1.7 Contactor Example

What will be learned:

- Using the Model Browser
- Using layers to control object visibility
- Using edge Contactors
- Using face Contactors
- Using material-based Contactors
- Checking contactors
- Using Symbols and Expressions

This tutorial demonstrates some of the capabilities of Thermal Desktop's Contactors. The example model is a pipe with circular, plate fins and a small block-shaped sensor. The plate fins will be connected to the pipe by edge contactors that could represent a braze or weld. The sensor is connected to the pipe by an area contactor that could represent a gasket or insulation.

Contactors, like contact created with the contact tab in the object edit window, are used to thermally connect two objects. However, contactors provide more functionality than contact such as:

- allowing a gap between the objects being connected
- allowing material, radiation, one-way, and insulation defined connections
- allowing the user to select which objects will be included in the connection tests.

Note: This tutorial is meant to show different capabilities of contactors. To accomplish this, the best modeling options may not have been used. For example, using solid disks (with only one subdivision in the thickness direction) instead of planar disks for the fins would have eliminated having to specify the thickness of the fin for the contactor, but using planar disks gives you practice with edge contactors.

Contactor Example

1. Double click on the file `Contactors.dwg` located in the `Tutorials\Thermal Desktop - legacy\Contactors` folder.

   Thermal Desktop opens with the `Contactors` drawing on the screen.

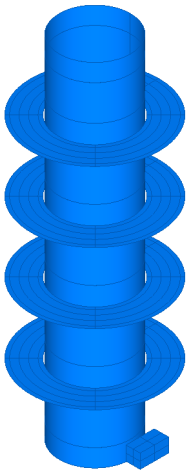
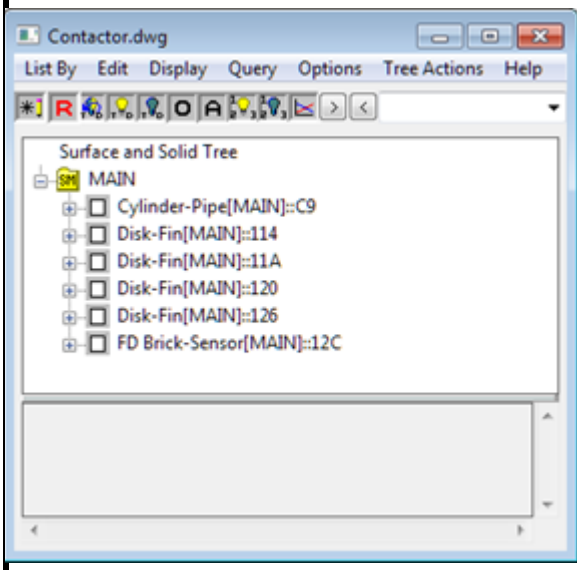


Figure 1-8: Initial View

Contactor Example (Continued)

2.  or **Thermal** > **Model Browser.**

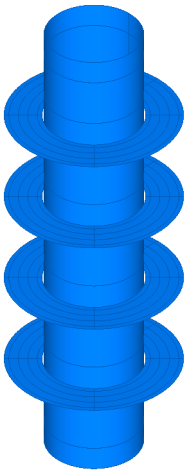
   The **Model Browser** window appears on the left side of the screen.



3. Using the Model Browser menu bar click on **List By** to confirm that **Surfaces/Solids** is checked.
4. If necessary, expand the Main tree by clicking on the + sign in front of the folder.
5. Click on **FD Brick-Sensor.**
6.  or **Display** > **Turn Visibility Off** in the Model Browser toolbar.
7. Minimize the **Model Browser** window or move so it does not block the drawing.
8. Press <**ESC**> to be sure the selection set is clear.

Use model browser to set selection options and turn off objects that will not be modified during upcoming steps.

The drawing should now appear similar to the view below:



Contactor Example (Continued)

9.  or **Thermal** > **FD/FEM Network** > **Contactor**.

   The Command line should now read:

```
Select faces or edge domains contacting
from or [MB]:
```

10. Select each of the four fins in the drawing area.

    The Command line should now read:

```
Select faces or edge domains contacting
from or [MB]:
```

11. Press <**ENTER**>.

    The Command line should now read:

```
Select surfaces, solids, or nodes con-
tacting to or [MB]:
```

12. Select the pipe in the drawing area.

    The Command line should now read:

```
Select surfaces, solids, or nodes con-
tacting to or [MB]:
```

13. Press <**ENTER**>.

    The **Contactor** dialog box appears. (next page)

14. Type **Fins to pipe** in the comment field.
15. From the drop-down list in the `Contact From` field select **Edges**.
16. Select the **Use Material** check box.

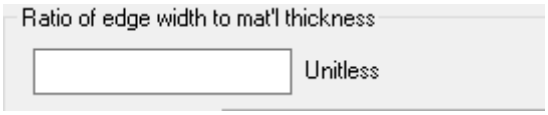
    The **Use Material** field becomes active.

17. From the drop-down list in the **Use Material** field select **Aluminum, 2024-T6.**

Create edge contactors to thermally connect the fins to the pipe. The connection is assumed to be an aluminum weld of thickness WeldThickness.

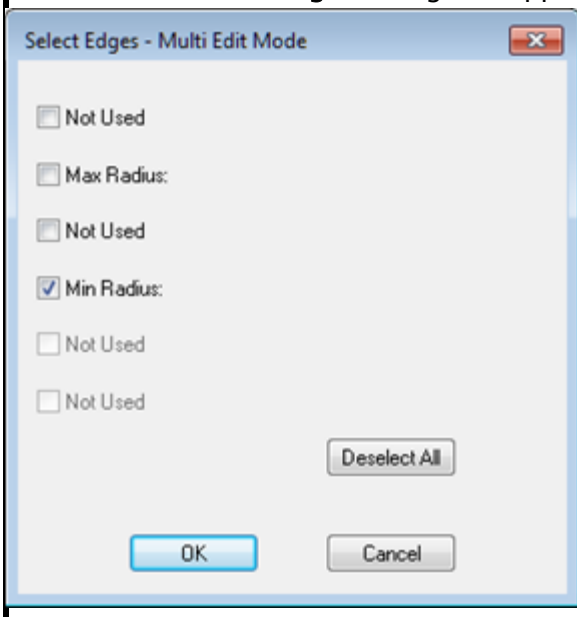
Important: Contactors do not calculate the conductance from the node to the edges of surfaces connected by contactors. Therefore, that conductance should be included in the contactor coefficient or the better method is to use edge nodes. In this model, edge nodes are used for the fins and sensor.

Important: In most cases, surfaces with smaller nodal areas should be chosen as the From surfaces. All integration points on a From surface are used in the testing algorithm.

Contactor Example (Continued)	
18. Double click in the empty field below **Ratio of edge width to mat'l thickness**..  The **Expression Editor** dialog box appears. Using right-click to select the symbol names from the general list, enter the following expression in the expression field: `FinThickness/WeldThickness` 19. Click **OK** to close the dialog box. The **Contactor** dialog box updates to show **6** in the **Ratio of edge width to mat'l thickness** field in bold type.	The SINDA conductor value resulting from a contactor is either kA/L, hA, or a Radk (εi*Bij*Ai). When Use Material is selected for an edge contactor, the conductivity is obtained from the chosen material property and the length of the surface edge is taken from the geometry. Therefore, to complete kA/L, the Coeff value must be the thickness of the edge (FinThickness) divided by the distance in the direction of the heat flow (WeldThickness). To see definitions of the symbols being used, select the **Add Symbol** button while in the Expression editor.

Contactor Example (Continued)

20. Select all four fins in the `From:` field.
21.  Edit From Object icon at the bottom of the **Contactor** dialog box.
22. The **Select Edges** dialog box appears.



23. Select the **Deselect All** button
24. Check **Min Radius** so the box is checked.
25. Click **OK** to close the dialog box.

    The **Contactor** dialog box updates to show Min Radius beside each object in the `From` field.
26. Click **Show Calcs** to close the **Contactor** dialog box and show the contactor markers.

When the Contactor dialog box closes, the graphical image for the contactors are displayed:

- The **from** surfaces have **green** arrows on the edges (or faces) included in the contactor.
- The **to** surfaces have **gold** arrows at the centroid of each face.

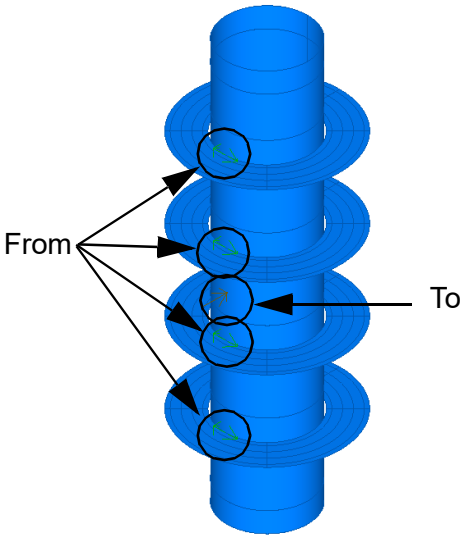


Figure 1-9: Contactors

Contactor Example (Continued)

Yellow lines connecting the edges of the disks to nodes of the pipe appear.

Changing to wireframe,  , will make the markers more visible.

27.  toggles node visibility on.

28.  or **Thermal > Model Checks > Clear Contact/or Markers**

    The contactor markers are cleared.

29.  toggles node visibility off.

Use contactor markers to verify connection of the Fins to Pipe contactor.

The contactor markers connect the integration points of the From edges to the nodes of the To surfaces.

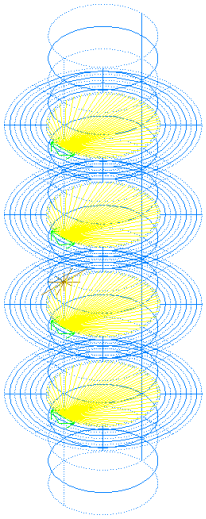


Figure 1-10: Contactor markers

Note: If the Coef field is 0, then the contactor markers will not be drawn.

Ten contactor markers are drawn from the inner edges of each fin (Figure 1-10). The markers show which integration points have met the requirements of the testing algorithm. Any integration point not within the tolerance of the To surface would be marked with a red cross.

When nodes are visible, note that not all pipe nodes are connected, but all inner edges of the fins are connected. Also note that To surface nodes can be connected multiple times, but test points are connected only once.

Contactor Example (Continued)

30. Restore the **Model Browser** Window.
31. Select the four fins in the Model Browser tree.
32.  **Turn Visibility Off** icon in the Model Browser toolbar.

    The disks representing the fins disappear from the graphics window.
33. Select the **Sensor**.
34.  **Turn On Visibility** icon in the Model Browser toolbar.

    The brick representing the sensor appears in the graphics window.
35. Right-click the sensor and choose **Send Selection Set to AutoCAD**.
36.  or **Thermal** > **FD/FEM Network** > **Contactor.**

    The Command line should now read:

```
Select surfaces contacting to or [MB]:
```

37. Type **MB**

    A new **Model Browser** window opens.
38. Select **Cylinder-Pipe** and close the new Model Browser Window.

    The Command line should now read:

```
1 object selected
1 added
1 found
Select surfaces contacting to or [MB]:
```

39. Press <**ENTER**>.

    The **Contactor** dialog box appears.

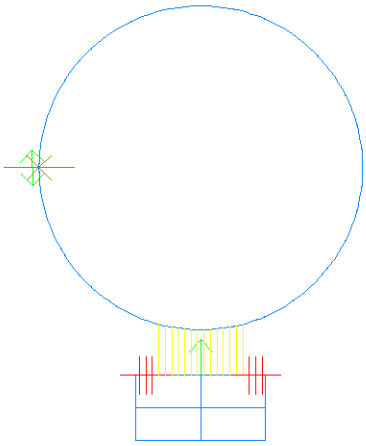
Create area contactor to thermally connect the sensor to the pipe. The connection is a per-area coefficient.

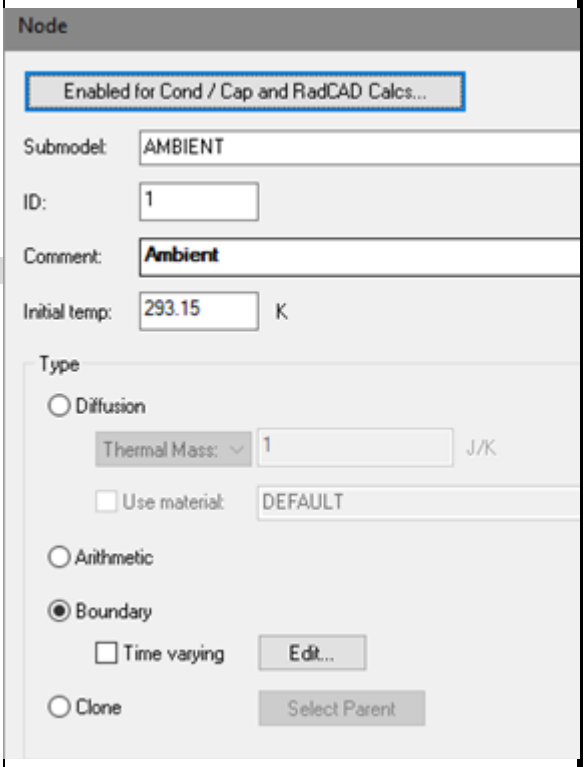
The Model Browser typically minimizes to the upper left corner of the display.

The Contactor command accepts preselected items (the sensor in this case) as the from object(s) and moves on to selecting To surfaces.

The MB option allows selection from a model browser window. Whatever is selected when the newly opened Model Browser is closed is added to the selection set.

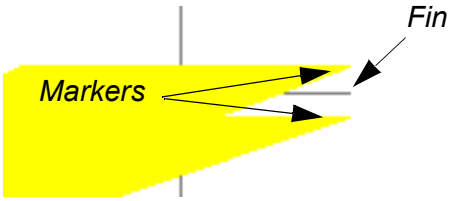
Contactor Example (Continued)	
40. Type **Sensor to pipe** in the comment field. 41. Highlight the current value in the **Tolerance** field and type **0.008**. 42. Highlight the current value in the **Conduction Coefficient** field and type **5**. 43. Choose **Ray Trace Algorithm** in the Inputs for **Connection Algorithm Section**.	For the ray trace algorithm, a ray of length Tolerance is shot normal to the From surface at each test point. If the ray intersects with a To surface, the ray terminates and a connection is made. By contrast, the point algorithm checks for surfaces within tolerance in all directions.
44. Double-click the sensor in the **From** field. 45. Deselect all check-boxes except **YMAX**. 46. Select **OK** to close the **Select Faces** dialog. 47. Select **Show Calcs** to close the **Contactor** dialog box and show the contactor markers. A text window with a log file will appear showing that the contactor did not make 100% connection due to the tolerance used. The contactor markers will show gold (connected) and red (outside of tolerance). 48. Close the text window.	The contactor is limited to only the side where the actual contact is made. Using ray tracing and tolerance would also eliminate the non-contact sides, but calculation time would be required to determine this. Selecting only certain sides, prevents unnecessary calculations. Use contactor markers to verify connection of the Sensor to Pipe contactor.

Contactor Example (Continued)	
49. **View** > **3D Views** > **Top**. The markers can be seen more easily. 50.  or **Thermal** > **Model Checks** > **Clear Contact/or Markers** The contactor markers are cleared. 51. **View** > **3D Views** > **SW Isometric**. 52. Restore the **Model Browser** Window. 53.  **Display All** icon in the Model Browser toolbar. The fins appear in the graphics window. 54. Minimize the **Model Browser** window.	When the view is changed to Top, the graphics display should look like this:  Since the ray trace algorithm was chosen, the markers appear as rays normal to the From surface. Test points that are not within the tolerance are shown in red.

Contactor Example (Continued)	
55. Using the Layer Drop Down Menu, select **boundary** as the current layer. The **Layer Drop Down Menu** originally says **Objects** and is located next to the  button. The drop down menu is accessed by clicking on the down-arrow to the right of the word Objects. 56.  or **Thermal** > **FD/FEM Network** > **Node** `Origin point <0,0,0>` appears in the Command Line area. 57. Type **-0.1,0,0** in the Command Line, then return. 58. Double-click the node. The Node dialog box appears. 59. Select **Boundary.** 60. Type **Ambient** in the **Comment** field. 61. Double-click in the **Submodel** field to highlight **MAIN**. 62. Type **AMBIENT** into the **Submodel** field. 63. Select **OK** to close the dialog box.	Create a boundary node to represent the ambient air so contactors can be created from the fins to the air. 
64.  or **View** > **Zoom** > **Extents**	

Contactor Example (Continued)	

65.  or **Thermal** > **FD/FEM Network** > **Contactor**.
The Command line should now read:
`Select faces or edge domains contacting from or [MB]:`
66. Select all four fins in the drawing area.
The Command line should now read:
`Select faces or edge domains contacting from or [MB]:`
67. Press <**ENTER**>.
The Command line should now read:
`Select surfaces, solids, or nodes contacting to or [MB]:`
68. Select the newly created node in the drawing area.
The Command line should now read:
`Select surfaces, solids, or nodes contacting to or [MB]:`
69. Press <**ENTER**>.
The Contactor dialog box appears.
70. Type **Fin faces to ambient** in the `comment` field.
71. Highlight the current value in the **Conduction Coefficient** field and type **50**.
72. Select all four fins in the From: field.
73.  **Edit From Object** icon near the bottom of the **Contactor** dialog box.
The **Select Faces** dialog box appears.
74. Turn on both top and bottom.
75. Click **OK** to close the dialog box.
76. Click **Show Calcs** to close the **Contactor** dialog box and display the contactor markers.
	Create convection from faces of fins using contactors.
	
	Note new Contactor graphical objects when complete.
	
	Here the order of selecting **From** and **To** is important. The area of the contact is calculated using the **From** surfaces.

Contactor Example (Continued)	
77. **View > 3D Views > Front.** 78.  or **Thermal > Model Checks > Clear Contact/or Markers** The contactor markers are cleared. 79. **View > 3D Views > SW Isometric.**	Use contactor markers to verify connection of the Fin faces to Ambient contactor. Notice the separation between the ends of the contact markers and the fins in the view below:  **Figure 1-11: Contactors with surface thickness** This happens because the test points are allowing for the thickness of the fins.

Contactor Example (Continued)

80.  or **Thermal** > **FD/FEM Network** > **Contactor**.

    The Command line should now read:

```
Select faces or edge domains contacting
from or [MB]:
```

81. Select all four fins in the drawing area.

    The Command line should now read:

```
Select faces or edge domains contacting
from or [MB]:
```

82. Press <**ENTER**>.

    The Command line should now read:

```
Select surfaces, solids, or nodes con-
tacting to or [MB]:
```

83. Select the boundary node in the drawing area.

    The Command line should now read:

```
Select surfaces, solids, or nodes con-
tacting to or [MB]:
```

84. Press <**ENTER**>.

    The **Contactor** dialog box appears.

85. Type **Fin edges to ambient** in the **comment** field.

86. From the drop-down list for the **Contact From** field select **Edges**.

87. Double-click in the **Conduction Coefficient** field.

    The **Expression Editor** dialog box appears,

88. Right-click to select the symbol names in the `general` list and enter the following expression in the `Expression` field

```
FinThickness*50
```

89. Click **OK** to close the dialog box.

    The **Conduction Coefficient** field now shows **0.3**.

Create convection from edges of fins using contactors.

Again, the **From** objects are used for the geometry. For an edge contact, the length of the edge is calculated so the thickness of the edge must be included in the coefficient.

Contactor Example (Continued)	
90. Select all four fins in the **From:** field. 91.  **Edit From Object** icon. The Select Edges dialog box appears. 92. Check **Max Radius** and uncheck any other checked boxes. 93. Click **OK** to close the dialog box. 94. Click **OK** to close the Contactor dialog box.	
95. Select **File** > **Exit**. A **Thermal Desktop/AutoCAD** dialog box appears asking to save the drawing changes. 96. Select **Yes**.	Exit Thermal Desktop and save as prompted.

Running the model requires a heat load or a fixed boundary temperature (different than the boundary node already defined). The user can add a heat load to the pipe surface or change the pipe nodes to boundary nodes and obtain a solution. The node IDs must also be resequenced.

If the user runs a transient solution, the time step taken by SINDA/FLUINT will likely be very small. This is caused by the large conductance at the base of the fins: G = k*A/L. If the user adds a factor to the coefficient of the fin-to-pipe contactor, he or she can see how the conductance of the contactor can affect the solution time step.