



LS-DYNA Database Binary Output Files

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LS-DYNA DATABASE

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INTRODUCTION

Three databases are discussed, these are:

1. State Database (G=ptf, default name d3plot)
2. Time History Database (F=thf, default name d3thdt)
3. Interface Force Database (S=iff, no default name)

The purpose of this information is to give guidance on how to access and read the various databases.

The databases are written as word addressable fixed length binary files. The actual length depends on the amount of data saved, but will always be a multiple of 512 words. Since it is likely that the database cannot be contained in a single file of length, FEMLEN, the data will spread over several files known as a family of files. The root name for a family is the name of the first file member. Successive member names are compiled by appending a two or three digit number to the root name starting with 01, 02, through to 99, then 100 and ending with 999. Root names are limited to 75 characters. The original reason for a family of files was because the hard disks used for dyna3d runs could not cope with a single contiguous files large enough to contain all the data output. Subsequently, it has been found that splitting the output into separate files allows some unwanted data to be discarded and aids the copying, saving and movement of the data. Very large files can be impossible to transfer reliably over networks. Total output data can amount to several gigabytes or more depending on the model size.

For ls-dyna runs with mesh adaptivity, the root name has a two letter appendage for each adapted mesh. Starting from 'aa' through 'az', then 'ba' through 'bz' and continuing up to 'zz', this gives a maximum of 676 possible adaptations. For example if the root name is 'd3plot' the subsequent files related to the original mesh are 'd3plot01', d3plot02, ..., after adaption the new mesh and undeformed geometry is put in 'd3plotaa' and the subsequent files for the new mesh are: 'd3plotaa01', d3plotaa02, ... The next adapted mesh will be in file 'd3plotab' and so on. A set of files at a particular adaption can be read separately by giving the root name with appendage, as the base file name.

For example command: 'lspost d3plot' will read in all the file with root name 'd3plot'

While: 'lspost d3plotab' will read in only files have 'd3plotab' in the name.

LSPOST will read the binary databases separately or combined.

Eg: lspost d3plot, lspost d3thdt, lspost iffname, lspost d3plot h=d3thdt f=iffname

LS-DYNA DATABASE

The file length used is set in the ls-dyna run as the default size of 7x512x512 words. The size can be changed on the command line with the ' $x=factor$ ' parameter giving a size of: *factor*x512x512 words.

If the initial data or state data is larger than the given file length, the data will automatically split across files. This condition is not desirable because it is not clear whether any non root file can be discarded without destroying the continuity of the data. Ls-dyna checks before writing to a file, to ensure that there is room left in the file to contain the data at a particular state time. If not, it closes the current family member and starts writing the state data in the next file member. The files are written with a block size of 512 words, and if the data does not complete the last block it is padded out. This means that files cannot be concatenated and read together. The word size is 4 bytes for the single precision version of ls-dyna and 8 bytes for the double precision version, unless 32bit ieee format is defined, see *DATABASE_FORMAT, IBINARY.

FILE GENERAL STRUCTURE

The root file starts with a control words section, followed by node coordinates, then element connectivity for solids, thick shells, beams, and shells. Next are lists to reference the sequential internal numbering to the users number. State data is output next always starting with the time word. Data is of fixed length through the file members except where the mesh is adapted. The length of each area can be calculated from the information in the control words. The first file at adaption is like the root file in structure, so the new control words are used to recalculate the size of the subsequent data. The root file contains the initial data and also state data if there is room to write it. Further state data is written to the family members and each file will start with the time word provided data from the previous state did not overflow onto the file.

If the disk address, DA, of the data being written exceeds the maximum file length, then data is written into file number $\text{int}(DA/FAMLEN)$ at location $DA-FAMLEN*\text{int}(DA/FAMLEN)$. If the state length is greater than the remaining length, the disk address is increased to start the writing at the beginning of the next file.

STATE DATABASE (d3plot)

There are three sections in this database. The first contains 64 words of control information plus extensions. The second contains geometric information including the nodal coordinates and element connectivities and user numbering lists. The third section contains the results of the analysis at sequential output intervals. The output at a given time, called a state, contains a time word, global variables such as total energies and momenta for the whole model and each material (part), node data consisting of displacements, velocities, accelerations, and optionally temperatures, and finally element data that can include stresses and strains at integration points, and element deletion flags. The control data provides information about what is in the file and is used to calculate the various data length.

There are two other state database files, namely: d3drfl and d3part, these are similar to d3plot but contain less data. The dynamic relaxation file, d3drfl, provides the state at the end of the DR process, while d3part is state output for a reduced number of parts in the model.

CONTROL DATA

VALUE	#WORDS	DISK		DESCRIPTION
		ADDRESS		
Title	10	0		Model identification
Run time	1	10		Time of day
Date	1	11		Date
Machine	1	12		Computer identification
Code	1	13		Code name
Version	1	14		Code version, floating number, eg 960.0 it is used to distinguish the fp format, like cray, ieee, dpieee
NDIM	1	15		Number of dimensions (2 or 3). If 5 or 7 then an array of material types is read (MATYP=1), element connectivities are unpacked and NDIM=3. If 4 then element connectivities are unpacked in the DYNA3D database and NDIM is reset to 3. If >5 then state data contains movement of rigid road surface.
NUMNP	1	16		Number of nodal points
ICODE	1	17		Flag to identify finite element code=2: old DYNA3D, code=6: NIKE3D, LS-DYNA3D, LS-NIKE3D database

LS-DYNA DATABASE

NGLBV	1	18	Number of global variable to be read with each state in LS-DYNA3D, NUMRW=number of rigid walls. = 6 + 6 * (NUMMAT8 + NUMMAT2 + NUMMAT4 + NUMATT + NGPSPH) + NUMRW
IT	1	19	Flag for temperatures = 0 none, = 1 read in a temperature for each node
IU	1	20	Flag for current geometry (=1 or 0)
IV	1	21	Flag for velocities (=1 or 0)
IA	1	22	Flag for accelerations (=1 or 0)
NEL8	1	23	Number of 8 node solid elements
NUMMAT8	1	24	Number of materials used by the 8 node solids
BLANK	1	25	Insert zero
BLANK	1	26	Insert zero
NV3D	1	27	Number of values in database for each solid element. =7+NEIPH-6*ISTRN
NEL2	1	28	Number of 2 node one-dimensional elements
NUMMAT2	1	29	Number of materials used by the 2 node 1D elements
NV1D	1	30	Number of values in database for each 1D element = 6 + BEAMIP * 5
NEL4	1	31	Number of four node two-dimensional elements
NUMMAT4	1	32	Number of materials used by the 4 node 2D elements
NV2D	1	33	Number of values in database for each 2D element Are: $MAXINT*(6*IOSHL(1)+IOSHL(2)+NEIPS)+8*IOSHL(3)+4*IOSHL(4)+12*ISTRN$
NEIPH	1	34	Number of additional values per solid element to be written in the type 6 database, NV3D=7+NEIPH
NEIPS	1	35	Number of additional values per integration point to be written into the type 6 database for shell elements.
MAXINT	1	36	Number of integration points dumped for each shell. The magnitude of MAXINT must be greater than or equal to 3. if MAXINT>=0, then MDLOPT=0 MAXINT=MAXINT elseif MAXINT<0, then MDLOPT=1 MAXINT=abs(MAXINT) elseif MAXINT<10,000, then MDLOPT=2 MAXINT=abs(MAXINT)-10,000

endif

MDLOPT controls the element deletion table (see below). The increase in state lengths allows deletion by nodes or elements.

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EDLOPT	1	37	Element deletion flag (not standard) =xxx1 Solids deleted =xx1x Beams deleted =x1xx Shells deleted =1xxx Thick Shells deleted (Not used in LS-DYNA)
NMSPH	1	37	Number of SPH Nodes
NGSPH	1	38	Number of SPH materials
NARBS	1	39	Additional storage required for arbitrary node and element numbering in type 6 database =0 Sequential numbering =(10+NUMNP+ NEL8+NEL2+NEL4+NELT).
NELT	1	40	Number of 8 node thick shell elements.
NUMMATT	1	41	Number of materials used for the 8 node thick shell element.
NV3DT	1	42	Number of values in database for each thick shell $MAXINT*(6*IOSHL(1)+IOSHL(2)+NEIPS)+12*ISTRN$
IOSHL(1)	1	43	6 stress components flag, if 1000 =1 else =0
IOSHL(2)	1	44	Plastic strain flag, if 1000 =1 else =0
IOSHL(3)	1	45	Shell force resultants flag, if 1000 =1 else =0
IOSHL(4)	1	46	Shell thickness, energy+2 others, if 1000 =1 else =0
IALEMAT	1	47	Number of fluid material ids
NCFDV1	1	48	Bit flags for CFD nodal values
NCFDV2	1	49	Further bit flags for CFD nodal values
NADAPT	1	50	Number of adapted element to parent pairs (not implemented)
BLANK	13	51	Unused space.

ISTRN can only be computed as follows and if $NEL4 > 0$.

If $NV2D-(MAXINT*(6*IOSHL(1)+IOSHL(2)+NEIPS)+8*IOSHL(3)+4*IOSHL(4)) > 1$

Then $ISTRN = 1$, else $ISTRN = 0$

Or $NELT > 0$

If $NV3DT-MAXINT*(6*IOSHL(1)+IOSHL(2)+NEIPS) > 1$

Then $ISTRN = 1$, else $ISTRN = 0$

MATERIAL TYPE DATA

The material section contains the material type numbers. This section is skipped if MATTYP is zero.

This data is required because those shell elements that are in a rigid body have no element data output in the state data section. The normal length of the shell element state data is: $NEL4 * NV2D$, when the MATTYP flag is set the length is: $(NEL4 - NUMRBE) * NV2D$. When reading the shell element data, the material number must be check against IRBRTYP list to find the element's material type. If the type = 20, then all the values for the element to zero. This option is set in *DATABASE_EXTENT_BINARY, with DCOMP=2

VALUE	LENGTH	DESCRIPTION
NUMRBE	1	Number of rigid body shell elements.
NUMMAT	1	Number of materials in the database.
IRBTYP	NUMMAT	Material type numbers

FLUID MATERIAL ID DATA

The fluid material section contains the material numbers for solid elements that are used to define an Euler grid or Arbitrary Lagrangian Euler mesh. This section is skipped if IALEMAT is zero.

VALUE	LENGTH	DESCRIPTION
FLUIDID	IALEMAT	Fluid material number used in solid element mesh

LS-DYNA DATABASE

SMOOTH PARTICLE HYDRODYNAMICS ELEMENT DATA FLAGS

This section is only output if $NMSPH > 0$. The section is a list of flags to indicate what SPH data is output for each SPH node/element. The first number is the length in words for this array, currently = 9.

SPH elements are centered at nodes, and cover a spherical volume defined by the radius of influence. They do not have a connectivity with other SPH elements. They should be displayed as a dot or a spherical surface, with radius scaling to reduce the size and enable each element to be distinguishable.

As follows:

- isphfg(1) = 9 - length of sph flags array
- isphfg(2) = 1 - radius of influence
- isphfg(3) = 1 - pressure in particle
- isphfg(4) = 6 - 6 true stress components
- isphfg(5) = 1 - plastic strain, > 0.0 if effective stress exceeds yield strength
- isphfg(6) = 1 - density of particle material
- isphfg(7) = 1 - internal energy (strain)
- isphfg(8) = 1 - number of neighbors affecting particle
- isphfg(9) = 6 - 6 true strain components

If the value of $isphfg(2-9) = 0$, then the particular data item is not output for the particle. To calculate the size of data add the isphfg values from isphfg(2) through isphfg(9) and add one. One value is always output which is the material number as a floating point number for each particle.

If this value is negative then the particle has been deleted from the model.

Full output for each particle is:

mat#, radius, pressure, {sx, sy, sz, sxy, syz, sxz} ps, rho, ie, nn, {ex, ey, ez, exy, eyz, exz}.

Hence total size is 19.

When a particle is deleted from the model, data is still output for it because the length of data must always be the same for each state.

GEOMETRY DATA

The geometry section contains the nodal coordinates and the element connectivities. The ordering of the nodal points is the same as the ordering of the nodal data in the state data that follows. If NDIM=3 the connectivities are assumed to be packed with 3 integers per word, if NDIM>3, then connectivities are not pack, (the default for LS-DYNA, LS-DYNA3D and LS-NIKE3D. The order of the elements are 3, 2, and 1 dimensional elements if the database is ICODE=2 or 6.

VALUE	LENGTH	DESCRIPTION
X(3,1)	NDIM*NUMNP	Array of nodal coordinates X1,Y1,Z1, X2,Y2,Z2, X3,Y3,Z3, ... ,Xn,Yn,Zn
IX8(9,1)	9*NEL8	Connectivity and material number for each 8 node solid element
IXT(9,1)	9*NELT	Connectivity and material number for each 8 node thick shell element.
IX4(5,1)	5*NEL4	Connectivity and material number for each 4 node shell element
IX2(6,1)	6*NEL2	Connectivity, orientation node, two null entries, and the material number for each 2 node beam element

Note the node numbers are the LS-DYNA internal numbers for nodes, these will be the same as the user's numbers if NARBS = 0, otherwise, the arbitrary number lists are used to find the user's numbers, similarly, for element numbers and material numbers.

Beam Element Section Information

These data are related to the keyword: “*INTEGRATION_BEAM and Circular Sections. Beam types are: circular/tube, W, C, Angle, T, Box, Z sections. . Other beams are taken to be box or solid in section. For the defined beam sections the numbers in the beam connectivity array are as follows:

The first node and second node for ends of beam.

The third node indicates the direction from the first node for the S-axis. If zero there is no sectional axis (tie only).

The first to second node is the direction of the R-axis.

The connectivity array numbers 4 through 6 provide data for the section height, width and type.

These data are stored as integers are follows:

Word 4 = ((int)(100 * Beam Height / Beam Length) << 6) | type

Word 5 = (int)(100 * Beam Width / Beam Length)

Word 6 = Material number.

For Circular Sections

Beam Height is the outer diameter and Beam Width is the inner diameter.

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Types are: 0=default; 1=circular; 2=W; 3=C; 4=Angle; 5=T; 6=box; 7=Z and 8=trapezoidal;
9=spotweld; 10=spring; 11=damper.

USER MATERIAL, NODE, AND ELEMENT IDENTIFICATION NUMBERS

Skip this section if NARBS (disk address 39) is zero. The user node and element numbers must be in ascending order. *It assumed that if this option is used all node and element data anywhere in the databases is in ascending order in relation to the user numbering.* The total length of the data in this data is equal to:

$$NARBS=10+NUMNP+NEL8+NEL2+NEL4+NELT,$$

if sequential numbering is used of the materials. For arbitrary material numbering the total length is increased by $6+NUMMAT8+NUMMAT4+NUMMAT2+NUMMATT$. Material numbers are not in ascending order.

VALUE	LENGTH	DESCRIPTION
NSORT	1	Pointer to arbitrary node numbers in LS-DYNA source code, a negative sign flags that arbitrary material identification numbers are also used.
NSRH	1	Pointer to arbitrary solid element numbers in LS-DYNA source code: =NSORT+NUMNP
NSRB	1	Pointer to arbitrary beam element numbers in LS-DYNA source code: =NSRH+NEL8
NSRS	1	Pointer to arbitrary shell element numbers in LS-DYNA source code: =NSRB+NEL2
NSRT	1	Pointer to arbitrary thick shell element numbers in LS-DYNA source code: =NSRS+NEL4
NSORTD	1	Number of nodal points
NSRHD	1	Number of 8 node solid elements
NSRBD	1	Number of 2 node beam elements
NSRSD	1	Number of 4 node shell elements
NSRTD	1	Number of 8 node thick shell elements
NSRMA	1	Pointer to an array in the LS-DYNA source code that list the material ID's in ascending order.
NSRMU	1	Pointer to an array in the LS-DYNA source code that gives the material ID's in the actual order that they are defined in the user input.

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VALUE	LENGTH	DESCRIPTION
NSRMP	1	Pointer to an array in the LS-DYNA source code that gives the location of a member in the array originating at NSRMU for each member in the array starting at NSRMA.
NSRTM	1	Total number of materials
NUMRBS	1	Total number of nodal rigid body constraint sets
NMMAT	1	Total number of materials
NUSERN	NSORTD	Array of user defined node numbers
NUSERH	NSORTH	Array of user defined solid element numbers
NUSERB	NSORTB	Array of user defined beam element numbers
NUSERS	NSORTS	Array of user defined shell element numbers
NUSERT	NSORTT	Array of user defined thick shell numbers
NORDER	NMMAT	Ordered array of user defined material ID's
NSRMU	NMMAT	Unordered array of user material ID's
NSRMP	NMMAT	Cross reference array

ADAPTED ELEMENT PARENT LIST (not implemented)

List of element id pairs for H-type shell element adaptivity.

Length of data is $2 * NADAPT$, pairs are element number and element parent number

SMOOTH PARTICLE HYDRODYNAMICS NODE AND MATERIAL LIST

If $NMSPH > 0$ List of sph node and its material number

Length of data $2 * NUMSPH$

RIGID ROAD SURFACE DATA

If NDIM > 5

NNODE Number of nodes in road surface
 NSEG Total number of 4 noded road surface segments
 NSURF Number of road surfaces
 MOTION Flag to indicate motion data is output for each state
 NODEID NNODE list of IDs
 SURFNODE XYZ Coordinate for each node
 Lists of 4 noded segments for each surface
 SURFID Surface ID Number
 SURFNSEG Number of segments in surface
 SURFSEGS SURFNSEG of 4 node ids for each segment

Length of data = 4 + NNODE + 3 * NNODE + NSURF * (2 + 4 * SURFNSEG)

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STATE DATA

The state data has three parts:

- Time word and global data
- Node data
- Element data for solids, shell, and beams, respectively

VALUE	LENGTH	DESCRIPTION
TIME	1	Time word
GLOBAL	NGLBV	Global variables for this state. LS-DYNA3D Global Variables: KE, IE, TE, X, Y, and Z velocity, External Work IE for each material KE for each material X, Y, and Z velocity for mat 1 ... X, Y, and Z velocity for mat n Mass for each material Force for each rigid wall $= 6 + 6 * (\text{NUMMAT8} + \text{NUMMAT2} + \text{NUMMAT4} + \text{NUMMATT} + \text{NGPSPH}) + \text{NUMRW}$
NODEDATA	NND	Total nodal values for state. FOR LS-DYNA3D and LS-DYNA $= (\text{IT} + \text{NDIM} * (\text{IU} + \text{IV} + \text{IA})) * \text{NUMNP}$ where IT=temperature flag, IU=coordinates flag, IV=velocities flag, and IA=accelerations flag.
CFDDATA	CFD	Bit flag: NCFDV1, bits from right to left Eg Pressure, Resultant Vorticity, and Density $\text{NCFDV1} = 2 + 32 + 1024 = 1058$ 2 Pressure 3 X Vorticity 4 Y Vorticity 5 Z Vorticity 6 Resultant Vorticity 7 Enstrophy 8 Helicity 9 Stream Function 10 Enthalpy 11 Density 12 Turbulent KE 13 Dissipation 14-20 Eddy Viscosity Bit flag: NCFDV2

2-11 Species 1 through 10

ELEMDATA ENN

Total element data for state.
 =NEL8*NV3D+NEL2*NV1D+NEL4*NV2D
 The organization of the element data for each element type is described below. The data for the solid elements (7 values/element) is printed first, followed by the data for the beam elements (6 values/element), and then the data for the shell elements (typical 33 or 45 values/element depending on whether the strains are included).

This state data is repeated for each state in the database.

Element data is defined at the integration points within the element. Contour and fringe plots require that the data be extrapolated to the nodal points. In LS-TAURUS and LS_POST the element values are averaged at the nodes. Element strains are not output by default, these are only output for solids, shell, and thick shell when *DATABASE_EXTENT_BINARY, STRFLG=1

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SOLID ELEMENTS – 8 node Hexahedron, other solid elements like wedge, pyramid, and tetrahedron are identified by repeated final connectivities. Eg tetrahedron = 1,2,3,4,4,4,4,4

The database for solid elements consists of 7+NEIPH values per element. NEIPH extra values are defined if and only if NEIPH is greater than zero. If strain components are output, then the last 6 neiph values are true strains: ex, ey, ez, exy, eyz, exz, in the global system.

They are:

1. Sigma-x (true stress in the global system)
 2. Sigma-y
 3. Sigma-z
 4. Sigma-xy
 5. Sigma-yz
 6. Sigma-zx
 7. Effective plastic strain or material dependent variable
 8. First extra value (if NEIPH>0)
 9. Second extra value (if NEIPH >1)
 10. Etc. until NEIPH extra values are defined if ISTRN=1
- 7+NEIPH-5. Epsilon-x
7+NEIPH-4. Epsilon-y
7+NEIPH-3. Epsilon-z
7+NEIPH-2. Epsilon-xy
7+NEIPH-1. Epsilon-yz
7+NEIPH. Epsilon-zx

For thick shell elements the database contains $NV3DT = MAXINT * (6 * IOSHL(1) + IOSHL(2) + NEIPS) + 12 * ISTRN$ values per element. Three sets of global stresses are always put into the database for each thick shell and are located at the mid surface, the inner integration point surface, and the outer integration point surface, respectively. If one integration point is used the same through the thickness stress state is outputted three times. If two integration points are used then the mid surface value is taken as the average value. The inner values of the stress are always set to the values at the innermost integration point and likewise for outer values. If the integration point does not lie at the center, ie, an even number of integration points through the thickness, a value is computed that is an average of the two integration point nearest the mid surface.

The IOSHL flags indicate which shell element data is included which is suppressed.

The flags are set in ls-dyna by *DATABASE_EXTENT_BINARY, SIGFLG, EPSFLG, RLFLG, and ENGFLG

The ordering of the data follows:

1. Sigma-x (mid surface true stress in global system)
2. Sigma-y
3. Sigma-z
4. Sigma-xy
5. Sigma-yz
6. Sigma-zx
7. Effective plastic strain or material dependent variable
- *. **Define NEIPS additional history values here for mid surface**
8. Sigma-x (inner surface true stress in global system)
9. Sigma-y
10. Sigma-z
11. Sigma-xy
12. Sigma-yz
13. Sigma-zx
14. Effective plastic strain or material dependent variable
- *. **Define NEIPS additional history values here for inner surface**
15. Sigma-x (outer surface true stress in global system)
16. Sigma-y
17. Sigma-z
18. Sigma-xy
19. Sigma-yz
20. Sigma-zx

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- 21. Effective plastic strain or material dependent variable
- *. **Define NEIPS additional history values here for outer surface**
- *. **If ISTRN=1, then define strain components Epsilon (x, y, z, xy, yz, zx) here for inner surface and outer surface**

If $MAXINT > 3$ then define an additional $(MAXINT-3) * (6 * IOSHL(1) + 1 * IOSHL(2) + NEIPS)$ quantities here.

For beam elements the database contains NV1D=6 values per element. They are:

- 1. Axial force
- 2. S shear resultant
- 3. T shear resultant
- 4. S bending moment
- 5. T bending moment
- 6. Torsional resultant

If there are values output at beam integration points, then $NV1D = 6 + 5 * BEAMIP$

- 1. RS shear stress
- 2. TR shear stress
- 3. Axial stress
- 4. Plastic strain
- 5. Axial strain

BEAMIP is set in *DATABASE_EXTENT_BINARY

For shell elements the database contains NV2D values, where:
 $NV2D = MAXINT * (6 * IOSHL(1) + 1 * IOSHL(2) + NEIPS) + 8 * IOSHL(3) + 4 * IOSHL(4) + 12 * ISTRN$ values per deformable element. If MATTYP=1 and IRBTYP(I)=20, where I=internal element number, then the material is rigid and the compressed database contains no data for the element. If the minimum value of *MAXINT* is used, i.e., 3, the stresses are typically located at the mid surface, the inner surface, and the outer surface, respectively. If one integration point is used the stress is written three times. If two integration points are used then the mid surface value is taken as the average value. The inner values of the stress are always set to the values at the innermost integration point and likewise for outer values. If no integration point lies at the center, i.e., an even number of integration points through the thickness, a value is computed that is an average of the two integration point lying nearest the mid surface.

The ordering of the data follows:

1. Sigma-x (mid surface true stress in global system)
2. Sigma-y
3. Sigma-z
4. Sigma-x
5. Sigma-yz
6. Sigma-zx
7. Effective plastic strain or material dependent variable
- *. **Define NEIPS additional history values here for mid surface**
8. Sigma-x (inner surface true stress in global system)
9. Sigma-y
10. Sigma-z
11. Sigma-xy
12. Sigma-yz
13. Sigma-zx
14. Effective plastic strain or material dependent variable
- *. **Define NEIPS additional history values here for inner surface**

LS-DYNA DATABASE

15. Sigma-x (outer surface true stress in global system)
16. Sigma-y
17. Sigma-z
18. Sigma-xy
19. Sigma-yz
20. Sigma-zx
21. Effective plastic strain or material dependent variable

*. **Define NEIPS additional history values here for outer surface**

If $MAXINT > 3$ then define an additional $(MAXINT-3) * (6 * IOSHL(1) + 1 * IOSHL(2) + 8 * IOSHL(3) + 4 * IOSHL(4) + NEIPS)$ quantities here

22. Bending moment-Mx (local shell coordinate system)
23. Bending moment-My
24. Bending moment-Mxy
25. Shear resultant-Qx
26. Shear resultant-Qy
27. Normal resultant-Nx
28. Normal resultant-Ny
29. Normal resultant-Nxy
30. Thickness
31. Element dependent variable
32. Element dependent variable
33. Internal energy (if and only if ISTRN=0)

The following quantities are expected if and only if ISTRN=1

33. eps-x (inner surface strain in global system)
34. eps-y
35. eps-z
36. eps-xy
37. eps-yz
38. eps-zx
39. eps-x (outer surface strain in global system)
40. eps-y
41. eps-z
42. eps-xy
43. eps-yz
44. eps-zx
45. Internal energy (if and only if NV2D>=45)

Element Deletion Option

Skip this section if the word MAXINT is greater than or equal to zero, (MDLOPT=0). If MDLOPT=1, then the list is equal to the number of nodal points (NUMNP) and contains a one if the node is visible and a zero if the node is not visible, (only used in vec-dyna3d). If MDLOPT=2, then the list equals the total number of elements (NEL8 + NELT + NEL4 + NEL2), in this order, and each value is set to the element material number or =0, if the element is deleted. All these numbers are output as floating point values and not integers.

LS-DYNA DATABASE

Smooth Particle Hydrodynamics Node/Element State data

This section is only output if NMSPH>0

For each SPH node the follow values are output:

NUM_SPH_DATA = 1 + \sum isphfg(i), i=2:9

Currently isphfg(1) = 9, ie number of sph data flags, this could be changed in the future.

Length of data = NUM_SPH_DATA * NUMSPH

Material number, if =0 then element is deleted.

If isphfg(2) =1, radius of particle influence

If isphfg(3) =1, pressure in particle

If isphfg(4) =6, stress components for particle, sx, sy, sz, sxy, syz, sxz

If isphfg(5) =1, plastic strain for particle

If isphfg(6) =1, density of particle material

If isphfg(7) =1, internal energy of particle

If isphfg(8) =1, number of particle neighbors

If isphfg(9) =6, strain components for particle, ex, ey, ez, exy, eyz, exz

Road Surface Motion

If NDIM > 5 output rigid body displacement, dx, dy, dz and velocity, vx, vy, vz of each road surface.

Length of data = 6 * NSURF

End of File Marker

Value = -999999.0

TIME HISTORY DATABASE (d3thdt)

There are three sections in the LS-DYNA time history database. The first used to contain 144 words of control information, but now depends upon the number of node and elements the user defines in LS-DYNA. The second contains geometric information including the nodal coordinates and element connectivities. The third section contains the results of the analysis at sequential output intervals for a subset of solids, beams, and shells. The output at a given time, called a state, contains a time word, global variables such as total energies and momenta, nodal data consisting of accelerations, velocities, and displacements, and finally element data is written that may include stresses and strains at integration points. The control information provides information on what is in the file and which database is contained.

CONTROL DATA

VALUE	#WORDS	DISK ADDRESS	DESCRIPTION
Title	10	0	Model identification
Run time	1	10	Time of day
Date	1	1	Date
Machine	1	12	Computer identification
Code	1	13	Code name
Version	1	14	Code version, a real number, not integer
NDIM	1	15	Number of dimensions (2 or 3), is set to 4 if element connectivities are unpacked in the LS-DYNA database and NDIM is reset to 3
NUMNP	1	16	Number of nodal points
ICODE	1	17	Flag to identify finite element code =2 old DYNA3D, NIKE3D database =6 new LS-DYNA3D, LS-NIKE3D, LS-DYNA3D, LS-DYNA database
NGLBV	1	18	Number of global variables to be read in each state
IT	1	19	Flag for temperatures =0 none, =1 read in a temperature for each node
IU	1	20	Flag for current geometry (=1)
IV	1	21	Flag for velocities (=1)
IA	1	22	Flag for accelerations (=1)

LS-DYNA DATABASE

NEL8	1	23	Number of 8 node solid elements
NUMMAT8	1	24	Number of materials used by the 8 node solids
NDS	1	25	Number of node blocks for plotting
NST	1	26	Number of element blocks for plotting. =NSTH + NSTB + NSTS +NSTT
NV3D	1	27	Number of values in database for each solid element
NEL2	1	28	Number of 2 node one-dimensional elements
NUMMAT2	1	29	Number of materials used by the 2 node 1D elements
NV1D	1	30	Number of values in database for each 1D element
NEL4	1	31	Number of four node two-dimensional elements
NUMMAT4	1	32	Number of materials used by the 4 node 2D elements
NV2D	1	33	Number of values in database for each 2D element
NEIPH	1	34	Number of additional values per solid element to be written in the type 6 database =NEIPH-6*ISTRN
NEIPS	1	35	Number of additional values per integration point to be written into the type 6 database for shell elements
MAXINT	1	36	Number of integration points dumped for each shell element.
NMSPH	1	37	Number of SPH Nodes
NGSPH	1	38	Number of SPH materials
NARBS	1	39	Additional storage required for arbitrary node and element numbering in type 6 database
BLANK	3	40	Unused space
IOSHL(1)	1	43	stress components flag (=1000 yes)
IOSHL(2)	1	44	Strain components, ISTRN (=1000 yes)
IOSHL(3)	1	45	Shell force resultants (=1000 yes)
IOSHL(4)	1	46	Shell thickness, energy + 2 others (=1000 yes)
BLANK	1	47	Unused space, ignore value
NCFDV1	1	48	Bit flags for CFD nodal values
NCFDV2	1	49	Further bit flags for CFD nodal values
BLANK	8	50	Unused space
NSTP	1	58	Number of SPH element blocks

IFLAGD	1	59	Number of node blocks + 1000 flag
NSTH	1	60	Number of solid element blocks
NSTB	1	61	Number of beam element blocks
NSTS	1	62	Number of shell element blocks
NSTT	1	63	Number of thick shell element block
NDSB	2*NDS	64	Node blocks for which time histories are output. The locations 2n-1, where n=1 through NDS correspond to the first node in the block and locations 2n correspond to the last node in the block.
NSTHB	2*NSTH	64+2*NDS	Solid element blocks start and end numbers These are defined in a similar manner to the nodal time history blocks
NSTBB	2*NSTB	64+2*NDS +2*NSTH	Beam element block start and end numbers
NSTSB	2*NSTS	64+2*NDS +2*NSTH +2*NSTB	Shell element block start and end numbers
NSTTB	2*NSTT	64+2*NDS +2*NSTH +2*NSTB +2*NSTS	Thick shell element block start and end numbers
NSTPB	2*NSTP	64+2*NDS +2*NSTH +2*NSTB +2*NSTS +2*NSTT	SPH element block start and end numbers

ISTRN can only be computed as follows and if NSTS > 0.

If $NV2D-MAXINT*(6*IOSHL(1)+IOSHL(2)+NEIPS)+8*IOSHL(3)+4*IOSHL(4) > 10$

Then ISTRN = 1, else ISTRN = 0

Or NSTT > 0

If $NV3DT-MAXINT*(6*IOSHL(1)+IOSHL(2)+NEIPS) > 10$

Then ISTRN = 1, else ISTRN = 0

LS-DYNA DATABASE

SMOOTH PARTICLE HYDRODYNAMICS ELEMENT DATA FLAGS

This section is only output if $NMSPH > 0$. The section is a list of flags to indicate what SPH data is output for each SPH node/element. The first number is the length in words for this array, currently = 9.

SPH elements are centered at nodes, and cover a spherical volume defined by the radius of influence. They do not have a connectivity with other SPH elements. They should be displayed as a dot or a spherical surface, with radius scaling to reduce the size and enable each element to be distinguishable.

As follows:

isphfg(1) = 9 - length of sph flags array

isphfg(2) = 1 - radius of influence

isphfg(3) = 1 - pressure in particle

isphfg(4) = 6 - 6 true stress components

isphfg(5) = 1 - plastic strain, > 0.0 if effective stress exceeds yield strength

isphfg(6) = 1 - density of particle material

isphfg(7) = 1 - internal energy (strain)

isphfg(8) = 1 - number of neighbors affecting particle

isphfg(9) = 6 - 6 true strain components

If the value of $isphfg(2-9) = 0$, then the particular data item is not output for the particle. To calculate the size of data add the $isphfg$ values from $isphfg(2)$ through $isphfg(9)$ and add one. One value is always output which is the material number as a floating point number for each particle.

If this value is negative then the particle has been deleted from the model.

Full output for each particle is:

mat#, radius, pressure, {sx, sy, sz, sxy, syz, sxz} ps, rho, ie, nn, {ex, ey, ez, exy, eyz, exz}.

Hence total size is 19.

When a particle is deleted from the model, data is still output for it because the length of data must always be the same for each state.

GEOMETRY DATA

The geometry section contains the nodal coordinates and the element connectivities. The ordering of the nodal points is assumed to be the same as the ordering of the nodal data in the state data that follows. The connectivities are assumed to be packed with 3 integers per word unless NDIM is set to 4 as in the new LS-DYNA3D, LS-NIKE3D, LS-DYNA databases. The order of the elements are 3, 2, and 1 dimensional elements if the database is ICODE=2 or 6.

VALUE	LENGTH	DESCRIPTION
X(3,1)	NDIM*NUMNP	Array of nodal coordinates X1,Y1,Z1, X2,Y2,Z2,X3,Y3,Z3, ... ,Xn,Yn,Zn
IX8(9,1)	9*NEL8	Connectivity and material number for each 8 node solid element
IXT(9,1)	9*NELT	Connectivity and material number for each 8 node thick shell element
IX2(6,1)	6*NEL2	Connectivity, orientation node, two null entries, and the material number for each 2 node beam element
IX4(5,1)	5*NEL4	Connectivity and material number for each 4 node shell element

LS-DYNA DATABASE

USER MATERIAL, NODE, AND ELEMENT IDENTIFICATION NUMBERS

Skip this section if NARBS (disk address 39) is zero. The user node and element numbers must be in ascending order. *It is assume that if this option is used all the node and element data in the databases is in ascending order in relation to the user numbering.* The total length of the data in this database is equal to

$$\text{NARBS}=10+\text{NUMNP}+\text{NEL8}+\text{NEL2}+\text{NEL4}+\text{NELT}$$

if sequential numbering is used of the materials. For arbitrary material numbering the total length is increased by $6+\text{NUMMAT8}+\text{NUMMAT4}+\text{NUMMAT2}+\text{NUMMATT}$. Material numbers are not in ascending order.

VALUE	LENGTH	DESCRIPTION
NSORT	1	Pointer to arbitrary node numbers in LS-DYNA source code, a negative sign flags that arbitrary material identification numbers are also used.
NSRH	1	Pointer to arbitrary solid element numbers in LS-DYNA source code: =NSORT+NUMNP
NSRB	1	Pointer to arbitrary beam element numbers in LS-DYNA source code: =NSRH+NEL8
NSRS	1	Pointer to arbitrary shell element numbers in LS-DYNA source code: =NSRB+NEL2
NSRT	1	Pointer to arbitrary thick shell element numbers in LS-DYNA source code: =NSRS+NEL4
NSORTD	1	Number of nodal points
NSRHD	1	Number of 8 node solid elements
NSRBD	1	Number of 2 node beam elements
NSRSD	1	Number of 4 node shell elements
NSRTD	1	Number of 8 node thick shell elements
NSRMA	1	Pointer to an array in the LS-DYNA source code that list the material ID's in ascending order.
NSRMU	1	Pointer to an array in the LS-DYNA source code that gives the material ID's in the actual order that they are defined in the user input

LS-DYNA DATABASE

VALUE	LENGTH	DESCRIPTION
NSRMP	1	Pointer to an array in the LS-DYNA source code that gives the location of a member in the array originating at NSRMU for each member in the array starting at NSRMA.
NSRTM	1	Total number of materials
NUMRBS	1	Total number of nodal rigid body constraint sets.
NMMAT	1	Total number of materials
NUSERN	NSORTD	Array of user defined node numbers
NUSERH	NSORTH	Array of user defined solid element numbers
NUSERB	NSORTB	Array of user defined beam element numbers
NUSERS	NSORTS	Array of user defined shell element numbers
NUSERT	NSORTT	Array of user defined solid shell numbers
NORDER	NMMAT	Ordered array of user defined material ID's
NSRMU	NMMAT	Unordered array of user material ID's
NSRMP	NMMAT	Cross reference array

LS-DYNA DATABASE

TIME HISTORY DATA

The time database contains the following data:

- Time word
- Node data
- Node data for solids, thick shells, and shells, respectively
- Element data for solids, thick shells, beams, and shells, respectively

VALUE	LENGTH	DESCRIPTION
TIME	1	Time word
GLOBAL	NGLBV	Global variables for this state. LS-DYNA Global Variables: KE, IE, TE, X, Y, and Z velocity IE for each material KE for each material X, Y, and Z velocity for mat 1 ... X, Y, and Z velocity for mat n Mass for each material Force for each rigid wall $= 6 + 6 * (\text{NUMMAT8} + \text{NUMMAT2} + \text{NUMMAT4} + \text{NUMMATT} + \text{NGPSPH}) + \text{NUMRW}$

SKIP THE FOLLOWING DATA IF THE NUMBER OF NODE BLOCKS FOR PLOTTING IS ZERO (VALUE NUMDS AT DISK ADDRESS 25)

TIME	1	Time word
NODEDATA	NND	Total nodal values for state where $\text{NLN} = 10 * \text{TNODS}$ where TNODS is the number of nodes put into database. The database contains TNODS vectors each with up to 10 components: temperature (if IT=1); x, y, and z coordinates; x, y, and z velocities; and x, y, and z accelerations.

CFDDATA

CFD

Bit flag: NCFDV1, bits from right to left
Eg Pressure, Resultant Vorticity, and Density

$NCFDV1=2+32+1024=1058$

- 14 Pressure
- 15 X Vorticity
- 16 Y Vorticity
- 17 Z Vorticity
- 18 Resultant Vorticity
- 19 Enstrophy
- 20 Helicity
- 21 Stream Function
- 22 Enthalpy
- 23 Density
- 24 Turbulent KE
- 25 Dissipation
- 14-20 Eddy Viscosity

Bit flag: NCFDV2

2-11 Species 1 through 10

Count number of bits on * NUMNP

LS-DYNA DATABASE

SKIP THE FOLLOWING DATA IF THE NUMBER OF ELEMENT BLOCKS FOR IS ZERO
(VALUE NUMDS AT DISK ADDRESS 26)

****SKIP THE FOLLOWING IF THERE IS NO DATA FOR SOLID ELEMENTS ****

TIME	1	Time word
SOLIDDATA	ENV	Total nodal values for solid elements where $ENV=56*TBELM$ where $TBELM$ is the total number of solid elements to be put into the database. The data contains $TBELM$ vectors each with 56 components ordered as follows: 8 connectivities: x,y,z coordinates for each of the 8 nodes; and, lastly, x,y,z velocities for each of the 8 nodes.

For solid elements the database contains $(7+NEIPH-6*ISTRN)$ values per element. One set of global stresses are always put into the database for each solid element followed by $NEIPH$ history values. Only data for elements defined in the time history blocks is output. The ordering of the data follows:

1. Sigma-x (true stress in the global system)
 2. Sigma-y
 3. Sigma-z
 4. Sigma-xy
 5. Sigma-yz
 6. Sigma-zx
 7. Effective plastic strain or material dependent variable
 8. First extra value (if $NEIPH>0$)
 9. Second extra value (if $NEIPH >1$)
 10. Etc. until $NEIPH$ extra values are defined if $ISTRN=1$
- $7+NEIPH-5$. Epsilon-x
 $7+NEIPH-4$. Epsilon-y
 $7+NEIPH-3$. Epsilon-z
 $7+NEIPH-2$. Epsilon-xy
 $7+NEIPH-1$. Epsilon-yz
 $7+NEIPH$. Epsilon-zx

****SKIP THE FOLLOWING IF THERE IS NO DATA FOR THICK SHELLS ****

TIME	1	Time word
TSHELLDATA	ENV	Total nodal values for thick shell elements where $ENV=56*TBSEL$ where $TBSEL$ is the total number of thick shell elements in the database. The data contains $TBSEL$ vectors each with 56 components ordered as follows: 8 connectivities: x,y,z coordinates for each of the 8 nodes; and, lastly, x,y,z velocities for each of the 8 nodes.

****SKIP THE FOLLOWING IF THERE IS NO DATA FOR SHELL ELEMENTS ****

TIME	1	Time word
SHELLDATA	ENVS	Total nodal values for shell elements where $ENVS=28*TSELM$ where $TSELM$ is the total number of shell elements in the database. The data contains $TSELM$ vectors each with 28 components ordered as follows: 4 connectivities: x,y,z coordinates for each of the 4 nodes; and, lastly, x,y,z velocities for each of the 4 nodes.

****SKIP THE FOLLOWING IF THERE IS NO DATA FOR THICK SHELLS ****

For thick shell elements the database contains NV3DT values per element. Three sets of global stresses are always put into the database for each thick shell and are located at the mid surface, the inner surface, and the outer surface, respectively. If one integration point is used the single state is written three times. If two integration points are used then the mid surface value is taken as the average value. The inner values of the stress are always set to the values at the innermost integration point and likewise for outer values. If no integration point lies at the center, i. e. an even number of integration points through the thickness, a value is computed that is an average of the two integration point lying nearest the mid surface. Only data for elements defined in the time history blocks is output. The ordering of the data follows:

1. Sigma-x (mid surface true stress in global system)
2. Sigma-y
3. Sigma-z
4. Sigma-xy

LS-DYNA DATABASE

5. Sigma-yz
 6. Sigma-zx
 7. Effective plastic strain or material dependent variable
 - *. **Define NEIPS additional history values here for midsurface**
 8. Sigma-x (inner surface true stress in global system)
 9. Sigma-y
 10. Sigma-z
 11. Sigma-xy
 12. Sigma-yz
 13. Sigma-zx
 14. Effective plastic strain or material dependent variable
 - *. **Define NEIPS additional history values here for inner surface**
 15. Sigma-x (outer surface true stress in global system)
 16. Sigma-y
 17. Sigma-z
 18. Sigma-xy
 19. Sigma-yz
 20. Sigma-zx
 21. Effective plastic strain or material dependent variable
 - *. **Define NEIPS additional history values here for outer surface**
 21. Effective plastic strain or material dependent variable
 - *. **Define NEIPS additional history values here for outer surface**
- If MAXINT >3 then define an additional (MAXINT-3)* (6*IOSHL(1) + 1*IOSHL(2) + NEIPS) quantities here
- *. **If ISTRN=1, then define strain components Epsilon (x, y, z, xy, yz, zx) here for inner surface and outer surface**

****SKIP THE FOLLOWING IF THERE IS NO DATA FOR BEAM ELEMENTS ****

TIME	1	Time word
BEAMDATA	BESV	Total element values for beam elements where $BESV = NV1D * TBELM$. The data contains TBELM vectors each with NV2D values ordered as described below.

For beam elements the database contains $NV1D=6$ values per element. They are:

1. Axial force
2. S shear resultant
3. T shear resultant
4. S bending moment
5. T bending moment
6. Torsional resultant

If there are values output at beam integration points, then $NV1D = 6 + 5 * BEAMIP$

7. RS shear stress
8. TR shear stress
9. Axial stress
10. Plastic strain
11. Axial strain

BEAMIP is set in *DATABASE_EXTENT_BINARY

LS-DYNA DATABASE

****SKIP THE FOLLOWING IF THERE IS NO DATA FOR SHELL ELEMENTS ****

For shell elements the database contains NV2D values per element. If the minimum value of MAXINT is 3, then the stresses are typically located at the mid surface, the inner surface, and the outer surface, respectively. If one integration point is used the stress is written three times. If two integration points are used then the mid surface value is taken as the average value. The inner values of the stress are always set to the values at the innermost integration point and likewise for outer values. If no integration point lies at the center, i. e. an even number of integration points through the thickness, a value is computed that is an average of the two integration point lying nearest the mid surface. Only data for elements defined in the time history blocks is output. The ordering of the data follows:

1. Sigma-x (mid surface true stress in global system)
2. Sigma-y
3. Sigma-z
4. Sigma-xy
5. Sigma-yz
6. Sigma-zx
7. Effective plastic strain or material dependent variable
- *. **Define NEIPS additional history values here for midsurface**
8. Sigma-x (inner surface true stress in global system)
9. Sigma-y
10. Sigma-z
11. Sigma-xy
12. Sigma-yz
13. Sigma-zx
14. Effective plastic strain or material dependent variable
- *. **Define NEIPS additional history values here for inner surface**
15. Sigma-x (outer surface true stress in global system)
16. Sigma-y
17. Sigma-z
18. Sigma-xy
19. Sigma-yz
20. Sigma-zx
21. Effective plastic strain or material dependent variable
- *. **Define NEIPS additional history values here for outer surface**

If MAXINT >3 then define an additional (MAXINT-3)* (6*IOSHL(1) + 1*IOSHL(2) + 8*IOSHL(3) + 4*IOSHL(4) + NEIPS) quantities here

22. Bending moment-mx (local shell coordinate system)
23. Bending moment-my
24. Bending moment-mxy
25. Shear resultant-qx
26. Shear resultant-qy
27. Normal resultant-nx
28. Normal resultant-ny
29. Normal resultant-nxy
30. Thickness
31. Element dependent variable
32. Element dependent variable
33. Internal energy (if and only if ISTRN=0)

The following quantities are expected if and only if ISTRN=1

33. eps-x (inner surface strain in global system)
34. eps-y
35. eps-z
36. eps-xy
37. eps-yz
38. eps-zx
39. eps-x (outer surface strain in global system)
40. eps-y
41. eps-z
42. eps-xy
43. eps-yz
44. eps-zx
45. Internal energy (if and only if ISTRN=1)

LS-DYNA DATABASE

****SKIP THE FOLLOWING IF THERE IS NO DATA FOR SPH ELEMENTS ****

TIME	1	Time word
SPHDATA	SPHV	Data for each sph element according to the sph flags SPHV=NSTP*NUM_SPH_DATA

INTERFACE FORCE DATABASE

There are three sections in the interface force database. The first contains 64 words of control information. The second contains geometric information, i.e. the nodal coordinates and segment connectivities for each segment contained in the master and slave surface definitions. The third section contains the results of the analysis at sequential output intervals. The output at a given time is called a state. The state contains a time word, global variables such as total energies and momenta, nodal data consisting of accelerations, velocities, and displacements, and finally segment data is written that include the pressure and shear stress acting on each segment and nodal forces for each node that defines the segment. The control information that follows provides information as to what is in the file and which database is being processed.

CONTROL DATA

VALUE	#WORDS	DISK ADDRESS	DESCRIPTION
Title	10	0	Problem identification
Run time	1	10	Time of day
Date	1	1	Date
Machine	1	12	Computer identification
Code	1	13	Code name
Version	1	14	Code version
NDIM	1	15	Insert 4 for DYNA3D database
NUMNP	1	16	Number of nodal points
ICODE	1	17	Insert 6 for DYNA3D database
NGLBV	1	18	Number of global variable to be read
BLANK	1	19	Insert zero
IU	1	20	Flag for current geometry (=1)
IV	1	21	Flag for velocities (=1)
BLANK	1	22	Insert zero
BLANK	1	23	Insert zero
BLANK	1	24	Insert zero
BLANK	1	25	Insert zero
BLANK	1	26	Insert zero
BLANK	1	27	Insert zero

LS-DYNA DATABASE

BLANK	1	28	Insert zero
BLANK	1	29	Insert zero
BLANK	1	30	Insert zero
NUMSG	1	31	Total number of slave and master segments in sliding interface definitions.
NUMMAT4	1	32	= 2 times the number of, sliding interfaces.
NV2D	1	33	= 16, 17 or 21 for force database.
BLANK	5	34	Unused space
NARBS	1	39	Additional storage required for arbitrary node and element numbering in type 6 database This number equals the sum of (10+ NUMNP+NEL8+NEL2+NEL4+ NELT)
BLANK	24	40	Unused space

GEOMETRY DATA

The geometry section contains the nodal coordinates and the element connectivities. The ordering of the nodal points is assumed to be the same as the ordering of the nodal data in the state data that follows.

VALUE	LENGTH	DESCRIPTION
X(3,1)	NDIM*NUMNP	Array of nodal coordinates X1,Y1,Z1, X2,Y2,Z2,X3,Y3,Z3, ... ,Xn,Yn,Zn
IX4(5,1)	5*NUMSG	Connectivity and identification number for each 3 or 4 node interface segment. For sliding interface n the identification number in 2n-1 for the slave surface and 2n for the master surface.

USER MATERIAL, NODE, AND ELEMENT IDENTIFICATION NUMBERS

Skip this section if NARBS (disk address 39) is zero. The user node and element numbers must be in ascending order. *It is assumed that if this option is used all node and element data anywhere in the databases is in ascending order based on user numbering.* The total length of the data in this database is equal to

$$\text{NARBS} = 10 + \text{NUMNP} + \text{NEL8} + \text{NEL2} + \text{NEL4} + \text{NELT}$$

if sequential numbering is used of the materials. For arbitrary material numbering the total length is increased by $6 + \text{NUMMAT8} + \text{NUMMAT4} + \text{NUMMAT2} + \text{NUMMATT}$. Material numbers are not in ascending order.

VALUE	LENGTH	DESCRIPTION
NSORT	1	Pointer to arbitrary node numbers in LS-DYNA source code, a negative sign flags that arbitrary material identification numbers are also used.
NSRH	1	Pointer to arbitrary solid element numbers in LS-DYNA source code: =NSORT+NUMNP
NSRB	1	Pointer to arbitrary beam element numbers in LS-DYNA source code: =NSRH+NEL8
NSRS	1	Pointer to arbitrary shell element numbers in LS-DYNA source code: =NSRB+NEL2
NSRT	1	Pointer to arbitrary thick shell element numbers in LS-DYNA source code: =NSRS+NEL4
NSORTD	1	Number of nodal points
NSRHD	1	Number of 8 node solid elements
NSRBD	1	Number of 2 node beam elements
NSRSD	1	Number of 4 node shell elements
NSRTD	1	Number of 8 node thick shell elements
NSRMA	1	Pointer to an array in the LS-DYNA source code that list the material ID's in ascending order.
NSRMU	1	Pointer to an array in the LS-DYNA source code that gives the material ID's in the actual order that they are defined in the user input.

LS-DYNA DATABASE

VALUE	LENGTH	DESCRIPTION
NSRMP	1	Pointer to an array in the LS-DYNA source code that gives the location of a member in the array originating at NSRMU for each member in the array starting at NSRMA.
NSRTM	1	Total number of materials
NUMRBS	1	Total number of nodal rigid body constraint sets
NMMAT	1	Total number of materials
NUSERN	NSORTD	Array of user defined node numbers
NUSERH	NSORTH	Array of user defined solid element numbers
NUSERB	NSORTB	Array of user defined beam element numbers
NUSERS	NSORTS	Array of user defined shell element numbers
NUSERT	NSORTT	Array of user defined thick shell numbers
NORDER	NMMAT	Ordered array of user defined material ID's
NSRMU	NMMAT	Unordered array of user material ID's
NSRMP	NMMAT	Cross reference array

STATE DATA

The state data for the interface forces have three parts:

- Time word and global data
- Node data
- Force data for sliding interface segments

LS-TAURUS and LS-POST processes the node and element data and can interpolate between states.

VALUE	LENGTH	DESCRIPTION
TIME	1	Time word
GLOBAL	NGLBV	Global variables for this state
NODEDATA	NND	Total nodal values for state where $NND=(IT+NDIM*(IU+IV))*NUMNP$ DYNA3D writes 6 values per node, i.e., the three coordinates and the translational velocities. The Data is put into the database as two vectors: first X(3,NUMNP) and then V(3,NUMNP), respectively.
SEGMDATA	ENN	Data for sliding interface segments where the quantity $ENN = (16,17,or21)*NV2D$. The organization of the segment data is described below.

This state data is repeated for each state in the database.

For each sliding interface segment the database contains NV2D=16, 17 or 21 values per segment. The ordering of the data follows:

1. Normal interface pressure acting on segment
2. Maximum interface shear stress acting on segment
3. Shear stress in local r-direction of segment
4. Shear stress in local s-direction of segment
5. X force at node n1 of segment
6. Y force at node n1 of segment
7. Z force at node n1 of segment
8. X force at node n2 of segment
9. Y force at node n2 of segment

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10. Z force at node n2 of segment
11. X force at node n3 of segment
12. Y force at node n3 of segment
13. Z force at node n3 of segment
14. X force at node n4 of segment
15. Y force at node n4 of segment
16. Z force at node n4 of segment
17. contact gap at node n1
18. contact gap at node n2
19. contact gap at node n3
20. contact gap at node n4
21. surface energy density of segment

If contact gap at node n1 = -1.0, then no values are set. Similarly, if surface energy density is = -1.0, no value is set.

If contact gap is ≥ 999.0 ignore the value, this means that the interfaces are not in discernible contact.

CRACK FILE (d3crck)

The crack file is created in LS-DYNA when the Winfrith Concrete material model is used for solid elements. This model allows up to three orthogonal crack planes to develop each with an origin at the center of the element. The plane is assumed to project to the surface of the solid, and can be represented by drawing a line on any of the six solid element faces where it emerges. This cutting line can be found by considering the intersection of each plane and each solid face.

The crack file is written as a Fortran unformatted binary file, and each record in the file has a start record mark and an end record mark, each of which is 4 bytes for a single precision run and 8 bytes for a double precision run. The data is output for a state and contains:

VALUE	#WORDS	DESCRIPTION
TIME	1	State Time word
NUMBER OF CRACKS	1	NC, Number of sets of crack data
CRACK DATA	16 * NC	Sets of data for each crack

Data for each crack contains: Element ID, Flag for each crack plane, Normal vector for each crack plane and width for each crack plane.

Crack plane flags are as follows:

0 = no crack, 1 = cracked, but no sustaining tensile load, 2 = cracked but closed up, and 3 = fully cracked with no tensile strength.

Shown below is some C coding from LS-POST to illustrate how the crack data is used and the crack lines established. The important coding is picked out in bold type. Also, after the crack data was read in, the crack flags (3 words) were stored as bits in one word. NG and MAT are the Group number for elements and the Material ID we assign in LS-POST.

```

/* elm id, 3 2bit flags 0 -> 2, group no., mat no. */
int id, pflag, ng, mat;
float abc[9]; /* plane normals */
float cp[3]; /* crack width planes 1, 2 and 3 */

/* check brick element face against crack plane (nx,ny,nz) positioned
 * at element center (xe,ye,ze)
 */
int CrackPlane(float xe, float ye, float ze, float nx, float ny, float nz,
float xyz[3], float xs[2], float ys[2], float zs[2])
{
int i, k;
float x0, y0, z0, x1, y1, z1;
float xp1, yp1, zp1, xp2, yp2, zp2, pn, dn, t;

```

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```
k = 0;
x0 = xyz[3][0];
y0 = xyz[3][1];
z0 = xyz[3][2];
for (i=0; i<4; i++) {
    /* parametric line clip algorithm */
    xp1 = x0 - xe;
    yp1 = y0 - ye;
    zp1 = z0 - ze;
    x1 = xyz[i][0];
    y1 = xyz[i][1];
    z1 = xyz[i][2];
    xp2 = x1 - x0;
    yp2 = y1 - y0;
    zp2 = z1 - z0;
    x0 = x1;
    y0 = y1;
    z0 = z1;
    pn = nx*xp1 + ny*yp1 + nz*zp1;
    dn = nx*xp2 + ny*yp2 + nz*zp2;
    if (fabs(dn) < 1.0e-15) continue;
    t = -pn / dn;
    if (t < 0.0 || t > 1.0) continue;
    t = t - 1.0;
    xs[k] = x1 + t * xp2;
    ys[k] = y1 + t * yp2;
    zs[k] = z1 + t * zp2;
    k++;
    if (k > 1) break;
}
return k;
}
```

```
void SetCrackWidth(float v)
{
    min_crack_width = MAX(0.0, v);
}
```

```
void DrawCracks(int ist, float *bg_color)
{
    int i, k, m, n, nc, nd, kd, ip, ic, is;
    int id, facecode;
    int etype, nface, pflag, flag;
    unsigned int j;
    float xc, yc, zc, a, b, c;
    float xyz[24][3];
    float xi[2], yi[2], zi[2];
    int shrink, count, ns[2];
    float dx, dy, dz, ds, d;
    NDCOOR *nod;
    int ng=0;
    float rd, gn, bu;

    nod = node;
```

```

nod--;

rd = 1.0 - bg_color[0];
gn = 1.0 - bg_color[1];
bu = 1.0 - bg_color[2];
glDisable(GL_LIGHTING);
glColor3f(rd, gn, bu);
glLineWidth(2.0);
GetCrackData(ist);
glBegin(GL_LINES);
nc = cstate[ist].nc;
for (n=0; n<nc; n++) {
  pflag = crack[n].pflag;
  if (pflag == 0) continue;
  id = crack[n].id - 1;
  k = solid[id].mat & MASKBIT22;
  j = active_list[k].loc;
  facecode = (active_list[k].akey>>2) & FACEBITS1;
  if (j < BIT30 && facecode > 0) {
    id = j;
    ng = crack[n].ng;
    if (!part[ng].active) continue;
    dx = part[ng].dscale[0];
    dy = part[ng].dscale[1];
    dz = part[ng].dscale[2];
    ds = part[ng].dscale[3];
    shrink = part[ng].shrink_mode;
    etype = (active_list[k].akey) & 0x3;
    nface = FACE_NF[etype];
    xc = yc = zc = 0.0; ic = 0;

    for (i=0; i<nface; i++) {
      for (m=0; m<4; m++) {
        nd = FACE_P[etype][i][m];
        kd = solid[id].conn[nd];
        k = 4 * i + m;
        if (ds == 0.0) {
          xyz[k][0] = (disp_state+kd)->xyz[0];
          xyz[k][1] = (disp_state+kd)->xyz[1];
          xyz[k][2] = (disp_state+kd)->xyz[2];
        }
        else {
          GetScaledNodalCoord(kd, nod, disp_state, dx,dy,dz, xyz[k]);
        }
        xc += xyz[k][0];
        yc += xyz[k][1];
        zc += xyz[k][2];
        ic += 1;
      }
    }

    if (ic == 0) continue;
    d = 1.0 / (float)ic; xc *= d; yc *= d; zc *= d;
    if (shrink) {

```

