*SENSOR

The keyword *SENSOR provides a convenient way of activating and deactivating boundary conditions, airbags, discrete elements, joints, contact, rigid walls, single point constraints, and constrained nodes. The sensor capability is available as of the second release of version 971 and will evolve in later releases to encompass many more LS-DYNA capabilities and replace some of the existing capabilities, such as the airbag sensor logic. The keyword commands in this section are defined below in alphabetical order:

*SENSOR_CONTROL

*SENSOR_CPM_AIRBAG

*SENSOR_DEFINE_CALC-MATH

*SENSOR_DEFINE_ELEMENT

*SENSOR_DEFINE_FORCE

*SENSOR_DEFINE_FUNCTION

*SENSOR_DEFINE_MISC

*SENSOR_DEFINE_NODE

*SENSOR_SWITCH

*SENSOR_SWITCH_CALC-LOGIC

*SENSOR_SWITCH_SHELL_TO_VENT

An additional option **TITLE** may be appended to all the ***SENSOR** keywords. If this option is used, then an addition line is read for each sensor in 80a format which can be used to describe the sensor. At present, the title serves no purpose other than to perhaps lend clarity to input decks.

To define and use a sensor, three categories of sensor keyword commands are needed as shown in Figure 42-1.

1. Sensors are defined using the *SENSOR_DEFINE commands. Sensors provide a time history of model response that may be referred to by *SENSOR_SWITCH as a switching criterion. (Note: The time history of any sensor can be output using the SENSORD function in *DEFINE_CURVE_FUNCTION and *DATABASE_CURVOUT.)

   a) *SENSOR_DEFINE(_ELEMENT, _FORCE, _MISC, _NODE)

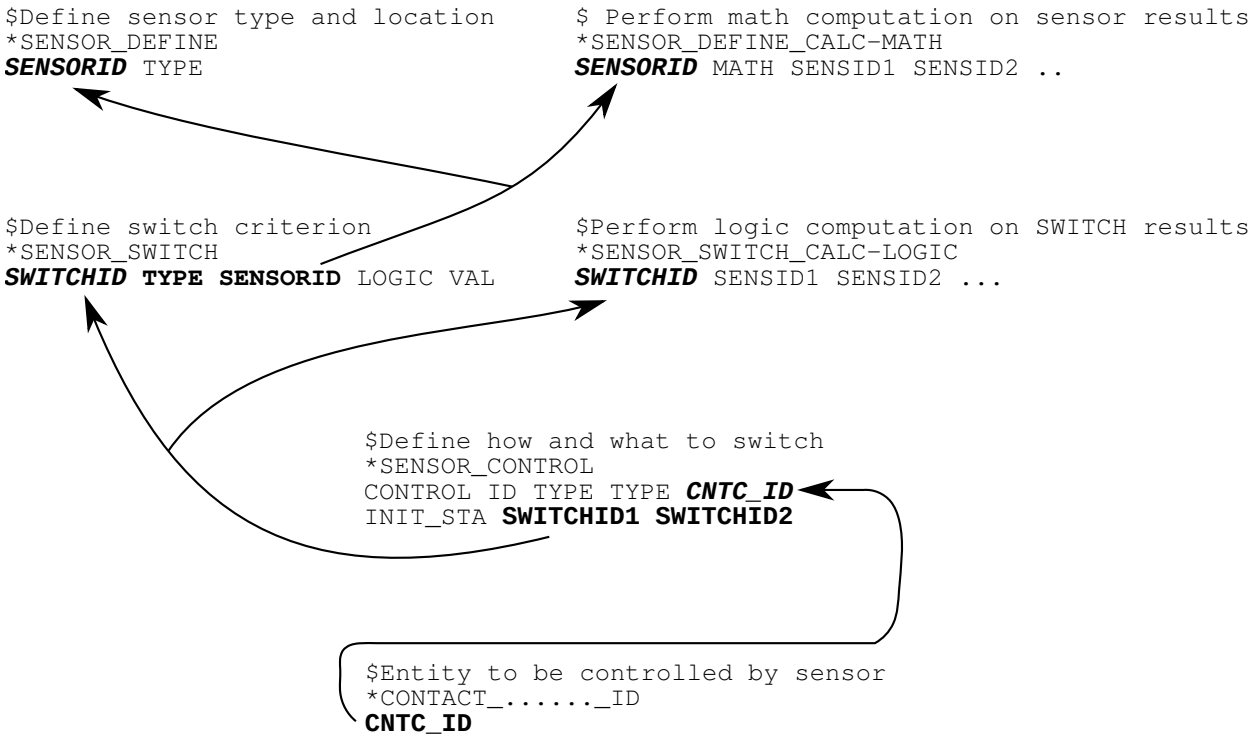

Figure 42-1. Relationship between sensor keyword definitions.

These commands define a sensor's ID, type, and location.

b) *SENSOR_DEFINE_CALC-MATH, *SENSOR_DEFINE_FUNCTION

These commands define a sensor whose value is a mathematical expression involving the values from other sensors.

2. The *SENSOR_SWITCH family of keywords define sensor switching criterion. *SENSOR_SWITCH can be combined with the logical calculation command *SENSOR_SWITCH_CALC-LOGIC for more complicated definitions. The logic value yielded by this category of commands can be referred by *SENSOR_CONTROL to determine if a status switch condition is met.

a) *SENSOR_SWITCH

This command compares the numerical value from *SENSOR_DEFINE or *SENSOR_DEFINE_CALC-MATH with the given criterion to see if a switching condition is met.

b) *SENSOR_SWITCH_CALC-LOGIC

This command performs logical calculation on the information from SENSOR_SWITCH.

3. *SENSOR_CONTROL determines how and what to switch based on the logical values from *SENSOR_SWITCH and/or *SENSOR_SWITCH_CALC-LOGIC.

*SENSOR_CONTROL

Purpose: This command uses switches (*SENSOR_SWITCH) to toggle on or off the effects of other LS-DYNA keywords, such as *CONTACT or *AIRBAG.

Card Summary:

Card Sets. For each sensor control, include a set of the following cards. This input ends at the next keyword ("*") card.

Card 1a. Include this card for all values of TYPE, except CURVE, PRESC-MOT, PRESC-ORI, PRESSURE, and ELESET.

CNTLID	TYPE	TYPEID		NREP			

Card 1b. Include this card for TYPE = CURVE, PRESC-MOT, PRESC-ORI, or PRESSURE (controlling *DEFINE_CURVE *BOUNDARY_PRESCRIBED_MOTION, *BOUNDARY_PRESCRIBED_RIGID_ORIENTATION, or *LOAD_SEGMENT_SET).

CNTLID	TYPE	TYPEID	TIMEOFF	NREP	DEFCV		

Card 1c. Include this card for TYPE = ELESET (controlling erosion of a set of elements of a specified type).

CNTLID	TYPE	TYPEID	IDISCL	NREP	ESTYP		

Card 2. This card is required.

INITSTT	SWIT1	SWIT2	SWIT3	SWIT4	SWIT5	SWIT6	SWIT7

All other values of Type Card. This card is included for all values of TYPE, except PRESC-MOT, PRESC-ORI, PRESSURE, and ELESET.

Card 1a	1	2	3	4	5	6	7	8
Variable	CNTLID	TYPE	TYPEID		NREP			
Type	I	A	I		I			

VARIABLE	DESCRIPTION
CNTLID	Sensor control ID
TYPE	Entity to be controlled:
	EQ.AIRBAG: *AIRBAG

VARIABLE	DESCRIPTION
	EQ.BAGVENTPOP: Opening and closing the airbag venting holes (see Remark 1)
	EQ.BELTPRET: Belt pretensioner firing (see Remark 2)
	EQ.BELTRETRA: Locking the belt retractor (see Remark 2)
	EQ.BELTSLIP: Controlling the slippage of slip ring element (see Remark 3)
	EQ.CONTACT: *CONTACT
	EQ.CONTACT2D: *CONTACT_2D
	EQ.CONSTRL: *CONSTRAINED_LOCAL
	EQ.CNRB: *CONSTRAINED_NODAL_RIGID_-BODY
	EQ.CPM: *AIRBAG_PARTICLE
	EQ.DEF2RIG: *DEFORMABLE_TO_RIGID_AUTOMATIC (see Remark 4)
	EQ.EM: EM solver (see Remark 6)
	EQ.FUNCTION: *DEFINE_CURVE_FUNCTION (see Remark 5)
	EQ.JOINT: *CONSTRAINED_JOINT
	EQ.JOINTSTIF: *CONSTRAINED_JOINT_STIFFNESS
	EQ.LOADTHM: *LOAD_THERMAL_VARIABLE
	EQ.M PRESSURE: *LOAD_MOVING_PRESSURE
	EQ.POREAIR: *MAT_ADD_PORE_AIR
	EQ.PZBC: *BOUNDARY_PZEPOT
	EQ.RWALL: *RIGID_WALL
	EQ.SPC: *BOUNDARY_SPC
	EQ.SPOTWELD: *CONSTRAINED_SPOTWELD
	EQ.BPWPN: *BOUNDARY_PWP_NODE/SET_ID
TYPEID	ID of entity to be controlled if TYPE ≠ FUNCTION, LOADTHM, or POREAIR. If TYPE = FUNCTION, see Remark 5. For TYPE = LOADTHM, TYPEID is the node set for which the temperature boundary condition specified by either *LOAD_THERMAL_VARIABLE or *LOAD_THERMAL_VARIABLE_NODE will be controlled. For TYPE = POREAIR, TYPEID is the ID of the

VARIABLE	DESCRIPTION
	part containing material with pore air.
NREP	Number of times to repeat a cycle of switches, SWIT*n*, defined on Card 2. For example, a definition of SWIT*n* like "601, 602, 601, 602, 601, 602" can be replaced by setting NREP to 3 and SWIT*n* to "601, 602". Setting NREP = -1 repeats the cycle for an infinite number of times. Default is 0.

TYPE CURVE, PRESC-MOT, PRESC-ORI, and PRESSURE Card. Include this card for TYPE = CURVE, PRESC-MOT, PRESC-ORI, or PRESSURE.

Card 1b	1	2	3	4	5	6	7	8
Variable	CNTLID	TYPE	TYPEID	TIMEOFF	NREP	DEFCV		
Type	I	A	I	I	I	A/F		

VARIABLE	DESCRIPTION
CNTLID	Sensor control ID
TYPE	Entity to be controlled: EQ.CURVE: *DEFINE_CURVE, time-dependent curve EQ.PRESC-MOT: *BOUNDARY_PRESCRIBED_MOTION EQ.PRESC-ORI: *BOUNDARY_PRESCRIBED_ORIENTATION_RIGID EQ.PRESSURE: *LOAD_SEGMENT_SET
TYPEID	ID of entity to be controlled
TIMEOFF	Flag to offset time in curve: EQ.0: No offset is applied. EQ.1: Offset the abscissa of the time-dependent curve by the time value at which the sensor is triggered.

Type Of Control	Curve Affected
CURVE	*DEFINE_CURVE
PRESSURE	*LOAD_SEGMENT_SET
PRESC-MOT	*BOUNDARY_PRESCRIBED_MOTION
PRESC-ORI	*BOUNDARY_PRESCRIBED_ORIENTATION_RIGID

VARIABLE	DESCRIPTION
NREP	Number of times to repeat a cycle of switches, SWIT*n*, defined on Card 2. For example, a definition of SWIT*n* like "601, 602, 601, 602, 601, 602" can be replaced by setting NREP to 3 and SWIT*n* to "601, 602". Setting NREP = -1 repeats the cycle for an infinite number of times. Default is 0.
DEFCV	Default curve value when a curve is not active for TYPE = CURVE only. If DEFCRV = "LASTSTEP", the curve value right before the curve is turned off becomes the default curve value.

TYPE ELESET Card. This card is included when TYPE is ELESET.

Card 1c	1	2	3	4	5	6	7	8
Variable	CNTLID	TYPE	TYPEID	IDISCL	NREP	ESTYP		
Type	I	A	I	I	I	A		

VARIABLE	DESCRIPTION
CNTLID	Sensor control ID
TYPE	Entity to be controlled: EQ.ELESET: Element set; see "ESTYP" below.
TYPEID	ID of entity to be controlled
IDISCL	For ESTYP = DISC, flag for updating the reference length of the discrete element with its length when it is turned on: EQ.0: Discrete element's reference length remains the same when it is turned on. EQ.1: Discrete element's length when it is turned on is used as its new reference length.
NREP	Number of times to repeat a cycle of switches, SWIT*n*, defined on Card 2. For example, a definition of SWIT*n* like "601, 602, 601, 602, 601, 602" can be replaced by setting NREP to 3 and SWIT*n* to "601, 602". Setting NREP = -1 repeats the cycle for an infinite number of times. Default is 0.

VARIABLE	DESCRIPTION
ESTYP	Type of element set to be controlled. With initial status set to "ON," all the elements included in set TYPEID can be eroded when the controller status is changed to "OFF." When TYPEID is not defined, all elements of type ESTYP in the whole system will be eroded. EQ.BEAM: Beam element set EQ.DISC: Discrete element set EQ.SHELL: Thin shell element set EQ.SOLID: Solid element set EQ.TSHELL: Thick shell element set

Card 2	1	2	3	4	5	6	7	8
Variable	INITSTT	SWIT1	SWIT2	SWIT3	SWIT4	SWIT5	SWIT6	SWIT7
Type	A	I	I	I	I	I	I	I

VARIABLE	DESCRIPTION
INITSTT	Initial status: EQ.On: Initial status is on. EQ.Off: Initial status is off.
SWIT*n*	ID of n^{th} switch. At the start of the calculation SWIT1 is *active*, meaning that it controls the state of the feature specified in TYPEID. After SWIT1 triggers, then SWIT2 becomes active; after SWIT2 triggers, then SWIT3 becomes active; this process will continue until the entire stack of switches has been exhausted.

Remarks:

1. **Activation of Bag Venting.** BAGVENTPOP activates (opens) or deactivates (closes) the venting holes of *AIRBAG_HYBRID and *AIRBAG_-WANG_NEFSKE. It overwrites the definitions of PVENT of *AIRBAG_HYBRID and PPOP of *AIRBAG_WANG_NEFSKE. More than one switch can be input to open/close initially closed/opened holes, and then reclose/reopen the holes.

2. **Seatbelt Retractors.** The locking (or firing) of seatbelt retractor (or pretensioner) can be controlled through either general sensor, option BELTRETRA (or BELTPRET), or seatbelt sensors, *ELEMENT_SEATBELT_SENSOR. When BELTRETRA (or BELTPRET) is used, the SBSID*i* in *ELEMENT_-SEATBELT_RETRACTOR (or PRETENSIONER) should be left blank.

3. **Seatbelt Slip Ring.** For a one-way slip ring, a non-zero DIRECT in *ELEMENT_SEATBELT_SLIPRING, BELTSLIP activates the constraint of one-way slippage when the status of *SENSOR_CONTROL is on. When the *SENSOR_-CONTROL is turned off, the one-way slippage constraint is deactivated, therefore allowing slippage in both directions.

   For a two-way slip ring (DIRECT = 0), BELTSLIP activates slippage in both directions when the status of *SENSOR_CONTROL is on. When the status of *SENSOR_CONTROL is off, the slip ring locks up, allowing no slippage.

4. **Switching Between Rigid and Deformable.** DEF2RIG provides users more flexibility controlling the material switch between rigid and deformable. Status of ON triggers the switch, so the deformable material becomes rigid. Rigidized material can then return to deformable status when status becomes OFF. As many as 7 switches can be input; any of them will change the status triggered by its preceding switch or the initial condition, INTSTT.

5. **Function for Sensor Control.** When the input parameter TYPE of *SENSOR_-CONTROL is set to "FUNCTION", the function "SENSOR(cntlid)" as described in *DEFINE_CURVE_FUNCTION takes on a value that depends on the current status of the *SENSOR_CONTROL. That status is either on or off at any given point in time. If the status is on, the value of function SENSOR(cntlid) is set to the integer value 1. If the status is off, the value of function SENSOR(cntlid) is set to the input parameter TYPEID (an integer) as specified in *SENSOR_CONTROL.

   To help clarify the relationship between *SENSOR_CONTROL and *DEFINE_-CURVE_FUNCTION, consider the following example. Suppose a *SENSOR_-CONTROL defined with CNTLID = 101, TYPE="FUNCTION", and TYPEID = -2 has a status of off. Then a *DEFINE_CURVE_FUNCTION defined as “2+3*sensor(101)” will have a value of 2 + 3(-2) = -4. On the other hand, if the status of the *SENSOR_CONTROL changes to on, the *DEFINE_CURVE_FUNCTION takes on a value of 2 + 3(1) = 5.

6. **EM Solver.** TYPE = EM can be used to turn on/off EM solver. Since it serves the same function as *EM_CONTROL_SWITCH, it cannot be in an input deck with *EM_CONTROL_SWITCH.

***SENSOR_CPM_AIRBAG**_*{OPTION}*

Available options include:

ID

TITLE

OPTION provides a means to specify an airbag ID number and a heading for the airbag.

Purpose: This command will associate a CPM airbag with a sensor switch (see *SENSOR_SWITCH). When the condition flag is raised, the specified CPM airbag will deploy. All time dependent curves used for the CPM airbag are shifted by the activation time including the *AIRBAG_PARTICLE curves for the inflator and vent as well as the *MAT_FABRIC curves for TSRFAC.

ID Card. Additional card for the ID or TITLE keyword option.

Card ID	1	2	3	4	5	6	7	8
Variable	ABID	HEADING						
Type	I	A70						

Card 1	1	2	3	4	5	6	7	8
Variable	CPMID	SWITID	TBIRTH	TDEATH	TDR	DEFPS	RBPID	TFIRE
Type	I	I	F	F	F	I	I	F

VARIABLE	DESCRIPTION
ABID	Airbag ID
HEADING	Airbag descriptor
CPMID	Bag ID of *AIRBAG_PARTICLE_ID
SWITID	Switch ID of *SENSOR_SWITCH
TBIRTH	If SWITID is set, TBIRTH is not active. If SWITID is 0, TBIRTH is the activation time for the bag with ID = CPMID. All of the time-dependent curves that are used in this bag will be offset by the

VARIABLE	DESCRIPTION
	value of TBIRTH.
TDEATH	Disable the CPMID bag when the simulation time exceeds this value.
TDR	If TDR is greater than 0 the bag with ID = CPMID will be rigid starting at first cycle and switch to deformable at time TDR.
DEFPS	Part set ID specifying which parts of the bag with ID = CPMID are deformable.
RBPID	Part ID of the rigid body to which the part is merged.
TFIRE	Control activation time for mass flow rate and temperature curves

***SENSOR_DEFINE_CALC-MATH**_{OPTION}

Available options include:

<BLANK>

UPDATE

With the UPDATE keyword option, you can specify the birth time, death time, and value update frequency for the sensor. Note that without the UPDATE keyword option LS-DYNA updates the sensor value every time step.

Purpose: Defines a new sensor with a unique ID. The values associated with this sensor are computed by performing mathematical calculations with the information obtained from sensors defined by the *SENSOR_DEFINE_*OPTION*.

Card Summary:

Card 1. Include this card or, if using the UPDATE keyword option, a set of this card and Card 2 for each math sensor. This input ends at the next keyword ("*") card.

SENSID	CALC	SENS1	SENS2	SENS3	SENS4	SENS5	SENS6

Card 2. Include a set of Card 1 and this card if using the UPDATE keyword option.

BIRTH	DEATH	DTUPD					

Data Card Definitions:

Math Sensor Cards. For each math sensor, include this card or, if using the UPDATE keyword option, a set of this card and Card 2. This input ends at the next keyword ("*") card.

Card 1	1	2	3	4	5	6	7	8
Variable	SENSID	CALC	SENS1	SENS2	SENS3	SENS4	SENS5	SENS6
Type	I	A	I	I	I	I	I	I

VARIABLE	DESCRIPTION
SENSID	Sensor ID
CALC	Mathematical calculation. See Table 42-2.

VARIABLE	DESCRIPTION
SENS*i*	i^{th} Sensor ID

UPDATE Card. Include a set of Card 1 and this card if using the UPDATE keyword option.

Card 2	1	2	3	4	5	6	7	8
Variable	BIRTH	DEATH	DTUPD					
Type	F	F	F/I					

VARIABLE	DESCRIPTION
BIRTH	Birth time of this sensor
DEATH	Death time of this sensor
DTUPD	Time interval between updates. If negative, -DTUPD is the curve defining update interval as a function of time.

Remarks:

All sensors, SENS*i*, defined with either SENSOR_DEFINE_NODE_SET or SENSOR_DEFINE_ELEMENT_SET, must refer to either the same node set or the same element set.

Mathematical Functions:

FUNCTION	DESCRIPTION	MATHEMATICAL FORM
ABSSUM	Absolute value of the sum of sensor values	$\lvert SENS1 + SENS2 + \cdots \rvert$
MIN	The minimum of sensor values	$\min(SENS1, SENS2, \ldots)$
MAX	The maximum of sensor values	$\max(SENS1, SENS2, \ldots)$
MAXMAG	The maximum of magnitude of sensor values	$\max(\lvert SENS1 \rvert, \lvert SENS2 \rvert, \ldots)$
MINMAG	The minimum of the magnitude of sensor values	$\min(\lvert SENS1 \rvert, \lvert SENS2 \rvert, \ldots)$
MULTIPLY	Multiplication of sensor values; negative for division (performed left to right)	$SENS1 \times SENS2 \times \cdots$

FUNCTION	DESCRIPTION	MATHEMATICAL FORM
SQRE	Summation of squared values of sensor values	$SENS1^2 + SENS2^2 + \cdots$
SQRTSQRE	Square root of the sum of squared values	$\sqrt{SENS1^2 + SENS2^2 + \cdots}$
SQRT	Summation of square root of sensor values; negative for subtracting values	$\sqrt{SENS1} + \sqrt{SENS2} + \cdots$
SUMABS	Summation of absolute sensor values	$\lvert SENS1\rvert + \lvert SENS2\rvert + \cdots$
SUM	Summation of sensor values; negative for subtracting values	$SENS1 + SENS2 + \cdots$

Table 42-2. Available mathematical functions.

Example:

```
$
$ assume set_2 to have 100 solid elements
*SENSOR_DEFINE_ELEMENT_SET
$ this sensor traces xx-strain of all 100 solid elements in set-2
        91     SOLID        -2        XX    STRAIN
*SENSOR_DEFINE_ELEMENT_SET
$ this sensor traces yy-strain of all 100 solid elements in set-2
        92     SOLID        -2        YY    STRAIN
*SENSOR_DEFINE_ELEMENT_SET
$ this sensor traces zz-strain of all 100 solid elements in set-2
        93     SOLID        -2        ZZ    STRAIN
*SENSOR_DEFINE_CALC-MATH
$ this sensor traces strain magnitudes of all 100 solid elements in set-2
       104  SQRTSQRE        91        92        93         0         0         0
*SENSOR_SWITCH
$ Because ELEMID of *sensor_define_element_set was input as "-2", SWITCH-1 will be
$ turned on if at least one of 100 elements has a strain magnitude>2.0E-4
$ On the other hand, If ELEMID was input as "2", SWITCH-1 will be turned on if
$ all 100 elements have strain magnitudes>2.0E-4
         1    SENSOR       104        GT    2.0E-4         0     0.001
$
```

*SENSOR_DEFINE_ELEMENT_{OPTION1}_{OPTION2}

For *OPTION1* the available options are:

<BLANK>

SET

With the SET option active, the sensor value or values depends on a set of elements. See Remark 1.

For *OPTION2* the available options are:

<BLANK>

UPDATE

With the UPDATE keyword option, you can specify the birth time, death time, and value update frequency for the sensor. Note that without the UPDATE keyword option LS-DYNA updates the sensor value every time step.

Purpose: Define a strain gage type element sensor that checks the stress, strain, or resultant force of an element or element set.

Card Summary:

Card Sets. For each element sensor matching the specified keyword options include one set of the following data cards. Include as many sets as needed. This input ends at the next keyword ("*") card.

Card 1. This card is required.

SENSID	ETYPE	ELEMID	COMP	CTYPE	LAYER	SF	PWR

Card 2. Include this card if using the SET option. If only one element set is specified and the UPDATE keyword option is not used, this card may be omitted if not needed. Otherwise, it must be included, but it may be left blank. Note that if this card is included and ELEMID < 0, then this card must be blank.

SETOPT							

Card 3. Include this card if using the UPDATE keyword option.

BIRTH	DEATH	DTUPD					

Data Card Definitions:

Card 1	1	2	3	4	5	6	7	8
Variable	SENSID	ETYPE	ELEMID	COMP	CTYPE	LAYER	SF	PWR
Type	I	A	I	A	A	A/I	R	R

VARIABLE	DESCRIPTION
SENSID	Sensor ID
ETYPE	Element type. Available options include: EQ.BEAM: Beam element EQ.SHELL: Shell element EQ.SOLID: Solid element EQ.DISC-ELE: Discrete element EQ.SEATBELT: Seatbelt element EQ.TSHELL: Thick shell element
ELEMID	Element ID or element set ID when the SET keyword option is active. In the case of the SET keyword option with SETOPT not defined, determining the status of a related *SENSOR_SWITCH depends on the sign of ELEMID. If SETOPT is defined, then ELEMID must be greater than 0. See Remark 1.
COMP	Component type. The definition of the component, and its related coordinate system, is consistent with that of elout. Leave blank for discrete elements. Available options for elements other than discrete elements include: EQ.XX: x-normal component for shells, thick shells, and solids EQ.YY: y-normal component for shells, thick shells, and solids EQ.ZZ: z-normal component for shells, thick shells, and solids EQ.XY: xy-shear component for shells, thick shells, and

VARIABLE	DESCRIPTION
	solids
	EQ.YZ: *yz*-shear component for shells, thick shells, and solids
	EQ.ZX: *zx*-shear component for shells, thick shells, and solids
	EQ.HYDR: Hydrostatic stress or strain, meaning the average of the three normal components, for shells, thick shells, and solids
	EQ.MAXS: Maximum shear stress or strain for shells, thick shells, and solids
	EQ.PRIN1: 1st principal stress or strain for shells, thick shells, and solids
	EQ.PRIN2: 2nd principal stress or strain for shells, thick shells, and solids
	EQ.PRIN3: 3rd principal stress or strain for shells, thick shells, and solids
	EQ.VM: von Mises stress for shells, thick shells, and solids
	EQ.F[ID]: Value of a function, *DEFINE_FUNCTION, with all 6 stress/strain components as input. It is available for shells, thick shells, and solids. The ID of the function must follow right after F. For instance, F1000 means the function with ID of 1000 defines the sensed value.
	EQ.AXIAL: Axial
	EQ.SHEARS: Local *s*-direction
	EQ.SHEART: Local *t*-direction
CTYPE	Sensor type:
	EQ.STRAIN: Strain component for shells, thick shells, and solids
	EQ.STRESS: Stress component for shells, thick shells, and solids
	EQ.FORCE: Force resultants for beams, seatbelt, or translational discrete element; moment resultant for rotational discrete element
	EQ.MOMENT: Moment resultants for beams

VARIABLE	DESCRIPTION
	EQ.DLEN: Change in length for discrete or seatbelt element
	EQ.FAIL: Failure of the element, sensor value = 1 when the element fails, = 0 otherwise.
LAYER	Layer of the integration point in a shell or thick shell element. Options include: EQ.BOT: Component at lower surface meaning the integration point with the smallest through-the-thickness local coordinate EQ.TOP: Component at upper surface meaning the integration point with the largest through-the-thickness local coordinate When CTYPE = STRESS, LAYER could be an integer i to monitor the stress of the i^{th} integration point.
SF, PWR	Optional parameters, scale factor and power, for users to adjust the resultant sensor value. The resultant sensor value is $[\text{SF} \times (\text{Original Value})]^{\text{PWR}}$

SET Card. Additional card for the SET keyword option. If you specify more than one element set sensor or additionally use the UPDATE keyword option, this card must be included for each set sensor even if left blank. If ELEMID < 0 and this card is included, it must be blank.

Card 2	1	2	3	4	5	6	7	8
Variable	SETOPT							
Type	A							
Default	Optional							

VARIABLE	DESCRIPTION
SETOPT	Option to process set of data when the SET keyword option is specified (see Remark 1). If you set SETOPT, then ELEMID must be greater than 0. When SETOPT is defined, a single value will be reported. The single reported value could be: EQ.AVG: The average value of the dataset

VARIABLE	DESCRIPTION
	EQ.MAX: The maximum value of the dataset
	EQ.MIN: The minimum value of the dataset
	EQ.SUM: The sum of the dataset

UPDATE Card. This card is included if the UPDATE keyword option is used.

Card 3	1	2	3	4	5	6	7	8
Variable	BIRTH	DEATH	DTUPD					
Type	F	F	F/I					

VARIABLE	DESCRIPTION
BIRTH	Birth time of this sensor
DEATH	Death time of this sensor
DTUPD	Time interval between updates. If negative, -DTUPD is the curve ID for a curve defining the update interval as a function of time.

Remarks:

1. **SET option.** When SETOPT is not defined for the SET option, a list of elemental data will be reported, one for each element in the element set. *SENSOR_DEFINE_FUNCTION and *SENSOR_DEFINE_CALC-MATH can process these reported elemental values, resulting in a list of processed values. Note that all sensor definitions referred to by these two processing commands must have the same number of data points. These elemental values also can determine if the status of a *SENSOR_SWITCH will be changed. Depending on the sign of ELEMID, it can take only one single data point (ELEMID < 0) or the whole data set (ELEMID > 0) to meet the switch condition to change the status of the related *SENSOR_SWITCH. The reported elemental values cannot be accessed by commands like *DEFINE_CURVE_FUNCTION; see SENSORD option.

   When SETOPT is defined, the elemental values of all elements in the element set will be processed, depending on the definition of SETOPT; the resulting value is reported as the single sensor value. The reported value can be processed by both *SENSOR_DEFINE_FUNCTION and *SENSOR_DEFINE_CALC-MATH as well as other regular sensors. It can also be used to determine the status of a *SENSOR_SWITCH. A *DEFINE_CURVE_FUNCTION using the SENSORD

option may also access this reported value. Note that ELEMID *must be greater* than 0 for this case.

*SENSOR_DEFINE_FORCE_{OPTION}

Available options include:

<BLANK>

UPDATE

The UPDATE keyword option enables providing the birth time, death time, and value update frequency for the sensor. Note that without the UPDATE keyword option, LS-DYNA updates the sensor value every time step.

Purpose: Define a force transducer-type sensor.

Card Summary:

Card 1. For each force sensor, include one of this card or, if using the UPDATE keyword option, a set of this card and Card 2. This input ends at the next keyword ("*") card.

SENSID	FTYPE	TYPEID	VID	CRD			

Card 2. Include this card in a set with Card 1 for the UPDATE keyword option.

BIRTH	DEATH	DTUPD					

Data Card Definitions:

Force Sensor Cards. Include one additional card for each force sensor. This input ends at the next keyword ("*") card.

Card 1	1	2	3	4	5	6	7	8
Variable	SENSID	FTYPE	TYPEID	VID	CRD			
Type	I	A	I	A/I	I			

VARIABLE	DESCRIPTION
SENSID	Sensor ID.
FTYPE	Force type. See Table 42-3 and Remark 1.
TYPEID	ID defined in the associated KEYWORD command. See Table 42-3.

VARIABLE	DESCRIPTION
VID	Vector along which the forces is measured.
	EQ.X: *x*-direction in coordinate system CRD
	EQ.Y: *y*-direction in coordinate system CRD
	EQ.Z: *z*-direction in coordinate system CRD
	EQ.XL: *x*-direction in the local coordinate system for JOINTSTIF only
	EQ.YL: *y*-direction in the local coordinate system for JOINTSTIF only
	EQ.ZL: *z*-direction in the local coordinate system for JOINTSTIF only
	EQ.M: Force magnitude
	EQ.XMOMENT: *x*-direction moment for JOINT, JOINTSTIF, PRESC-MOT or SPC
	EQ.YMOMENT: *y*-direction moment for JOINT, JOINTSTIF, PRESC-MOT or SPC
	EQ.ZMOMENT: *z*-direction moment for JOINT, JOINTSTIF, PRESC-MOT or SPC
	EQ.XLMOMENT: *x*-direction moment in the local coordinate system for JOINTSTIF only
	EQ.YLMOMENT: *y*-direction moment in the local coordinate system for JOINTSTIF only
	EQ.ZLMOMENT: *z*-direction moment in the local coordinate system for JOINTSTIF only
	EQ.MMOMENT: Moment magnitude for JOINT, JOINTSTIF, PRESC-MOT or SPC
	VID∈{INT}: Vector ID n in coordinate system CRD
CRD	Optional coordinate system, defined by *DEFINE_COORDINATE_NODES, to which vector VID is attached. If blank, the global coordinate system is assumed.

UPDATE card. Include this card in a set with Card 1 for the UPDATE keyword option.

Card 2	1	2	3	4	5	6	7	8
Variable	BIRTH	DEATH	DTUPD					
Type	F	F	F/I					

VARIABLE	DESCRIPTION
BIRTH	Birth time of this sensor
DEATH	Death time of this sensor
DTUPD	Time interval between updates. If negative, -DTUPD is the curve defining update interval as a function of time.

FTYPE	TYPEID (Enter ID defined in following KEYWORD commands)	OUTPUT	ASCII FILE
AIRBAG	*AIRBAG	Airbag pressure	ABSTAT
CONTACT	*CONTACT	Contact force on the surfa side	RCFORC
CONTACT2D	*CONTACT_2D	Contact force on the surfa / sph side	RCFORC
CPM	*AIRBAG_PARTICLE	Airbag pressure	ABSTAT_CPM
JOINT	*CONSTRAINED_JOINT	Joint force	JNTFORC
JOINTSTIF	*CONSTRAINED_JOINT_STIFFNESS	Joint stiffness force	JNTFORC
PRESC-MOT	*BOUNDARY_PRESCRIBED_MOTION	Prescribed motion force	BNDOUT
RWALL	*RIGIDWALL	Rigid wall force	RWFORC
SPC	*BOUNDARY_SPC	SPC reaction force	SPCFORC
SPOTWELD	*CONSTRAINED_POINTS	Spot weld force	SWFORC

FTYPE	TYPEID (Enter ID defined in following KEYWORD commands)	OUTPUT	ASCII FILE
X-SECTION	*DATABASE_CROSS_SECTION	Section force	SECFORC

Table 42-3. Force transducer-type sensor

Remarks:

1. **FTYPE = PRESC-MOT.** A sensor registers the same force as in the BNDOUT file. In case of multiple *BOUNDARY_PRESCRIBED_MOTION instances defining the kinematics of an entity (node/node set/rigid body, etc.), this sensor registers a resultant force of all related *BOUNDARY_PRESCRIBED_MOTION to the entity. For example, let the *BOUNDARY_PRESCRIBED_MOTION with ID 100 prescribe the x-displacement of node 50, and the *BOUNDARY_PRESCRIBED_MOTION instance with ID 200 the y-displacement of node 50. BNDOUT registers the resultant reaction force due to both of these prescribed motions. The x-direction force in BNDOUT is attributed to the prescribed motion with ID 100 and the y-direction to that with ID 200.

*SENSOR_DEFINE_FUNCTION_{OPTION}

Available options include:

<BLANK>

UPDATE

With the UPDATE keyword option, you can specify the birth time, death time, and value update frequency for the sensor. Note that without the UPDATE keyword option LS-DYNA updates the sensor value every time step.

Purpose: Defines a new sensor with a unique ID. The value associated with this sensor is computed by performing mathematical calculations defined in *DEFINE_FUNCTION, with the information obtained from other sensors defined by the *SENSOR_DEFINE_*OPTION*.

Card 1	1	2	3	4	5	6	7	8
Variable	SENSID	FUNC	SENS1	SENS2	SENS3	SENS4	SENS5	SENS6
Type	I	I	I	I	I	I	I	I

Sensor Cards. Additional Cards needed when SENS1 < -5. Include as many cards as needed to specify all |SENS1| cards.

Card 2	1	2	3	4	5	6	7	8
Variable	SENS7	SENS8	SENS9	SENS10	SENS11	SENS12	SENS13	SENS14
Type	I	I	I	I	I	I	I	I

UPDATE Card. Additional card for the UPDATE keyword option to control how often the sensor value will be updated.

Card 3	1	2	3	4	5	6	7	8
Variable	BIRTH	DEATH	DTUPD					
Type	F	F	F/I					

VARIABLE	DESCRIPTION
SENSID	Sensor ID
FUNC	Function ID
SENS1	1st sensor ID, the value of which will be used as the 1st argument of function FUNC. If defined as negative, the absolute value of SENS1, |SENS1|, is the number of sensors to be input. If |SENS1| > 5, additional cards will be needed to input the ID of all sensors. The number of sensors is limited to 15.
SENS*i*	*i*th Sensor ID, the value of which will be used as the *i*th argument of function FUNC
BIRTH	Birth time of this sensor
DEATH	Death time of this sensor
DTUPD	Time interval between updates. If negative, -DTUPD is the curve defining update interval as a function of time.

***SENSOR_DEFINE_MISC**_{OPTION}

Available options include:

<BLANK>

UPDATE

With the UPDATE keyword option, you can specify the birth time, death time, and value update frequency for the sensor. Note that *without* the UPDATE keyword option LS-DYNA updates the sensor value every time step.

Purpose: Trace the value of a miscellaneous item. This keyword replaces *SENSOR_DEFINE_ANGLE.

Force Sensor Cards. For each miscellaneous sensor, include this card or, if the UPDATE keyword option is used, sets of this card and Card 2. This input ends at the next keyword ("*") card.

Card 1	1	2	3	4	5	6	7	8
Variable	SENSID	MTYPE	I0	I1	I2	I3	I4	I5
Type	I	A	I/A	I/A	I/A	I/A	I/A	I/A

UPDATE Card. Include this card in a set with Card 1 for each miscellaneous sensor if the UPDATE keyword option is used. This card controls how often the sensor value is updated.

Card 2	1	2	3	4	5	6	7	8
Variable	BIRTH	DEATH	DTUPD					
Type	F	F	F/I					

VARIABLE	DESCRIPTION
SENSID	Sensor ID
MTYPE	Entity to be traced:
	EQ.ANGLE: Angular accelerometer sensor tracing the angle between two lines, $0° \le \theta \le 180°$. The fields I1 and I2 are node numbers defining the

VARIABLE	DESCRIPTION
	1st line, while I3 and I4 are node numbers defining the 2nd line.
EQ.BNDOUT:	Boundary condition energy as reported in file bndout. I1 is the ID as defined in *BOUNDARY_PRESCRIBED_MOTION.
EQ.CURVE:	The value of a time-dependent curve defined by *DEFINE_CURVE_FUNCTION or *DEFINE_CURVE. I1 is the curve ID.
EQ.CVBAG:	Information reported in ABSTAT for control volume airbag I1, including
	I0.EQ.TEMP: Airbag temperature
	I0.EQ.VOL: Airbag volume
EQ.ICVOL:	Information reported in ICVOUT for incompressible control volume I1, see *DEFINE_CONTROL_VOLUME, including
	I0.EQ.PRES: Temperature of control volume
	I0.EQ.VOL: Volume of control volume
EQ.MATSUM:	Information reported in MATSUM for part set I1, including
	I0.EQ.ADDMASS: Added mass
	I0.EQ.ERODEIE: Eroded internal energy
	I0.EQ.ERODEKE: Eroded kinetic energy
	I0.EQ.INTERNAL: Internal energy
	I0.EQ.KINETIC: Kinetic energy
EQ.NFAILE:	Number of failed elements of type I0 in set I1 will be traced. I0, element type, can be "SOLID" for solid elements, "SHELL" for thin shell elements, "TSHELL" for thick shell elements, "BEAM" for beam elements or "DISC" for discrete elements. I1 is the related element set number. If undefined, the failure of all elements of type I0 will be traced.
EQ.RETRACTOR:	Information about seat belt retractor I1, including (see Remark 1):
	I0.EQ.PULLRATE: Pull-out rate, default

VARIABLE	DESCRIPTION
	I0.EQ.PULLOUT: Total pull-out
	I0.EQ.FORCE: Force of the attached belt
	EQ.RIGIDBODY: Accelerometer sensor tracing the kinematics of a rigid body with ID I1. The I2 field specifies which kinematical component is to be traced. It may be set to "TX", "TY", or "TZ" for *X*, *Y*, and *Z* translations and to "RX", "RY", or "RZ" for the *X*, *Y*, and *Z* components of the rotation. The I3 field specifies the kinematics type: "D" for displacement, "V" for velocity, and "A" for acceleration. Output is calculated with respect to the global coordinate system when the I4 field is set to "0", its default value; the local rigid-body coordinate system is used when I4 is set to "1".
	EQ.SLIPRING: Information about seat belt slip ring I1, including:
	I0.EQ.SLIP: Slippage
	I0.EQ.WRAP: Wrap angle, theta
	I0.EQ.SKEW: Skew angle, alpha
	I0.EQ.FC: Friction coefficient
	I0.EQ.FN: Normal contact force
	I0.EQ.FSB1: Force of element on side 1
	I0.EQ.FSB2: Force of element on side 2
	EQ.TIME: The current analysis time is traced.
I0, …, I5	See MTYPE.
BIRTH	Birth time of this sensor
DEATH	Death time of this sensor
DTUPD	Time interval between updates. If negative, -DTUPD is the curve defining update interval as a function of time.

Remarks:

1. **Retractor pull-out and pull-in.** A negative value of pull-out represents pull-in in a retractor for retractor sensors (MTYPE = RETRACTOR) and sbtout (see *DATABASE_SBTOUT).

*SENSOR_DEFINE_NODE_{OPTION1}_{OPTION2}

For *OPTION1* the available options are:

<BLANK>

SET

For *OPTION2* the available options are:

<BLANK>

UPDATE

With the SET keyword option, you can specify a sensor for a set of nodes (see Remark 2 for details). This option can be useful when you want to specify a sensor switching condition based on a group of nodes. With the UPDATE keyword option, you can specify the birth time, death time, and value update frequency for the sensor. Note that without the UPDATE keyword option LS-DYNA updates the sensor value every time step.

Purpose: Define an accelerometer type sensor or temperature sensor.

a) *Accelerometer Sensor*. For an accelerometer sensor, this feature outputs the relative linear acceleration, velocity, or relative coordinate of Node 1 with respect to Node 2 along vector VID.

b) *Temperature Sensor*. For a temperature sensor, this feature outputs the temperature.

Card Summary:

Card Sets. For each nodal sensor matching the specified keyword options include one set of the following data cards. Include as many sets as needed. This input ends at the next keyword ("*") card.

Card 1. This card is required.

SENSID	NODE1	NODE2	VID		CTYPE	SETOPT	

Card 2. This card is included if the UPDATE keyword option is used.

BIRTH	DEATH	DTUPD					

Data Card Definitions:

Card 1	1	2	3	4	5	6	7	8
Variable	SENSID	NODE1	NODE2	VID		CTYPE	SETOPT	
Type	I	I	I	I		A	A	

VARIABLE	DESCRIPTION
SENSID	Sensor ID
NODE1,2	For an accelerometer sensor, these fields are the nodes defining the accelerometer. If CTYPE = TEMP, then the temperature at NODE1 will be output. If both NODE1 and NODE2 are defined, then the difference in temperature between these two nodes will be output. When the keyword option SET is active, NODE1 is a node set ID. If NODE2 is needed, it must be a node set of the same length as NODE1 with SETOPT defined, but it can be either a node or node set without SETOPT defined. When the SET option is active but SETOPT is not defined, determining the status of a related *SENSOR_SWITCH depends on the sign of NODE1. See Remark 2 for details.
VID	ID of vector along which the nodal values are measured, see *DEFINE_VECTOR. The magnitude of nodal values (coordinate, velocity, or acceleration) will be output if VID is 0 or undefined.
CTYPE	Output component type (character string): EQ.ACC: Acceleration EQ.VEL: Velocity EQ.COORD: Coordinate EQ.TEMP: Temperature
SETOPT	Option to process set of data when SET option is specified. When SETOPT is specified, a single value will be reported. The single reported value could be: EQ.AVG: The average value of the dataset EQ.MAX: The maximum value of the dataset

VARIABLE	DESCRIPTION
EQ.MIN:	The minimum value of the dataset
EQ.NS2NSMIND:	The minimum distance between two set of nodes. CTYPE is ignored.
EQ.SUM:	The sum of the dataset

UPDATE Card. Additional card for the UPDATE keyword option.

Card 2	1	2	3	4	5	6	7	8
Variable	BIRTH	DEATH	DTUPD					
Type	F	F	F/I					

VARIABLE	DESCRIPTION
BIRTH	Birth time of this sensor
DEATH	Death time of this sensor
DTUPD	Time interval between updates. If negative, -DTUPD is the curve defining update interval as a function of time.

Remarks:

1. **Time Evolution of Vector VID.** The vector direction is determined by *DEFINE_VECTOR. This vector direction is updated with time only if the coordinate system CID (see *DEFINE_VECTOR) is defined using *DEFINE_COORDINATE_NODES and the parameter FLAG is set to 1. Otherwise, the vector direction is fixed.

2. **SET Option.** When SETOPT is not defined for the SET option, a list of nodal data will be reported, one for each node in the node set, NODE1. *SENSOR_DEFINE_FUNCTION and *SENSOR_DEFINE_CALC-MATH can process these reported nodal values, resulting in a list of processed values. Note that all sensor definitions referred to by these two processing commands must have the same number of data points. These nodal values also can determine if the status of a *SENSOR_SWITCH will be changed. Depending on the sign of NODE1, it can take only one single data point (NODE1 < 0) or the whole data set (NODE1 > 0) to meet the switch condition to change the status of the related *SENSOR_SWITCH. The reported nodal values cannot be accessed by commands like *DEFINE_CURVE_FUNCTION; see SENSORD option.

When SETOPT is defined, the nodal values of all nodes in the node set will be processed, depending on the definition of SETOPT; the resulting value is reported as the single sensor value. The reported value can be processed by both *SENSOR_DEFINE_FUNCTION and *SENSOR_DEFINE_CALC-MATH as well as other regular sensors. It can also be used to determine the status of a *SENSOR_SWITCH. A *DEFINE_CURVE_FUNCTION using the SENSORD option may also access this reported value. If the reference node, NODE2, is needed, NODE2 must be a node set containing the same number of nodes as node set NODE1. The nodes in sets NODE1 and NODE2 must be arranged in the same sequence so that the nodal value of nodes in set NODE1 can be measured with respect to the correct node in set NODE2. For example, the following input traces the average of a relative coordinate.

```
*SENSOR_DEFINE_NODE_SET
$ trace the average of rel coord, i.e.,
$ (c(5)-c(12)+c(10)-c(19)+c(27)-c(38))/3
$   SENSID     NODE1     NODE2       VID       CRD     CTYPE    SETOPT
        40         5        12         1        99     COORD       AVG
*SET_NODE_LIST
5
5,10,27
*SET_NODE_LIST
12
12,19,38
```

3. **Rigid Body Acceleration Measurement Frequency.** When NODE1 is a node that belongs to a rigid body and CTTYPE = "ACC," the acceleration recorded by the sensor is approximated, not exact. *SENSOR_DEFINE_MISC with MTYPE = "RIGIDBODY" returns exact acceleration and is recommended for such application.

*SENSOR_SWITCH

Purpose: This command compares the value of a sensor, *SENSOR_DEFINE or *SENSOR_DEFINE_CALC-MATH, to a given criterion to check if the switch condition is met. It output a logic value of TRUE or FALSE.

Sensor Switch Cards. Include one additional card for each sensor switch. This input ends at the next keyword ("*") card.

Card 1	1	2	3	4	5	6	7	8
Variable	SWITID		SENSID	LOGIC	VALUE	FILTRID	TIMWIN	TDELAY
Type	I		I	A	F	I	F	F

VARIABLE	DESCRIPTION
SWITID	Switch ID can be referred directly by *SENSOR_CONTROL to control the status of entities like CONTACT and AIRBAG, or can be referred to by *SENSOR_SWITCH_CALC-LOGIC for logic computation.
SENSID	ID of the sensor whose value will be compared to the criterion to determine if a switch condition is met.
LOGIC	Logic operator, could be either LT (<) or GT (>).
VALUE	Critical value
FILTER	Filter ID (optional). See *DEFINE_FILTER for how to define a filter. See Remark 1.
TIMWIN	Trigger a status change when the value given by the sensor is less than or greater than (depending on LOGIC) the VALUE for a duration defined by TIMWIN.
TDELAY	Optional time delay. The status change will not happen immediately when both the switch condition and TIMWIN are met. Instead the status change is delayed by TDELAY.

Remarks:

1. **FILTER with *SENSOR_DEFINE.** The filter receives data from the sensor defined with *SENSOR_DEFINE either every time step or at the frequency specified with DTUPD when using the UPDATE keyword option.

*SENSOR_SWITCH_CALC-LOGIC

Purpose: This command performs a logic calculation for the logic output of other *SENSOR_SWITCH or *SENSOR_SWITCH_CALC-LOGIC definitions. The output is a logic value of either TRUE or FALSE.

Log Cards. Include one additional card for each logic rule. This input ends at the next keyword ("*") card.

Card 1	1	2	3	4	5	6	7	8
Variable	SWITID	SWIT1	SWIT2	SWIT3	SWIT4	SWIT5	SWIT6	SWIT7
Type	I	I	I	I	I	I	I	I

Switch Cards. Additional switch cards needed when the logic calculation involves more than seven switches. The first column must be occupied by the plus sign, "+". Include as many cards as needed.

Card 2	1	2	3	4	5	6	7	8
Variable	+	SWIT8	SWIT9	SWIT10	SWIT11	SWIT12	SWIT13	SWIT14
Type	A	I	I	I	I	I	I	I

VARIABLE	DESCRIPTION
SWITID	Switch ID can be referred directly by *SENSOR_CONTROL to control the status of entities like CONTACT and AIRBAG or can be referred to by *SENSOR_SWITCH_CALC-LOGIC for logic computation.
SWIT*n*	Input a positive sensor switch ID for "AND" and negative sensor switch ID for "OR". SWIT1 must always be positive.

This keyword implements standard Boolean logic:

true = 1,
false = 0,
and = multiplication,
or = addition

An expression evaluating to 0 is false, while any expression that evaluates to greater than 0 is true, and, therefore, set to 1.

Example:

Consider 5 switches defined as follows:

switch(11) = true
switch(12) = false
switch(13) = true
switch(14) = true
switch(15) = false.

To evaluate the expression

[switch(11) or switch(12) or switch(13)] and [switch(14) or switch(15)]

and assign the value to switch(103), the following would apply:

```
*SENSOR_SWITCH_CALC-LOGIC
101,11,-12,-13
102,14,-15
103,101,102
```

This translates into

$$\begin{aligned}
\text{switch}(101) &= \text{switch}(11) \text{ or switch}(12) \text{ or switch}(13) \\
&= \min((1 + 0 + 1), 1) \\
&= 1 \text{ (true)} \\
\text{switch}(102) &= \text{switch}(14) \text{ or switch}(15) \\
&= \min((1 + 0), 1) \\
&= 1 \text{ (true)} \\
\text{switch}(103) &= \text{switch}(101) \text{ and switch}(102) \\
&= \min((1 \times 1), 1) \\
&= 1 \text{ (true)}
\end{aligned}$$

Therefore,

$$\overbrace{[\text{switch}(11) \text{ or switch}(12) \text{ or switch}(13)]}^{\text{switch}(101)=\text{true}} \text{ AND } \overbrace{[\text{switch}(14) \text{ or switch}(15)]}^{\text{switch}(102)=\text{true}}$$
$$= \text{switch}(103)$$
$$= \text{true}$$

***SENSOR_SWITCH_SHELL_TO_VENT**_*{OPTION}*

Available options include:

ID

TITLE

OPTION provides a means to specify an airbag ID number and a heading for the airbag.

Purpose: This option will treat the failed shell elements as vent holes for the airbag defined by *AIRBAG_PARTICLE. The mass escaped from the vent will be reported in the abstat_cpm file.

ID Card. Additional card for the ID or TITLE keyword option.

Card ID	1	2	3	4	5	6	7	8
Variable	ABID	HEADING						
Type	I	A70						

Card 1	1	2	3	4	5	6	7	8
Variable	ID	ITYPE	C23	AMAX				
Type	I	I	F	F				

Shell Fail Time Cards. Optional Cards for setting time at which shells in a shell list (see *SHELL_LIST) change into vents. This card may be repeated up time 15 times. This input ends at the next keyword ("*") cards.

Optional	1	2	3	4	5	6	7	8
Variable	SSID	FTIME	C23V					
Type	I	F	F					
Default	none	0.	C23					

VARIABLE	DESCRIPTION
ABID	Airbag ID
HEADING	Airbag descriptor
ID	Part set ID/part ID
TYPE	Type for ID: EQ.0: part EQ.1: part set
C23	Vent Coefficient (Default = 0.7) LT.0: User defined load curve ID. The vent coefficient is a function of pressure.
AMAX	Maximum allowable area for failed vent surface area (VA). If the area is bigger than AMAX, C23 will be scaled down by a factor of AMAX/VA. Otherwise, C23 will be used.
SSID	ID of *SET_SHELL_LIST
FTIME	Time to convert shell list to vent
C23V	Vent Coefficient. LT.0: User defined load curve ID. The vent coefficient is a function of pressure.