIONAL\_MOTOR not working correctly in MPP.
- Fixed type 9 beam spot weld failure. The moment term in the failure calculation may have used the wrong beam length since the wrong beam element ID was used. The 3-sheet calculation was OK.
- Fix initialization of \*CONSTRAINED\_INTERPOLATION for solid only models.
- Fixed hex spot weld assemblies that under certain circumstances were failing at the wrong time.

Fix for hex weld assemblies so that those generated by \*DEFINE\_HEX\_SPOTWELD\_ASSEMBLY go through the assembly failure routine and output to *swforc* as an assembly instead of individual elements.

## 2.6 CONTACT

- Fix MPP automatic tiebreak contact to avoid crashes.

- Fix MPP contact types 3/5/10 that caused some nodes in contact with solid elements to be missed.
- Force orientation of MPP contact interfaces that include solid elements to the orientation implied by those solid elements.
- Added tied penalty contact support to MPP implicit.
- Fixed restart bug if tiebreak is used.
- Bug fix for single edge contact - (MPP only).
- Fixed a problem with large forces in segment based contact caused by tied contacts moving nodes in the first cycle.
- Enhance MPP beam-to-beam contact to agree with SMP results - (MPP only).
- Fixed bug in \*CONTACT\_TIEBREAK\_SURFACE\_TO\_SURFACE with failure values set incorrectly.
- Fix for MPP smooth contact not offsetting the control points for some non-forming contacts.
- Fixed the OPTT option on \*PART\_CONTACT for segment based contact. It was using the input value as the added thickness rather than half of it.
- Fixed a bug that could cause MPP segment based contact to hang if both single surface and surface eroding contact were used in the same model.
- Fix for unloading curve in rigid body to rigid body contact.
- Change MPP single surface and surface to surface contacts to do calculations in double precision.
- Fix some possible cases of MPP hanging in problems with automatic-tiebreak contacts.
- Change to the way MPP handles initial penetrations, so the full penetration amount is compensated for at first contact (no tolerance). The fixes some cases of nodes moving in models with no loads or movement.
- Added Contact ID to contact message "Penetrating node eliminated ...".
- Add a new feature to \*TERMINATION\_CONTACT allow the job to terminate when the maximum contact force is reached.
- Add guided cable contact to MPP.
- Add flag to turn on shell element offsets in contact.
- Fix for \*CONTACT\_AUTOMATIC\_...\_TIEBREAK with OPTION=3 fixed in SMP - MPP was ok.
- Fix for MPP handling of tied thickness when specified on the contact card.
- Fixed update orientation option for SMOOTH forming contact (MPP only)
- Fix for frictional energy calculation for auto tiebreak contact.
- MPP modifications to bucketsort for AUTO\_TIEBREAK contacts, to better handle very thick materials.
- Fixed a segment based contact bug that caused the optional thickness on \*PART\_CONTACT to be ignored if shell thickness updates were active and no parts used the thickness scale factor on \*PART\_CONTACT.

- Fix problem in automatic tiebreak options 8/10/11 where the mass of the slave node was being used, but was not being passed, resulting in NANs.
- MPP changes to better handle thickness changes in contact.
- Fix in MPP for initialization problems of some slave node arrays in \*CONTACT\_ERODING\_NODES\_TO\_SURFACE.

## 2.7 DATABASE & OUTPUT

- **JNTFORC** now includes energy for each penalty-based joint
- **SLEOUT** now includes frictional energy for each contact
- **EIGOUT** now includes participation factors for each mode in an eigenvalue analysis
- Fix some MPP problems in **INTFOR** database.
- Fixed thick shell output with CMPFLG=1 on \*DATABASE\_EXTENT\_BINARY.
- Fixed stress output for type 1 thick shell elements in **d3plot** and **elout** files.
- Fix MPP support for interface force file reading, when segment linking is used and there are more than 1 segment interfaces.
- **BINOUT** support for energy in LSDA based **JNTFORC** file.
- Print decomposition file and # of processors info to the screen, **d3hsp**, and **messag** files when MPP execution starts.
- Offer the same output of 'contact gap' (**INTFOR** file) for automatic tiebreak options 10 and 11 as already available for option 8.
- Bug fix for **d3hsp** output of \*MAT\_083 parameters HU and SHAPE.
- Fix **glstat** system damping energy calculation - (MPP only).
- MPP support for node mass info output to **d3plot**.
- Output first state of **SPCFORC** at t=0 rather than t=dt.
- Fix for rigid wall ID in the **BINOUT** files.
- Minor fix for accelerations in **NODOUT** whenever global damping is active.
- Fixed shell element types 6 and 7 when used with anisotropic material. The angle cosines and sines were not being initialized correctly. Also, fixed the output of stress and strain in shell elements that use different material models in different layers using either \*INTEGRATION\_SHELL or \*PART\_COMPOSITE.
- Fix **NCFORC** file for interfaces with IDs of more than 5 digits.
- Fix for beam elements whose internal energy is not kept as eroded internal energy when the beam fails.
- Slight modifications to prevent a nonzero pressure state in the reference configuration for parts with equation of state.
- Change to keyword processing of solid/beam/shell/thickshell element labels/ids related to time history blocks: previously they were all written together in the structured file. This

caused the **d3hsp** file to be wrong (all were identified as being SOLID elements), as well as the legends being written to the wrong places in the binout file.

- Fix for **MATSUM** output: the material numbers were mixed up.
- MPP fix for incorrect mass reported in **RCFORC** file.
- Fixed hex spotweld assembly output to **SWFORC**.
- Fix for bug related to **SECFORC** file and null beams.
- Bug fix for rb-velocity output to **D3PLOT**, **MATSUM** and **GLSTAT** files.
- MPP fix for **RBDOUT** output of rigid bodies that are shared among processors.
- Fixed thick shell type 2 strain output.
- Fixed output of \*DEFINE\_CONNECTION properties to **MESSAG** file to output parts instead of material ID's.
- Added local coordinate system option for **RCFORC** file.
- Fix energy growth related to bugs in moving flat rigid walls.
- Fix for KE calculation with \*CONSTRAINED\_INTERPOLATION.
- Added contact ID to contact message "Penetrating node eliminated ...".
- Fix for **RBDOUT** file in the BINOUT file, when rigid deformable switching is active, the number of rigid bodies can be different every cycle.
- Added new history variable (history var#11) to Gurson material (MAT\_120 and MAT\_120\_JC). It is a dimensionless value showing material damage:  $gurdam=(f-f_0)/(ff-f_0)$ . Only for post-processing.
- \*DAMPING\_FREQUENCY\_RANGE energy now included in System Damping Energy in **GLSTAT** file. Previously, the energy was counted as negative external work - this is no longer the case.
- Add list of untied nodes to **MESSAG** file for automatic tiebreak contact option.
- Enable particle database in **d3plot** file when using \*AIRBAG\_PARTICLE.
- Added all integration points to **d3plot** database; activated by setting MAXINT= to a negative number.
- Add MPP support for recent IOOPT option for **intfor** file.
- Added IOOPT=3 for \*DATABASE\_BINARY\_INTFOR.
- Add warning about not supporting prescribed motion during modal superposition.
- Fix for MPP output of peak pressures in intfor file: last state had all 0 for these.
- Fix for frictional energy calculation for auto tiebreak contact.
- Fix for rotations in MPP output of **drdisp.sif** file.
- Fix format to tell users to check **D3HSP** for printed curve IDs. The curves may be internally generated in the keyword reader.
- Fix for MPP rigid-body compression in d3plot when used with pre-decomposition.
- Fix: Internal energy is now computed for shell type 18.

- Fix for file **SSSTAT** in restart. Also we have separated the output interval of \*DATABASE\_SSSTAT\_MASS\_PROPERTIES and \*DATABASE\_GLSTAT.
- Changed the restart name from *messag* to *message#*
- Added flag to **d3plot** database to signal Isprepost that 4 inplane integration points are output. For 1 point shells 3 null inplane points are output.
- Fix missing legend in MPP version of *matsum* file.
- Fix for rigid body number in error message.

## 2.8 EFG & SPH

- Bug fixed in axisymmetric EFG.
- Fixed extra file created by tracer particle for SPH.
- Fixed 3D EFG adaptivity for \*MAT\_024.
- Fixed several bugs with 3D EFG adaptivity.
- Make 3D EFG adaptivity work for hex elements.
- Disable shape function reconstruction for 8 nodes solid in EFG adaptivity.
- Bug fixed related to IEBT=4 in stabilized EFG.
- MPP support for EFG solid element new feature (MAXENT).
- Added stabilization terms in EFG MAXENT approximation in 8-noded cells.
- Fix bug in dummy argument for \*INITIAL\_VELOCITY\_GENERATION with SPH elements.
- Bug fixed for MPP EFG shell type 41.
- Implement \*INITIAL\_VELOCITY\_GENERATION for SPH elements defined by part or set part.
- Fix bug for explosive materials with SPH. Elements with \*MAT\_HIGH\_EXPLOSIVE\_BURN were not detonating.
- Fix for SPH problem during contact initialization.
- Fix problem related to \*SET\_NODE\_GENERAL whenever the part ID is an SPH part.
- Normalized the distance function in MAXENT for EFG. This is to reduce the conditioning number in Hessain matrix.
- Fix bug for SPH elements during initialization of eos type \*EOS\_IGNITION\_AND\_GROWTH\_OF\_REACTION\_IN\_HE and \*EOS\_PROPELLANT\_DEFLAGRATION.
- Fixed a single precision bug in EFG solid 41.
- Fix for 3D EFG adaptivity with using TDEATH in adaptive control.
- Fix bug when multiple symmetry planes with SPH were used.
- Added two options in implicit 2D EFG:

1. 2nd order basis function.
2. Higher-order integration rule.

- Modified the stiffness in 2D plain strain EFG.
- Bug fixed for 2D axisymmetric EFG in centreing the stress point.
- Fix restart bug related to SPH and full deck restart.

## 2.9 IMPLICIT

- Reset stress initialization when implicit rejects a time step.
- Revision to \*MAT\_106 to select properties based on ending time of implicit step.
- Fix for tangent stiffness (implicit) of cohesive \*MAT\_138 and \*MAT\_186. Implicit had to get activated for mat 186 in the first place.
- Added tied penalty contact support to MPP implicit.
- Modified \*MAT\_106 to optionally use the total alpha for computing incremental thermal strains instead of the instantaneous alpha. Required for implicit.
- Fix bug for modal superposition using existing *d3eigv*.
- Fix SPC force reporting error for implicit when mass scaling is active.
- Add warning that implicit does not support \*CONTACT\_ENTITY.
- MPP support for soft=1/implicit time step fixes.
- Check for redundant tied constraints (implicit).
- Fixed a bug in type 20 triangles for buckling analysis.
- Add fix for implicit MPP with superelements and inertia relief.
- Added some useful output for LPRINT values greater than or equal to unity.
- Fix implicit treatment of shell-to-solid interface constraint.
- Add implicit sense switches to screen output.
- Fix for MPP implicit contact convergence.
- Add use of \*DEFINE\_CURVE\_FUNCTION for prescribed motion and implicit.
- Added synchronization of implicit time step after an adaptive remeshing.
- Added arlength method node control in MPP.
- Added implicit treatment of boundary prescribed orientation.
- Correct Implicit handling of tied nodes with failure constraints.
- Fix for rigid body coordinates for implicit to explicit switch.
- Fix for material 57 to correct the calculation of internal energy density which was inaccurate for the large time step sizes of the implicit solver.
- Fix for joints in the presence of implicit-explicit switching.
- Fix handling of sense switches (sw1,sw2,...) for implicit.

## 2.10 INPUT

- ESORT=2 in \*CONTROL\_SHELL to select DKT formulation for all triangles
- IMSCL and DT2MS in \*CONTROL\_TIMESTEP to invoke selective mass scaling
- \*INITIAL\_STRAIN\_SOLID, can now initialize strain in solid elements
- \*INITIAL\_STRESS\_DEPTH, automatically initialize stress in solids (stress assumed linear with depth)
- \*PART\_DUPLICATE to automatically duplicate and transform parts.
- Fix for \*MAT\_020 (RIGID) input issues.
- Add keyword \*CONTROL\_MPP\_IO\_LSTC\_REDUCE to use special REDUCE function in LSTC source to get consistent summation across processors – (MPP only).
- Bug fix for initial stresses in solid elements. Element sorting to tets and pentas was not supported.
- Bug fix for \*MAT\_WINFRITH\_REINFORCEMENT used with \*INCLUDE\_TRANSFORM.
- Fixed bug in \*PARAMETER if more than one definition was specified.
- Add support for \*TERMINATION\_NODE and \*TERMINATION\_BODY - (MPP only).
- Add new input processing capability for superelements.
- Preserved the case for \*KEYWORD\_ID.
- Add option STRESS=-3 for \*INCLUDE\_STAMPED\_PART\_BINARY, which activates long format for history variables and NO mapping of stresses.
- Add decomp option \*CONTROL\_MPP\_DECOMPOSITION\_ELCOST 2. Option:
  - 1 fjvpp, sun
  - 2 ia 64, AMD
  - 3 Intel xeon 64, xeon 32
  - 4 other

element costs for decomposition calculation. Users should be able to use different platforms for pre-decomposition to get consistent decomp – (MPP only).

- Added option to \*CONTROL\_ACCURACY. If INN=-2 triangular elements do not use the invariant system.
- If any \*PARAMETER definition is duplicated, LS-DYNA gives an error message and terminate the code after input phase.
- Fix to terminate calculation if \*ELEMENT\_MASS\_PART is used to add mass to solids or beams.
- A minor change to avoid including added mass distribution specified on the \*SECTION\_SHELL in the determination of the rotational mass at the nodal points.
- Fix for TITLE option for \*MAT\_ADD\_EROSION and \*MAT\_ADD\_THERMAL.

- Fix for \*DEFINE\_COORDINATE\_...\_TITLE when used with \*INCLUDE\_TRANSFORM. The title was lost causing major problem when using the *dyna.inc* file.
- Fix for \*INITIAL\_STRAIN\_SHELL which now works even if there is no \*INITIAL\_STRESS\_SHELL input.
- Fixed minor bug related to improper input into \*MAT\_036 which caused error termination.
- Fix bug in \*LOAD\_THERMAL\_VARIABLE if greater than 99999 load curves in input.
- Fix problem related to \*SET\_NODE\_GENERAL whenever the part ID is an SPH part.
- Fix bug that could lead to thermal material data being missed during Keyword input. This occurred occasionally in large models that contained lots of other data before the thermal material data.
- Added new option to initialize bolt stress: \*INITIAL\_AXIAL\_FORCE\_BEAM.
- Transform user-defined local coordinate system (LCO.ne.0) for rigid bodies reoriented during vehicle kinematics initialization.
- Allow part set to be specified for \*CONTROL\_TIMESTEP erode.
- Fixed \*INCLUDE\_TRANSFORM bug related to shells where \_THICKNESS was left off of *dyna.inc* keyword.
- Fix for load curve option in \*ELEMENT\_MASS\_PART keyword.
- Added time dependent added mass option by load curve for keyword \*ELEMENT\_MASS\_PART.
- Fix for \*PARAMETER. Allowed a -minus sign before any parameter definition; for example, -&VAR1.
- Fix \*SENSOR\_DEFINE\_NODE when n2>0
- Fix for MAT\_ARUP\_ADHESIVE in \*INCLUDE\_TRANSFORM.
- \*INITIAL\_DETONATION\_POINT can now use a larger PID (I10).
- Fix in keyword reader for \*MAT\_165. \*MAT\_COMPOSITE\_MSC\_DMG now can be read as well as \*MAT\_COMPOSITE\_DMG\_MSC or \*MAT\_162.

## 2.11 LOADING

- \*INITIAL\_STRAIN\_SOLID. Can now initialize strain in solid elements
- \*INITIAL\_STRESS\_DEPTH. Automatically initialize stress in solids (stress assumed linear with depth)
- \*LOAD\_BLAST\_ENHANCED for pressure from multiple and non-spherical charges
- \*DATABASE\_BINARY\_BLSTFOR to create binary output of blast pressure
- \*LOAD\_BODY\_GENERALIZED
  - SET\_NODE option to select node set for body loads and optional local coord system
  - SET\_PART option to select part set for body loads and optional local coord system

- Fix bug in \*LOAD\_THERMAL\_VARIABLE if greater than 99999 load curves in input.
- Bug fix for \*LOAD\_BEAM\_ELEMENT idtrans translation - (MPP only).
- Add MPP/idtrans support for \*INITIAL\_LOAD\_AXIAL\_BEAM.
- Enabling r-adaptive load\_thermal by initializing temperature after rezoning.
- Fix for load\_thermal\_element option for erroneous error check leading to termination.
- Fixed a bug in \*LOAD\_DENSITY\_DEPTH if number of parts is more than 8.
- Fix for format problem in DYNA.INC file related to \*LOAD\_PRESSURE\_SHELL.
- Added option \*LOAD\_SEGMENT\_SET\_ANGLE
- Add warning in \*LOAD\_BLAST when segments are too close and empirical equation may no longer be valid.

## 2.12 MATERIAL

- New and enhanced Material Models:
  - \*MAT\_030 (SHAPE\_MEMORY; now for Hughes-Liu beams)
  - \*MAT\_071 (CABLE\_DISCRETE\_BEAM)
  - \*MAT\_079 (HYSTERETIC\_SOIL)
  - \*MAT\_138 (COHESIVE\_MIXED\_MODE)
  - \*MAT\_153 (DAMAGE\_3)
  - \*MAT\_165 (PLASTIC\_NONLINEAR\_KINEMATIC)
  - \*MAT\_169 (ARUP\_ADHESIVE)
  - \*MAT\_171 (STEEL\_CONCENTRIC\_BRACE)
  - \*MAT\_172 (CONCRETE\_EC2)
  - \*MAT\_173 (MOHR\_COULOMB)
  - \*MAT\_174 (RC\_BEAM)
  - \*MAT\_191 (SEISMIC\_BEAM)
  - \*MAT\_197 (SEISMIC\_ISOLATOR)
  - Support of user defined failure for:
    - \*MAT\_123 (VP=1)
    - \*MAT\_103
    - \*MAT\_024 (VP=1)
  - \*MAT\_191 now supports end release for beams
  - \*MAT\_187 updates
  - \*MAT\_126 add corotational local coord. system for formulation-1
  - Add V option for aopt=3,4

- \*MAT\_026
- \*MAT\_126
- \*MAT\_036 added a cap to out-of-plane shear stress, when M is integer
- \*MAT\_172 added hourglass properties for shells
- \*MAT\_236 added interior strain point calculation
- \*MAT\_ADD\_THERMAL\_EXPANSION now supports \*LOAD\_THERMAL\_VARIABLE\_SHELL
- \*MAT\_SEATBELT added error termination if the maximum slope in the loading curve exceeds that of the unloading curve.
- Added warning if modulus in a load curve table exceeds Young's modulus for several material models.
- Print Warning if prca and prcb are blank in
  - \*MAT\_002
  - \*MAT\_022
  - \*MAT\_054
  - \*MAT\_055
- Added warning message or error termination if user inputs improper stress-strain curve for fitting for:
  - \*MAT\_027
  - \*MAT\_077
  - \*MAT\_177
  - \*MAT\_178
- Added the negative NUMINT option to material 123
- Added history output for viscoplastic strain rate to:
  - \*MAT\_024 (VP=1)
  - \*MAT\_123 (VP=1)
- Material orientation by CID number for all orthotropic material models.
- LCINT in \*CONTROL\_SOLUTION to control the discretization of material curves.
- Fixed \*MAT\_034 output error that caused a crash on SGI IRIX systems.
- Update \*MAT\_115 shell subroutine to fix single precision bug.
- Fixed \*MAT\_002 with thick shell element type 3.
- Fix 3D EFG adaptivity for \*MAT\_024.
- Fix for \*MAT\_108. The orthotropic transformations were missing.
- Fix for local coordinate systems with large ID's in \*MAT\_020.

- Fix for Gurson \*MAT\_120. With initial stresses from dynain several elements failed at  $t=0$  due to a bad starting value for the plasticity algorithm. Now, a better starting value is used for this case.
- Fix for \*MAT\_100\_DA with spotweld assemblies. The "no failure" option (negative con\_id) was not working before.
- Fix for \*MAT\_120 for nodal pressure tet (elform 13).
- Bug fix for \*MAT\_WINFRITH\_REINFORCEMENT + \*INCLUDE\_TRANSFORM.
- Fix treatment of scaling factor for prescribed motion on rigid bodies with option 4 and 8.
- Modified \*MAT\_106 to optionally use the total alpha for computing incremental thermal strains instead of the instantaneous alpha. Required for implicit.
- Fix to \*MAT\_106 due to initialization problem when restarting with a dynain file.
- Load curve input added to Gurson material \*MAT\_120\_JC (card 5, row 8). This load curve optionally replaces expression with D1, D2, and D3 (see manual).
- Fixed RATE option of \*MAT\_123.
- Fix for \*MAT\_123 to solve element deletion problem.
- Time step calculation problem with solid element type 12 and \*MAT\_106.
- Change pressure calculation in \*MAT\_084 to incremental. This fixes a bug that caused pressure jumps when the algorithm switched between crack-open and crack-closed modes. Results from existing models are likely to change.
- Fix principal stress direction calculation in \*MAT\_173.
- Fixed bug in \*MAT\_024 viscoplastic,  $vp=1.0$ , for solid element.
- Fixed minor bug related to improper input into \*MAT\_036 which caused error termination.
- Add \*MAT\_169, \*MAT\_173, \*MAT\_198 to wedge element (ELFORM 15) - without this, the automatic sorting would not work with these materials.
- Resolve \*MAT\_ACOUSTIC, \*BOUNDARY\_PART\_ACOUSTIC discrepancies with two-sided coupling.
- Fix bug in \*MAT\_ARUP\_ADHESIVE - for XEDGE=0, element failure could lead to a memory corruption with unpredictable consequences.
- Add \*MAT\_084 for wedges (elform 15) and add missing calls to rstrss for tet elements (elform=10) for.
- Enable type 3 and 17 triangle shells for \*MAT\_058.
- Small modification in \*MAT\_169: With new input parameter THKDIR (card 2, column 7), the determination of thru-thickness direction can be changed. THKDIR=0.0: smallest element dimension (default), THKDIR=1.0: direction face 1-2-3-4 to 5-6-7-8.
- Fixed timestep calculation for \*MAT\_089. Previously the material could go unstable if the elastic modulus increased or if the elements gained volume during elastic stretching.
- Fix read problem in \*MAT\_135 to ensure that it is consistent with the new 971 manual.
- Fix to stop auto sorting of degenerate solids for \*MAT\_100, \*MAT\_126.
- Fix for \*MAT\_017 to correct the stress reduction after failure.

- Add effective plastic strain failure to \*MAT\_106 shells.
- Fix for \*MAT\_172 (CONCRETE\_EC2) beams - FRACA was treated as 1.0 if set to any non-zero value.
- Fix for round-off error related to deformation gradient calculations for \*MAT\_057 foam.
- Added \*MAT\_236 based on Boeing user material for silicon carbide coating on reinforced carbon composite.
- Fixed \*MAT\_021 and \*MAT\_023 thermal strain so that good for large strain.
- Minor bug fix for shell element failure in \*MAT\_120. Resurrection of failed IP was possible in very special cases.
- Small modification of \*MAT\_138: more conservative "ek" (stiffness/area) for time step calculation.
- Modified cohesive \*MAT\_138 to be more robust. Only one damage variable instead of two is used. The input is backwards compatible, i.e. old input files run.
- Fix for shell \*MAT\_120: element deletion after NUMINT IPs failed did not work correctly.
- Fix for \*MAT\_DAMAGE\_3, \*MAT\_153 to store plastic strain.
- Fix \*MAT\_015 to take the absolute value of D3 since many users input this constant as a negative number when it should be positive.
- Bug fix for keyword input for \*MAT\_120 (MAT\_GURSON\_JC): One external load curve number (LCDAM) was not converted to internal.
- Fixed fabric (\*MAT\_034) triangle elements when ESORT=2 on \*CONTROL\_SHELL. A major history variable bug caused two-thirds of triangular elements to have zero stress.
- Error stop if initial yield stress is zero for \*MAT\_142.
- Update to: \*MAT\_019, \*MAT\_031, \*MAT\_036, \*MAT\_039, \*MAT\_040, \*MAT\_078, \*MAT\_079, \*MAT\_089, \*MAT\_101, \*MAT\_106, \*MAT\_127, \*MAT\_129, \*MAT\_144, \*MAT\_177, \*MAT\_178, \*MAT\_192 (and others) to eliminate load curve ID round-off in single precision.
- Bug fix for \*MAT\_120\_... where the strain rate was not properly initialized.
- Fix for material 57 to correct the calculation of internal energy density which was inaccurate for the large time step sizes of the implicit solver.
- Fix for material type 61 which goes unstable for tet types 10 and 13.
- Fix possible bug in mat 173 principal stress direction calculation.
- Fix for non working thinning for thick shell elements and material types 2, 22, 55, and 58.
- Fix for Green Naghdi stress rate problem for \*MAT\_035.
- Fix in keyword reader for \*MAT\_165. \*MAT\_COMPOSITE\_MSC\_DMG now can be read as well as \*MAT\_COMPOSITE\_DMG\_MSC or \*MAT\_162.
- Fix for FPE in load curve lookup for \*MAT\_187 (SAMP-1).
- Fix for \*MAT\_090 (\*MAT\_ACOUSTIC) with SMP consistency flag on.
- Fix for \*MAT\_083 with \*DEFINE\_TABLE and \*INCLUDE\_TRANSFORM. Strain rates are in Table abscissa are now transformed correctly.

- Fix for \*MAT\_036 related to out-of-plane shear stress cap.
- Fixes for \*MAT\_187. Time step calculation now also correct in case BULK and GMOD are not given.
- Fix for \*MAT\_034 (\*MAT\_FABRIC) and include transformation of FAC load curve.

## 2.13 MISCELLANEOUS

- \*ELEMENT\_MASS\_NODE\_SET, Distribute a mass over a set of nodes
- \*ELEMENT\_MASS\_PART\_{SET} option to distribute non-structural mass over a part set. Parameter FINMASS to specify total mass (structural + non-structural mass)
- Staged Construction. Breaks building construction process, including excavation, into stages.
- Fix for bug related to \*PART\_COMPOSITE and \*RIGIDWALL\_PLANAR.
- Add echo to d3hsp of control data for pore fluid and staged construction.
- Fix for cohesive element deletion to correctly handle both tied and merged cohesive nodal points.
- Fix to change solid element type 18 to type 1 for explicit calculations. Type 18 is for linear static problems only.
- Fix seamless springback processing for removed parts.
- Fix for 2D adaptive remeshing to include initialization of 2D beam elements. Also fixed problem related to 2D rigid bodies sharing nodes with deformable bodies that are remeshed.
- Fixed bug in Belytschko-Schwer beam related to offset vectors not being accounted for in the calculation of the beam fiber vectors. This caused large forces to develop with no applied loads.
- \*DAMPING\_FREQUENCY\_RANGE energy now included in System Damping Energy in glstat file. Previously, the energy was counted as negative external work - this is no longer the case.
- Fix MPP problem converting set ID information for velocity boundary conditions, which made it impossible to turn them on/off via SENSORS.
- Fix flexible rigid body containing nodal rigid bodies in MPP run.
- Added LCINT to input for CONTROL\_SOLUTION to allow the number of intervals to be defined in the load curve discretization.
- Gracefully exit when NaN detected.
- Fix for possible memory clobbering when \*RIGIDWALL\_PLANAR and \*PART\_COMPOSITE are used together.
- Add part set option for decomposition for partlist.
- Fix memory problem with \*CONTROL\_SHELL, ESORT=2 when the model contains any \*SECTION\_SHELL, ELFORM=5 or \*MAT\_034 (\*MAT\_FABRIC).

## 2.14 RESTARTS

- Fix to MPP full deck restart problem that only occurs if the new and previous models had a different number of rigid shell elements.
- Fixed bug in restart job if deleted element set is specified.

## 2.15 SEATBELT ELEMENTS

- Fixed memory expansion bug related to shell seatbelts.
- Small modification to slipping convergence: if the user input 0.0 for the material "birth size" (min element size), then the code would not converge for slippings, as this value was used when computing the initial guess. Now if they input 0.0, a small fraction of the element size is used.
- Added 1-way slipping
- Add slippings' fs and fd as function of time when <0.
- Fix for \*ELEMENT\_SEATBELT\_SENSOR, which now behaves consistently with the User's Manual.

## 2.16 SHELL ELEMENTS

- ESORT=2 in \*CONTROL\_SHELL to select DKT formulation for all triangles.
- Added an error check for mix materials with laminated shell theory with other material types.
- Fixed shell elements with user integration that mix materials.
- Fixed laminated shell theory for elements with mixed material models of the same type.
- Added option to \*CONTROL\_ACCURACY. If INN=-2 triangular elements do not use the invariant system.
- Fix for shells with offsets - not all options worked correctly.
- Fixed a bug in type 20 triangles for buckling analysis.
- Enable type 3 and 17 triangle shells for \*MAT\_058.
- Fixed collapsed type 6 and 7 shell elements that are sorted to type 4 triangles for use with anisotropic materials. The stress was wrong if angles per layer was used.
- Fixed shell element types 6 and 7 when used with anisotropic material. The angle cosines and sines were not being initialized correctly. Also, fixed the output of stress and strain in shell elements that use different material models in different layers using either \*INTEGRATION\_SHELL or \*PART\_COMPOSITE.
- Fix related to shell element sorting and bulk viscosity. Bulk viscosity was not considered, but now is.
- Add effective plastic strain failure to \*MAT\_106 shells.
- Fix for shell \*MAT\_120: element deletion after NUMINT IPs failed did not work correctly.

- Fixed \*INCLUDE\_TRANSFORM bug related to shells where \_THICKNESS was left off of dyna.inc keyword.
- Fixed fabric (\*MAT\_034) triangle elements when ESORT=2 on \*CONTROL\_SHELL. A major history variable bug caused two-thirds of triangular elements to have zero stress.
- Fixes related to triangular shell element coordinate system to account for invariant numbering.
- Fixes for laminated shell theory (materials 22, 54, 55, 76, 114). All Materials used 2x the correct weight on the on the top and bottom integration points for Lobatto quadrature. For materials 76 and 114 with user defined integration, the unsorted material properties were used for calculating shear strain terms, fxi, fyi and zi1. Since the sort routine orders them top to bottom, this likely caused all the material properties to be flipped if the user input the points in the order from bottom to top. This would cause incorrect results if different properties were used in each layer unless Lobatto quadrature was used. For materials 22 and 54, and 55, the unsorted material angles were used for calculating the shear strain terms, hi1, and hi2. For orthotropic material properties, the calculated hi1 and hi2 terms were therefore incorrect unless Lobatto quadrature was used.
- Fix for non working thinning for thick shell elements and material types 2, 22, 55, and 58.

## 2.17 SOLID ELEMENTS

- Solid tet ELFORM 13 implemented for materials 81,82,120,123,124
- Properly set implicit drilling rotation control for tetra 4 elements.
- Bug fix for \*INITIAL\_STRESS\_SOLID with elform 11.
- Fix for \*MAT\_120 for nodal pressure tet (elform 13).
- Bug fix for initial stresses in solid elements. Element sorting to tets and pentas was not supported.
- Time step calculation problem with solid element type 12 and \*MAT\_106.
- Fix for timestep calculation for tet 17.
- Add \*MAT\_169, \*MAT\_173, \*MAT\_198 to wedge element (ELFORM 15) - without this, the automatic sorting would not work with these materials.
- Add \*MAT\_084 for wedges (elform 15) and add missing calls to rstrss for tet elements (elform=10) for.
- Fix bug if \*CONTROL\_ACCURACY 2nd order stress update is on and fully integrated solid elements are used with EOS.
- Fix for material type 61 which goes unstable for tet types 10 and 13.
- Bug fix for selective mass scaling in conjunction with 10-noded tets.

## 2.18 THICK SHELL ELEMENTS

- Fixed thick shell output with CMPFLG=1 on \*DATABASE\_EXTENT\_BINARY.
- Fixed \*MAT\_002 with thick shell element type 3.

- Fixed stress output for type 1 thick shell elements in *d3plot* and *elout* files.
- Recoded thick shell output to *elout*, *d3plot*, *d3part*, *d3thdt* and *d3hsp*. Due to missing info, the CMPFLG=1 output is not available for \*MAT\_002 or \*MAT\_086 or for any material with thick shell type 3.
- Fixed thick shell strain output for case of more than 10 through thickness integration points or 3 or 5 integration points with user defined integration or Labatto quadrature.