



Shaper RTM User Manual 0.6.0

Keywords Reference Guide

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ShaperRTM Keywords Reference Guide.

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Document History ^(*)

Issue	Date	Notes
1.0	04/12/17	Initial issue. Target version is 0.4.0.
1.1	21/02/18	Added 3D solver. Target version is 0.5.0.
1.2	03/10/18	Improved writers, orientations and preform sections. Target version is 0.6.0

() add as many lines as required*

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Introduction

This guide describes the format of the Shaper RTM Input Deck and all cards available in Shaper RTM. Shaper RTM input decks follow few simple general rules:

- Shaper RTM Input Deck Cards are used to define model and solver entities (e.g. nodes, elements or steps). Shaper RTM Cards are formed by a keyword, followed by a list of parameters on the same line and, optionally, one or more data lines:

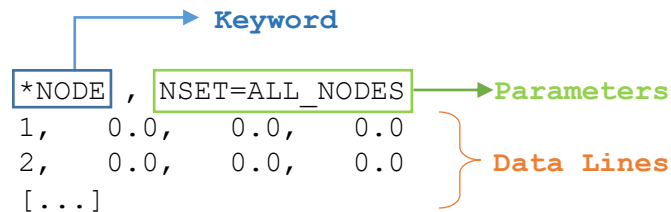


Figure 1: Shaper tRTM Card Format.

- Shaper RTM keywords begin with a single asterisk (“*”) (e.g. *NODE).
- Shaper RTM keywords can be followed by a list of commas separated parameters on the same line (e.g. NSET=).
- Shaper RTM parameters follow the syntax “PARAMETER NAME = PARAMETER VALUE” (e.g. NSET=ALL_NODES). Spaces are ignored.
- Shaper RTM keywords and parameters are NOT case sensitive (i.e. “*NODE” and “*node” are equivalent).
- ShaperRTM comments begin with a double asterisk (“**”). Any character following a double asterisk is ignored.
- Data lines use a comma separate format and can be written on multiple lines. A line can continue on a new one if it terminates with a comma (“,”):

```

*NODES, NSET=ALL_NODES
1, 0.0, 0.0,
0.0
2, 0.0, 0.0,
0.0
[...]
```

Notice, however, that parameters cannot be written on multiple lines.

- Shaper RTM input deck lines have a maximum length of 500 characters per line. Characters beyond this limit are ignored. Line continuation can be used to split a data line into multiple lines (see previous point).
- User-defined names cannot be longer than 200 characters, must start with a letter and can contain only letters, digits and dot (“.”), dash (“-”) or underscore (“_”) symbols.
- Shaper RTM keywords force the termination of the previous card, regardless of any continuation line convention defined in the previous line. In the following example, the first

card is terminated when the second starts, even if the last data line terminates with a comma:

```
*NSET, NAME=SET_1
  1,  2,  3,  4,  5,  6,  7,  8,  9, 10,
 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,
*NSET, NAME=SET_2
[...]
```

- It is the user's responsibility to provide consistent unit of measurement across all the cards of the Shaper RTM Input Deck.
- Deprecated keywords or parameters are highlighted in red (**deprecated**), experimental keywords or parameters are highlighted in yellow (**experimental**).

E

ELEMENT

This card is used to define an element by specifying its nodes.

Required Parameters

TYPE

Set this parameter equal to the element type. Currently, 3-nodes shells (*C2D3P*), 4-nodes shells (*C2D4P*), 4-nodes tetrahedra (*C3D4P*) and 8-nodes bricks (*C3D8P*) elements are supported.

Optional Parameters

ELSET

Set this parameter equal to the name of the element set to which these elements will be assigned.

Data Lines

First line:

1. Element number.
2. Number of the first of the element.
3. Number of the second node of the element.
4. Etc.

Continuation lines (only needed if the previous line ends with a comma):

1. Numbers of the remaining nodes of the element.

Repeat this set of data lines as often as necessary.

ELSET

This card is used to assign elements to an element set.

Required Parameters

ELSET

Set this parameter equal to the name of the element set to which the elements will be assigned.

Optional Parameters

GENERATE

If this parameter is included, each data line should give a first element, e_1 , a last element, e_n , and the increment in element numbers between these elements, i . Then, all elements going from e_1 to e_n in steps of i will be added to the set.

Data Lines if GENERATE is omitted

First line:

1. List of elements to be assigned to this element set.

Repeat this data line as often as necessary.

Data Lines if GENERATE is included

First Line:

1. First element in the set.
2. Last element in the set.
3. Increment in element numbers between elements in the set. The default is 1. If omitted, the default value will be used.

Repeat this data line as often as necessary.

I

INLET GATE

This card is used to define an inlet gate for an RTM step.

Dependency

This keyword can only be used within a STEP card.

Required Parameters

TYPE

Set this parameter equal to the inlet gate type. Currently, only the *PRESSURE* type is supported.

NSET

Set this parameter equal to the name of the node set containing the nodes which define this inlet gate.

Data Lines if the TYPE is PRESSURE

First line for constant in time pressure:

1. Prescribed pressure at the nodes.

First line for constant in time pressure:

1. Prescribed time
2. Prescribed pressure at the nodes.

Repeat this data line as often as necessary.

M

MATERIAL

This card is used to indicate the start of a material definition.

Required Parameters

NAME

Set this parameter equal to a label that will be used to refer to the material in the element property options. Material names in the same input deck must be unique.

There are no data lines associated with this option.

N

NODE

This card is used to define a node by specifying its coordinates.

Optional Parameters

NSET

Set this parameter equal to the name of the node set to which these nodes will be assigned.

Data Lines

First Line:

1. Node number.
2. X-coordinate of the node.
3. Y-coordinate of the node.
4. Z-coordinate of the node.

Repeat this data line as often as necessary.

NSET

This card is used to assign nodes to a node set.

Required Parameters

NSET

Set this parameter equal to the name of the node set to which the nodes will be assigned.

Optional Parameters

GENERATE

If this parameter is included, each data line should give a first node, n_1 , a last node, n_n , and the increment in node numbers between these nodes, i . Then, all nodes going from n_1 to n_n in steps of i will be added to the set.

Data Lines if GENERATE is omitted

First line:

1. List of nodes to be assigned to this node set.

Repeat this data line as often as necessary.

Data Lines if GENERATE is included

First Line:

1. First node in the set.
2. Last node in the set.
3. Increment in node numbers between nodes in the set. The default is 1. If omitted, the default value will be used.

Repeat this data line as often as necessary.

O

ORIENTATION

This card is used to define a local coordinate system for definition of material properties.

Required Parameters

NAME

Set this parameter equal to a label that will be used to refer to the orientation definition. Orientation names in the same input deck must be unique.

Optional Parameters

SYSTEM

Defines how the orientation is defined. Option can be set either to RECTANGULAR (default) or to ZRECTANGULAR. See for more details on how points are used to define the reference frame. If option is omitted, RECTANGULAR definition is assumed

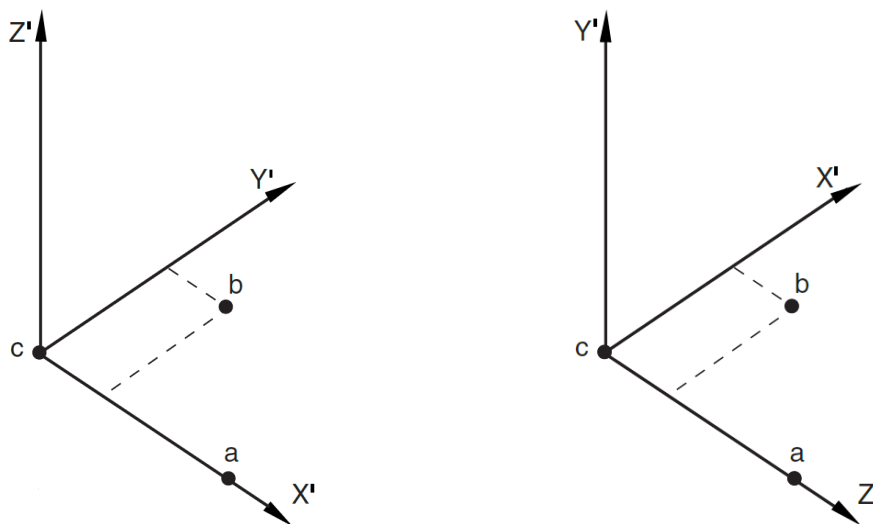


Figure 2: Points required to define an ORIENTATION system: RECTANGULAR system on the left, ZRECTANGULAR on the right.

Data Lines

First line:

1. X-coordinate of point A.
2. Y-coordinate of point A.
3. Z-coordinate of point A.
4. X-coordinate of point B.
5. Y-coordinate of point B.
6. Z-coordinate of point B.

The coordinates of point C (i.e. the origin) are optional. The default location of the origin C is the global origin.

7. X-coordinate of point C.
8. Y-coordinate of point C.
9. Z-coordinate of point C.

R

RESIN

This card is used to define the properties of the resin used for RTM injections.

Dependency

This keyword can only be used within a STEP card.

Data Lines

First line for constant in time viscosity:

2. Resin viscosity.

First line for constant in time pressure:

3. Prescribed time
4. Prescribed resin viscosity at the given time.

Repeat this data line as often as necessary.

S

SHELL PREFORM

This card is used to define the properties of a shell preform used in the RTM process. This property can be assigned only to sets of 2D elements (*CP3P* or *CP4P*). See *SOLID PREFORM* for 3D elements.

Required Parameters

ELSET

Set this parameter equal to the name of the element set containing the shell elements for which the preform is being defined.

PERMEABILITY

Set this parameter equal to the type of permeability used. Currently, only *DIRECT* type is supported, which requires the user to provide the full permeability tensor in the data lines.

Required/Optional Parameters

ORIENTATION

Set this parameter equal to the name of the orientation system definition used to orient the permeability tensor. If present, components K_{xx} is oriented along the projections of the X axis of the provided reference system on the plane of the shell element. K_{yy} is assumed to be perpendicular to K_{xx} within the plane of the shell. Note that the X axis of the provided reference frame shall not be perpendicular to the plane of the shell.

Keyword GLOBAL can be used to denote the global reference frame of the parent model, if no other user-defined orientation has been named GLOBAL.

Parameter can be omitted if the permeability tensor is isotropic, i.e. if K_{xx} is equal to K_{yy} and K_{xy} is null. If omitted, local element axes will be used to assign permeability orientation accordingly to the element definition.

Data Line if PERMEABILITY is DIRECT

First Line:

1. Preform thickness.
2. Fibre volume ratio.
3. K_{xx} component of the permeability tensor.
4. K_{yy} component of the permeability tensor.
5. K_{xy} component of the permeability tensor.

SOLID PREFORM

This card is used to define the properties of a solid preform used in the RTM process. This property can be assigned only to sets of 3D elements (*C3D8P*). See *SHELL PREFORM* for 2D elements.

Required Parameters

ELSET

Set this parameter equal to the name of the element set containing the solid elements for which the preform is being defined.

PERMEABILITY

Set this parameter equal to the type of permeability used. Currently, only *DIRECT* type is supported, which requires the user to provide the full permeability tensor in the data lines.

Required/Optional Parameters

ORIENTATION

Set this parameter equal to the name of the orientation system definition used to orient the permeability tensor. Components K_{xx} , K_{yy} and K_{zz} are oriented along the projections of the X, Y and Z axis of the provided reference system on the element, respectively.

Keyword GLOBAL can be used to denote the global reference frame of the parent model, if no other user-defined orientation has been named GLOBAL.

Parameter can be omitted if the permeability tensor is isotropic, i.e. if $K_{xx} = K_{yy} = K_{zz}$ and $K_{xy} = K_{xz} = K_{yz}$ are null. If omitted, local element axes will be used to assign permeability orientation accordingly to the element definition.

Data Line if PERMEABILITY is DIRECT

First Line:

1. Fibre volume ratio.
2. K_{xx} component of the permeability tensor.
3. K_{yy} component of the permeability tensor.
4. K_{xy} component of the permeability tensor.
5. K_{zz} component of the permeability tensor.
6. K_{xz} component of the permeability tensor.
7. K_{yz} component of the permeability tensor.

STEP

This card is used to begin each step definition.

Optional Parameters

NAME

Set this parameter equal to a label that will be used to refer to the step on the result files. Step names should be unique within a simulation deck. Duplicated names will be ignored.

SOLVER

Set this parameter equal to the name of the solver to be used for the simulation of the RTM injection. Supported options are *CONTROL VOLUME* (default) and *LEVEL SET*.

Control Volume Solver Parameters

SATURATION THRESHOLD

Set this parameter equal to the volume fill ratio which is used by the solver to determine if a region of the preform is fully saturated. Default value is 1.0 (i.e. a region is fully saturated when the resin has filled 100% of the volume void (given by the total volume of the region minus the volume occupied by the fibres – this value is controlled by the fibre volume ratio of the preform, see). Threshold must be between 0 and 1.

T

TERMINATOR

This card defines a termination criterion for the solver. Multiple terminators can be used within the same STEP. In this case, the simulation is terminated when any of the criteria is met first. If no terminator is provided in a STEP, the simulation iterates until the mesh is completely filled.

Dependency

This keyword can only be used within a STEP card.

Required Properties

TYPE

Set this parameter to the type of the terminator to be used. Supported types are *MaxIteration*, *NodeFilled* and *ElapsedTime*.

Data Lines if TYPE is MAXITERATION

First Line:

1. Maximum number of iterations for the solver.

Data Lines if TYPE is NODEFILLED

First Line:

1. Node number of the monitoring node. The simulation terminates when the specified nodes is completely filled.

Data Lines if TYPE is ELAPSEDTIME

First Line:

1. Target injection time. The simulation is terminated when the specified injection time is reached.

V

VACUUM PRESSURE

This card defines the value of the vacuum pressure used in the solver.

Dependency

This keyword can only be used within a STEP card.

Data Lines

First line:

1. Vacuum pressure value.

W

WRITER

This card defines a writer that the solver can use to store the solution on disc for later access. If no writer is specified, the solution will not be save to disc and only the total injection time will be displayed on screen at the end of the simulation.

Dependency

This keyword can only be used within a STEP card.

Optional Parameters

TYPE

Set this parameter to the writer type. Supported types are *NATIVE* and *HYPERMESH*. If parameter is omitte, *NATIVE* option is assumed by default.

NATIVE

The *NATIVE* writer saves simulation results in an iChrome compact and proprietary format that can be visualised with iChrome's CAE Viewer and Shaper products.

ASCII

The *ASCII* writer saves simulation results in an ASCII tabulated format compatible to the Shaper Table importer (see Table Loader section of the Shaper User Manual).

HYPERMESH

The *HYPERMESH* writer allows saving simulation results in an ASCII format that can be imported back with Hypermesh.

FREQUENCY

Set this parameter equal to the output frequency, in increments. The output will always be written to the result file at the first and last increment of each step. Set *FREQUENCY*=0 to suppress any intermediate output. If parameters *FREQUENCY*, *TIME INTERVAL* and *FILL INTERVAL* are omitted, output will be written at every increment of the step. *FREQUENCY*, *TIME INTERVAL* and *FILL INTERVAL* parameters are mutually exclusive.

TIME INTERVAL

Set this parameter equal to the time interval at which the output states are to be written. The output will always be written to the result file at the first and last increment of each step. Intermediate results are written to the output file at the increment ending immediately after the time dictated by the *TIME INTERVAL* parameter. If parameters *FREQUENCY*, *TIME INTERVAL* and *FILL INTERVAL* are omitted, output will be written at every increment of the step. *FREQUENCY*, *TIME INTERVAL* and *FILL INTERVAL* parameters are mutually exclusive.

FILL INTERVAL

Set this parameter equal to the fill percentage (i.e. ratio between filled and unfilled number of elements) at which the output states are to be written. The output will always be written to the result file at the first and last increment of each step. Intermediate results are written to the output file at the increment ending immediately after the filling percentage dictated by the FILL INTERVAL parameter. If this parameter and the FREQUENCY are both omitted, output will be written at every increment of the analysis for all procedure. The FREQUENCY and TIME INTERVAL parameters are mutually exclusive.

Data Lines

First line:

1. Comma separated list of requested outputs. Supported outputs depend on selected solver.

Control Volume Solver Parameters

The Control Volume (default) solver supports the following outputs: P (pressure), Q (mass flow rate), V (velocity), F (fill factor) and T (filling time). Option ALL (all results) and DEF or equivalently DEFAULT (i.e. P, F and T) are also supported.

Level Set Solver Parameters

The Level Set solver supports the following outputs: P (pressure), V (velocity), F (fill factor), LS (resin front level set) and T (filling time). Option ALL (all results) and DEF or equivalently DEFAULT (i.e. P, F and T) are also supported.

Appendix A

Example 1 – Shaper RTM Input Deck Template

```

*NODES, NSET=
1, 0.0, 0.0, 0.0
2, 1.0, 0.0, 0.0
3, 1.0, 1.0, 0.0
4, 0.0, 1.0, 0.0
** Continue
*ELEMENTS, TYPE=, ELSET=
1, 1, 2, 3, 4
** Continue
*NSET, NAME=
1, 2, 3, 4      ** Continue
*ELSET, NAME=
1, 2, 3, 4      ** Continue
*ORIENTATION, NAME=
0.0, 0.0, 0.0   ** A
1.0, 0.0, 0.0   ** B
0.0, 1.0, 0.0   ** C
*SHELL PREFORM, ELSET=, ORIENTATION=, PERMEABILITY=
1.0, 55.0, 5.0, 5.0, 0.0   ** Thickness, Fiber Volume Fraction,
                             ** Permeability tensor (Kxx, Kyy, Kxy)
*STEP, NAME=, SOLVER=, SATURATION THRESHOLD=
*RESIN
1e-09           ** Viscosity
*VACUUM PRESSURE
0.0             ** Value of the vacuum pressure
*INLET GATE, NSET=, TYPE=
10.0           ** Options depends on the type
*TERMINATOR, TYPE=
[...]         ** Depends on the type of the terminator
*WRITER, TYPE=
P, Q, V, F

```

Appendix B

Command Line Options

OPTION	TYPE	REQUIRED	DESCRIPTION
<i>inp=</i>	String	Y	Name of the Shaper RTM Input Deck file to run.
<i>cpus=</i>	Integer	N	Positive integer used to specify the maximum number of CPUs that the solver can use during the analysis. If omitted, the solver will use all available CPUs.