8. SPECIAL CASES

8.1. Overview

The following special cases are covered in this section:

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8.9.	Non Continuous Thermal Bridge Elements	page 8-92
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8.2 Meeting Rails

Meeting rail cross sections are the stiles or rails that meet in the middle of a sliding window. In this manual, the term "meeting rail' is used generically to describe meeting rails, meeting stiles, interlock stiles, interlocking stiles, sliding stiles, check rails, and check stiles.

8.2.1. Modeling Meeting Rails

When modeling a meeting rail, both the sashes and their associated glazing systems are modeled. Figure 8-1 shows an example of the meeting rail from a horizontal aluminum slider.

Creating the cross section for a meeting rail is no different than any other model in THERM. A few things to keep in mind are:

- Two glazing systems are imported, one facing up and one facing down
- Interior boundary conditions for each of the glazing systems are labeled with the **Edge** U-factor tag, and the program averages the values for both to derive one Edge U-factor.
- Model the meeting rail with the glazing systems facing up and down (see Section 6.3.2, "Cross Section Orientation" in this manual). If the DXF file is drawn with them in a horizontal position, draw the frame cross section, and then rotate it before inserting the glazing system.

The following discussion lists the steps for making a cross section with two glazing systems and assigning the correct boundary conditions.

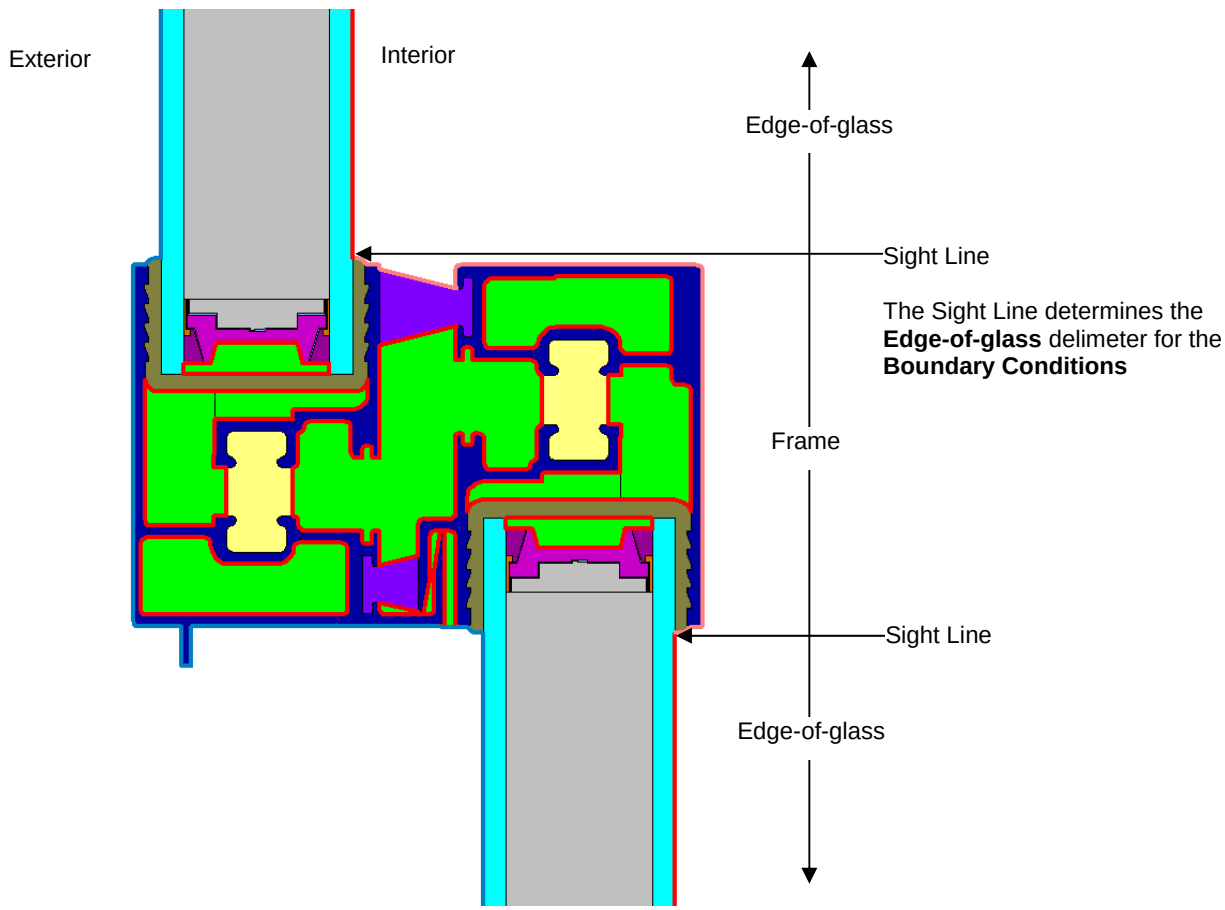


Figure 8-1. Meeting rail cross section.

8.2.2. Steps for Meeting Rail U-factor Calculation

1. Using dimensioned drawings or a DXF file, create the cross section for the frame portion of the meeting rail. In Figure 8-2, the frame for the horizontal aluminum slider meeting rail has been created.

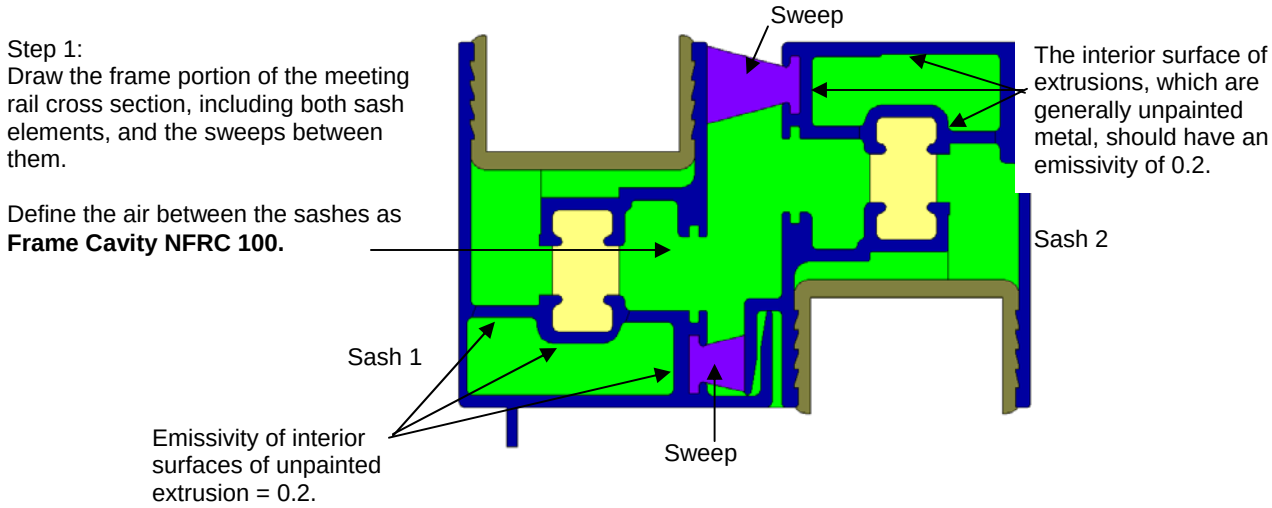


Figure 8-2. Frame portion of meeting rail cross section.

2. Position the **Locator** (using the **Draw/Locator** menu choice, or pressing **Shift F2**) in the lower left corner of the frame where the first glazing system will be inserted, as shown in Figure 8-3.

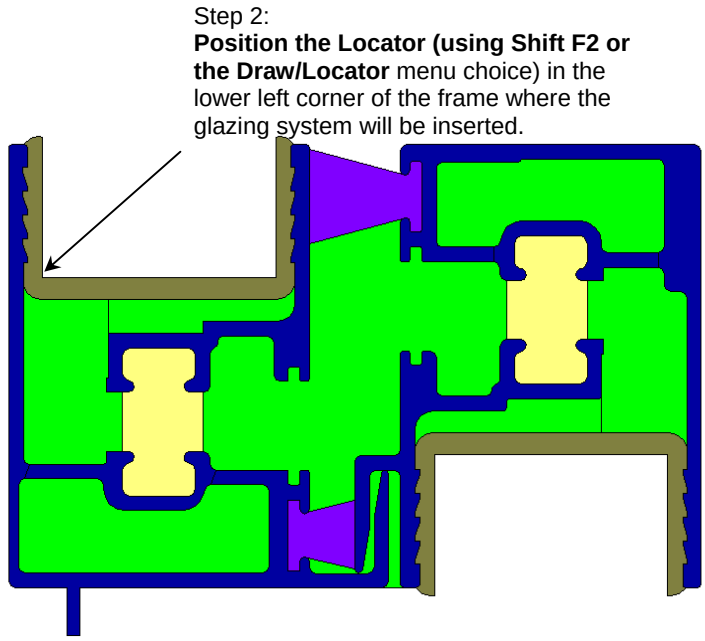


Figure 8-3. Position the Locator for the first glazing system.

3. Using the **Libraries/Glazing Systems** menu option (or the **F6** key), insert the upper glazing system, as shown in Figure 8-4. In this example, the spacer will be copied and pasted into the cross section later. Add a spacer and use the Material Link (Library/Create Link) to link the glazing system cavity conductivity with adjacent cavities in a spacer which is open to the glazing system cavity, if necessary.

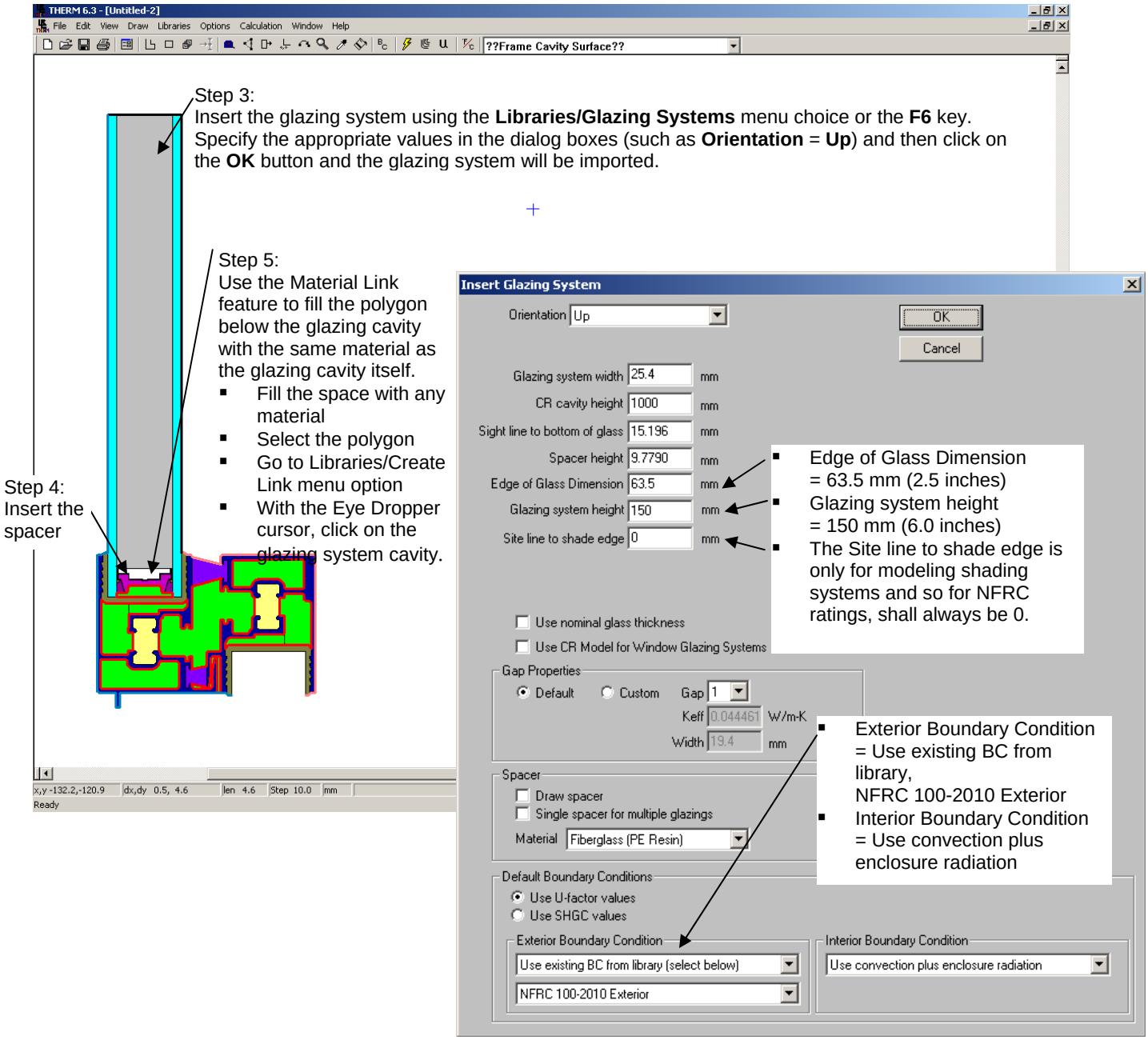


Figure 8-4. Insert the first glazing system.

4. Reposition the locator to the upper left corner for the 2nd glazing system.

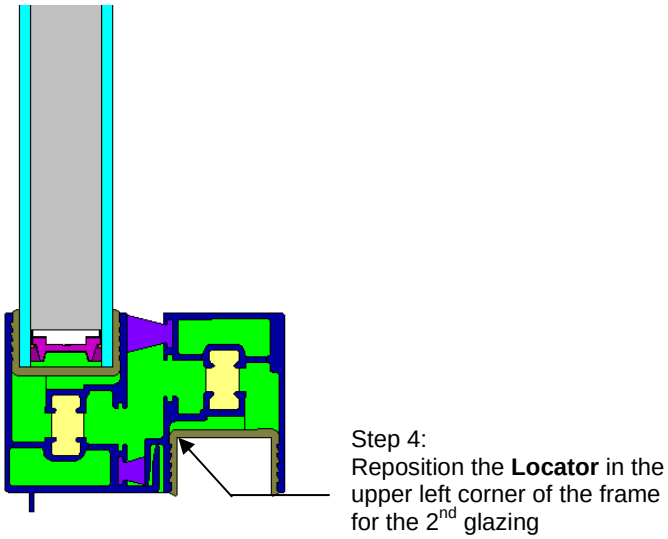


Figure 8-5. Reposition the Locator for the 2nd glazing system.

5. Insert the 2nd glazing system, setting the **Orientation** to "Down", and entering the correct values for **Sight line to bottom of glass** and **Spacer height**.

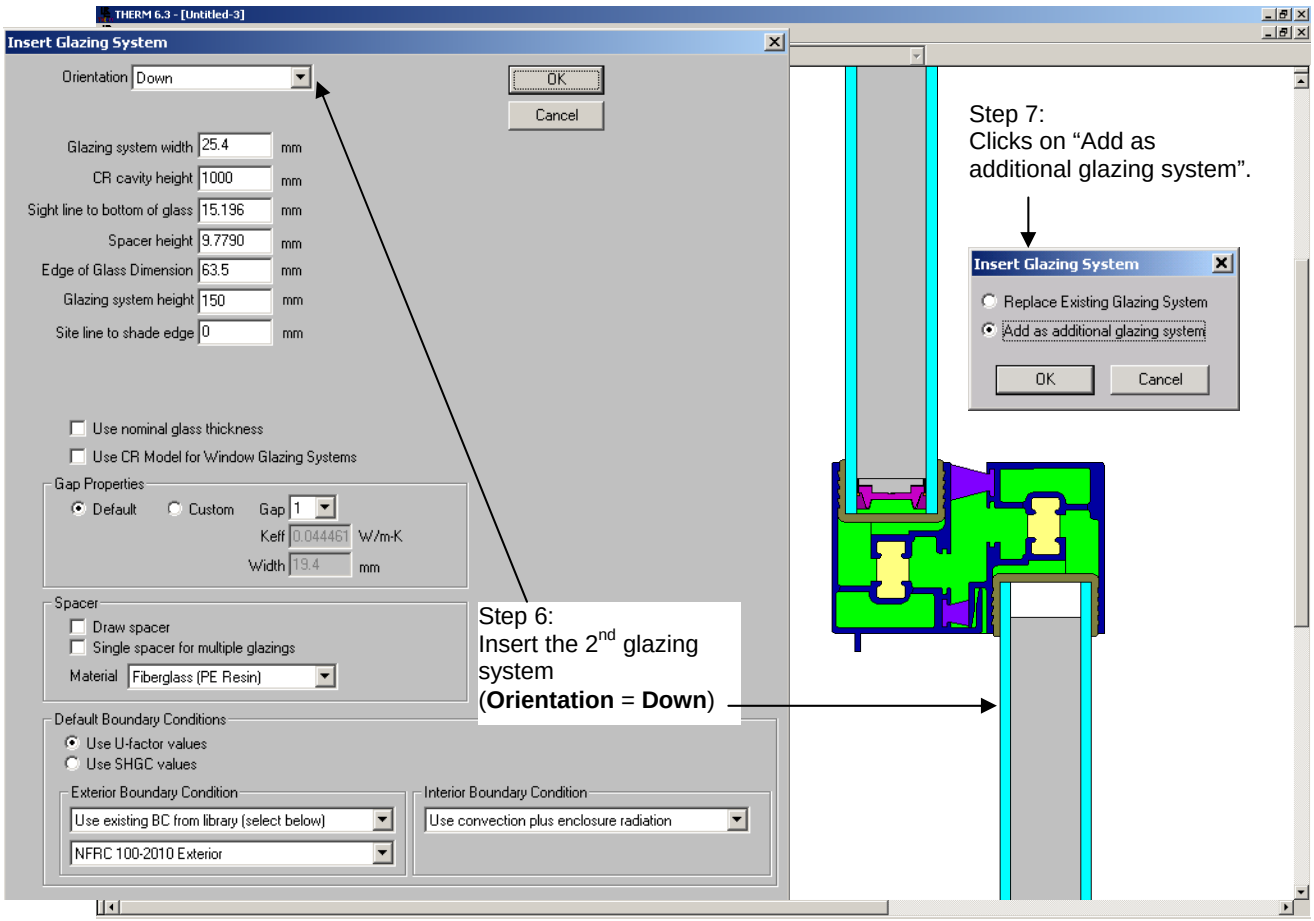


Figure 8-6. Insert the 2nd glazing system.

6. Add spacers and create materials linked to the glazing system cavity if necessary.

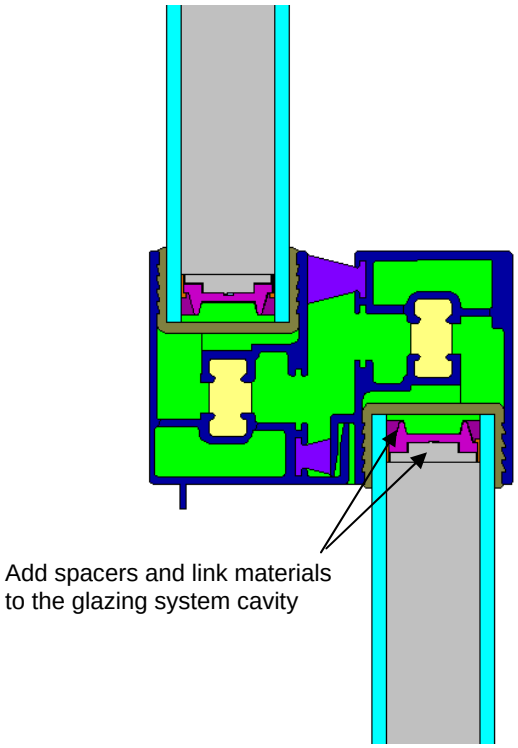


Figure 8-7. Add custom spacers.

7. Define the boundary conditions by pressing the **Boundary Conditions** toolbar button, or clicking on the **Draw/Boundary Conditions** menu choice, or pressing the **F10** key. Make sure that the interior boundary conditions are set to **Radiation Model** = "AutoEnclosure". Assign the **Edge U-factor tag** to each of the interior glazing system boundary conditions, as shown in Figure 8-8.

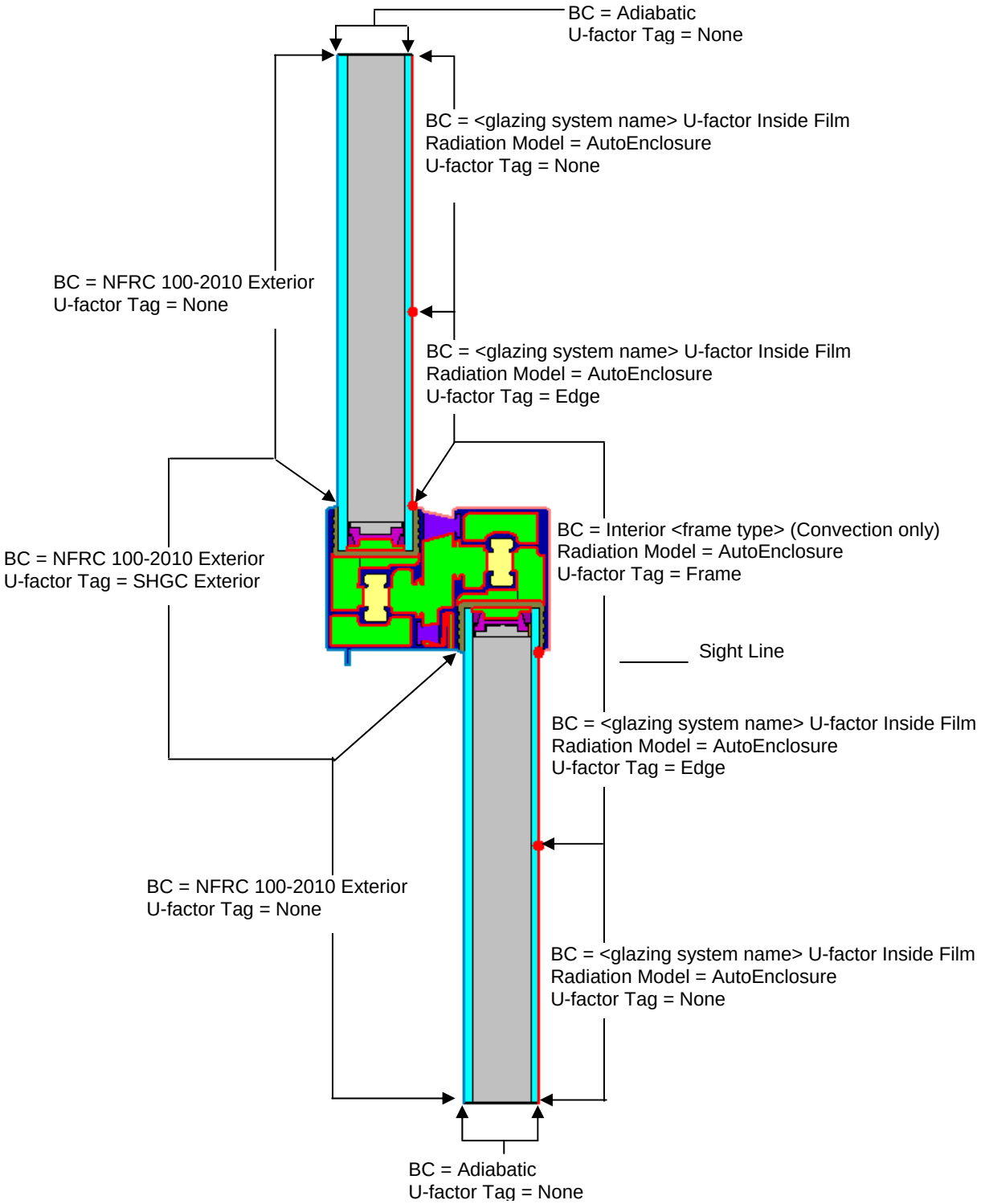


Figure 8-8. Define the Boundary Conditions for the meeting rail.

8. Run the simulation, by pressing the **Calc** toolbar button, clicking on the **Calculation/Calculation** menu choice, or pressing the **F9** key. The U-factor results are calculated for the **Frame** and **Edge U-factor tags**, as shown in the figure below.

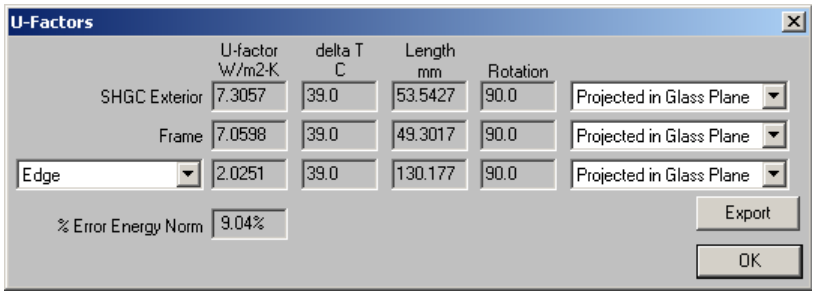


Figure 8-9. Calculate the results.

9. Import the THERM file into the WINDOW Frame Library.

8.2.3. Steps for Meeting Rail Condensation Resistance Calculation

The Condensation Resistance model is only appropriate for *horizontal meeting rails* (found in vertical sliding products) – THERM will not calculate the Condensation Resistance for a file with the **Cross Section Type** set to "Vertical Meeting Rail".

There are two methods for calculating the Condensation Resistance information in THERM, which will be used in WINDOW to calculate the total Condensation Resistance of the product:

- Check the "Use CR Model for Window Glazing System" checkbox when importing a glazing system

  OR

- In the Options menu, Preferences choice, THERM File Options tab, check the "Use CR Model for Glazing Systems", as shown in the figure below.

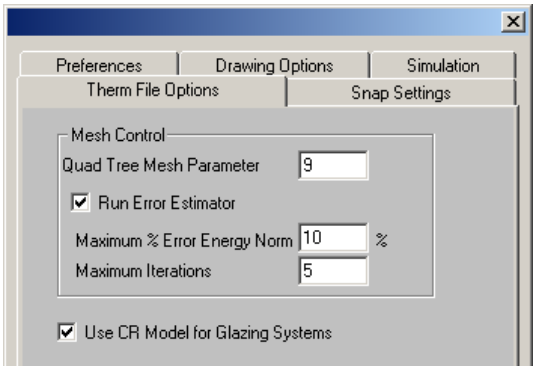


Figure 8-10 In Options/Preferences/Therm File Options, check the "Use CR Model for Glazing Systems" checkbox.

When the CR model has been "turned on", red boundary conditions will appear inside the glazing system, and the following steps should be taken to simulate the file:

1. Check the emissivities of these boundary conditions. They should be the following:
   - Emissivity of the surrounding surface, such as 0.84 for standard glass, 0.90 for most frame materials, 0.20 for metal, and so forth.
   - 1.0 for the adiabatic (open end) of the glazing cavity.
   - Actual cavity height per Table 6-2, Section 6.4.5

2. Simulate the model. The program will calculate both U-factor results and the Condensation Resistance results.
3. Import the results into the WINDOW **Frame Library** and use the meeting rail file to create the whole product in the **Window Library** as applicable.

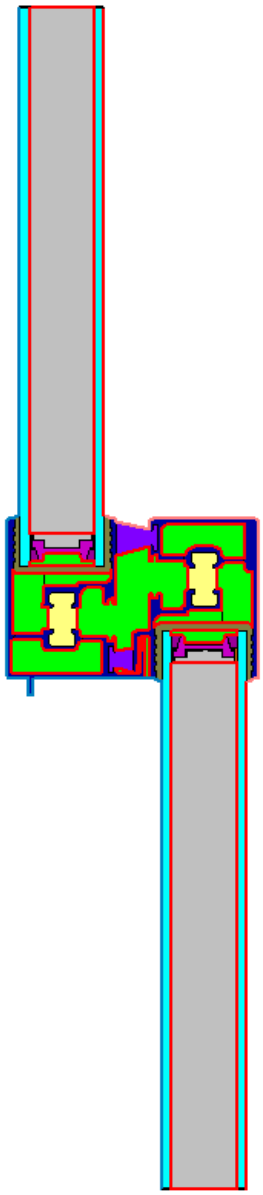


Figure 8-11 Red boundary conditions will appear inside the glazing system when the Condensation Resistance feature is activated. Check the emissivities of each of these boundaries. Note that Condensation Resistance is only modeled for horizontal meeting rails (such as in a double hung window).

8.3 Dividers

8.3.1. Internal Dividers (Suspended Grilles)

The criteria for when dividers are modeled can be found in *NFRC 100*, Section 1.4.4, "Simplifications to a Product Line". The discussion below describes the methodologies in WINDOW and THERM for modeling dividers when that criteria is met.

8.3.1.1. Modeling Steps

The modeling steps in THERM6 and WINDOW6 are the same for all divider shapes and all possible gas fills, in contrast to modeling steps in previous versions of THERM. These steps are the following:

In WINDOW:

- No new work is required, because the same glazing system that is used to model the rest of the product is used in the divider model.

In THERM:

- The new ISO 15099 modeling assumptions would theoretically warrant modeling horizontal and vertical dividers separately. However, a conservative simplification is to model all dividers, including horizontal ones, as vertical dividers. Therefore, only one divider model is created in THERM and referenced in WINDOW.
- Set the **Cross Section Type** to "Vertical Divider" for all dividers.
- Insert the glazing system twice, once facing up, with a spacer height defined as the same height as the divider height, and once facing down with the spacer height set to zero.
- *NOTE: Because all dividers are modeled as "Vertical Dividers" the CR model is not run in THERM for these files.* However, WINDOW will still calculate a whole product CR value when these dividers are used in a product, by using the U-factor temperatures for the dividers.
- Draw the true geometry of the divider in the upper glazing system, in the "spacer" area.
- Depending on the fill of the glazing system, assign the appropriate frame cavity material to the cavities between the glazing system and the divider, as well the cavity inside the divider, as follows:
  - For air-filled dividers: Assign "Frame Cavity NFRC 100-2010" material
  - For gas-filled dividers: Create a new material in the **Material Library** that is identical to the "Frame Cavity NFRC 100-2010" material, except that the gas used in the glazing system, found in the **Gas Library,** is referenced in the **Gas Fill** field. Assign this new material to the cavities in the divider. (See the example below)
- Assign Boundary Conditions.
- Simulate the results.

Import the file into the WINDOW Divider Library. Reference the Divider as appropriate from the Window Library when constructing the whole product.

8.3.1.2. Air Filled Glazing Systems

The modeling steps for a divider with an air-filled glazing system are explained in detail in the following pages.

In THERM:

1. Set the **Cross Section Type** to "Vertical Divider".
2. Import the glazing system for the divider, which is the same glazing system as the rest of the product, with the following settings:
   - **Orientation** = Up
   - **Actual Cavity height** = 1000 mm (39 inches)
   - **Sight line to bottom of glass** = height of the divider (in this example it is 19.05 mm [0.75 inches])
   - **Spacer height** = height of the divider (in this example it is 19.05 mm [0.75 inches)
   - **Edge of Glass Dimension** = 63.5 mm (2.5 inches)
   - **Glazing System Height:** 150 mm (6.0 inches)
   - **Draw spacer** = Not checked

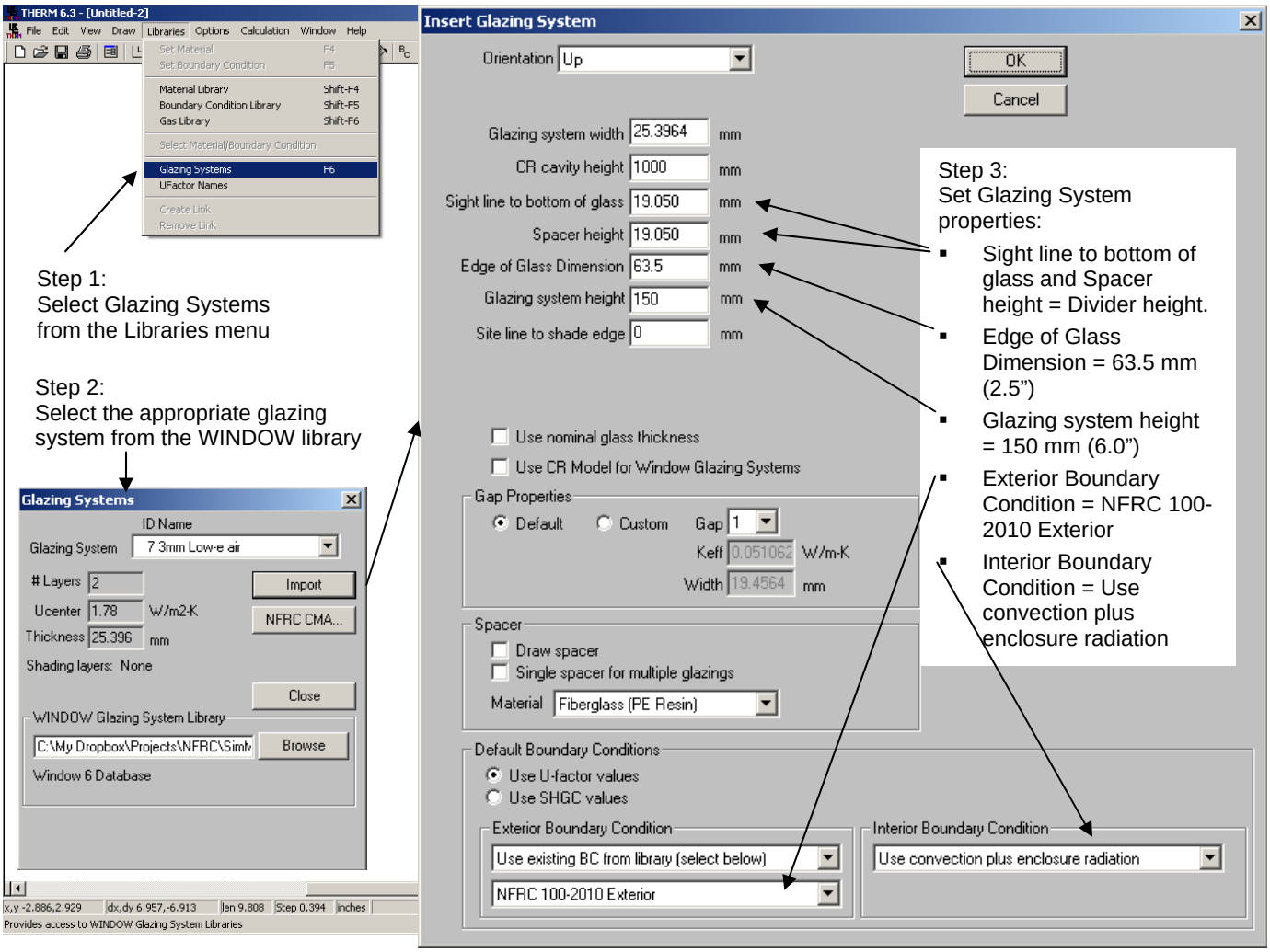


Figure 8-12. Import the first glazing system.

3. Import the glazing system again as an additional glazing system, below the first one (the locator does not have to be moved), but facing down this time. Use the following settings for this glazing system:
   - **Orientation** = Down
   - **Actual Cavity height** = 1000 mm (39 inches)
   - **Sight line to bottom of glass** = 0
   - **Spacer height** = 0
   - **Edge of Glass Dimension** = 63.5 mm (2.5 inches)
   - **Glazing System Height:** 150 mm (6.0 inches)
   - **Draw spacer** = Not checked

   Insert the glazing system as an **Additional Glazing**.

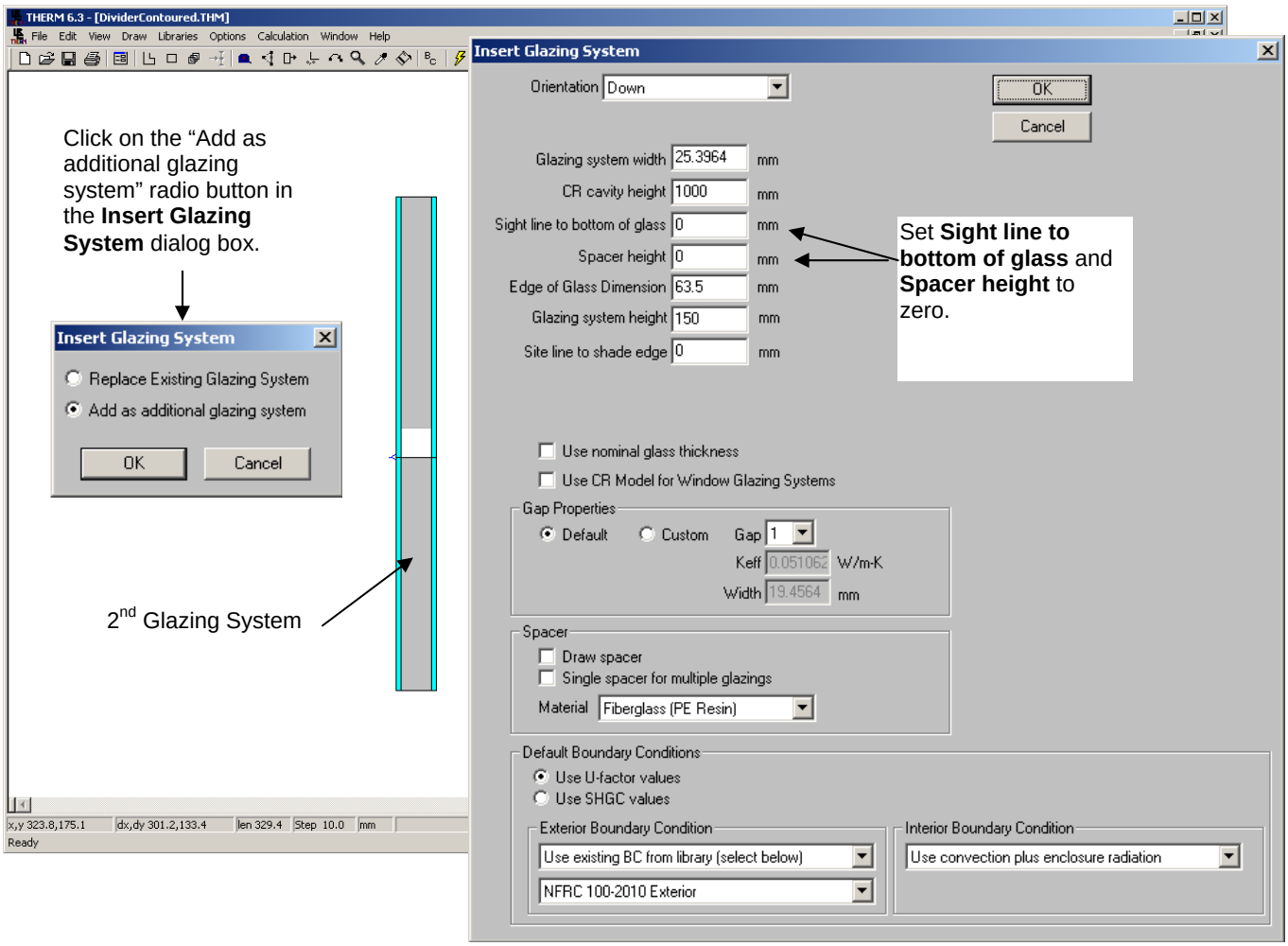


Figure 8-13. Import the second glazing system as an additional glazing system, facing down.

4. Draw (or copy and paste from another THERM file) the polygons in the cavity that represent the divider. The figure below shows the divider for this example drawn with the material set to Aluminum Alloy

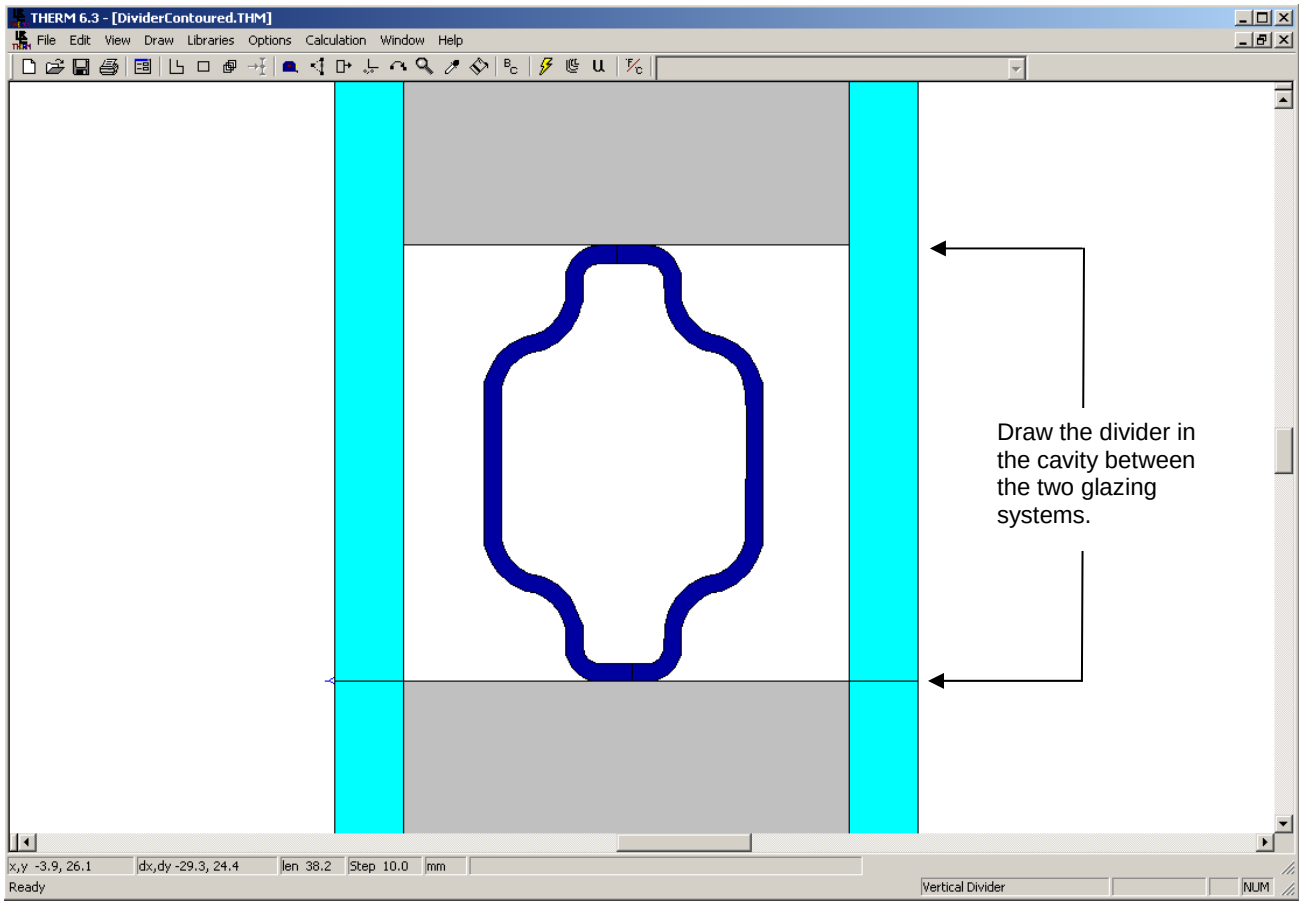


Figure 8-14. Draw the polygons to represent the divider.

5. Fill the cavities between the divider and the glass layers and inside the divider with the material "Frame Cavity NFRC 100". Divide the cavities up according to the 5 mm rule as necessary.

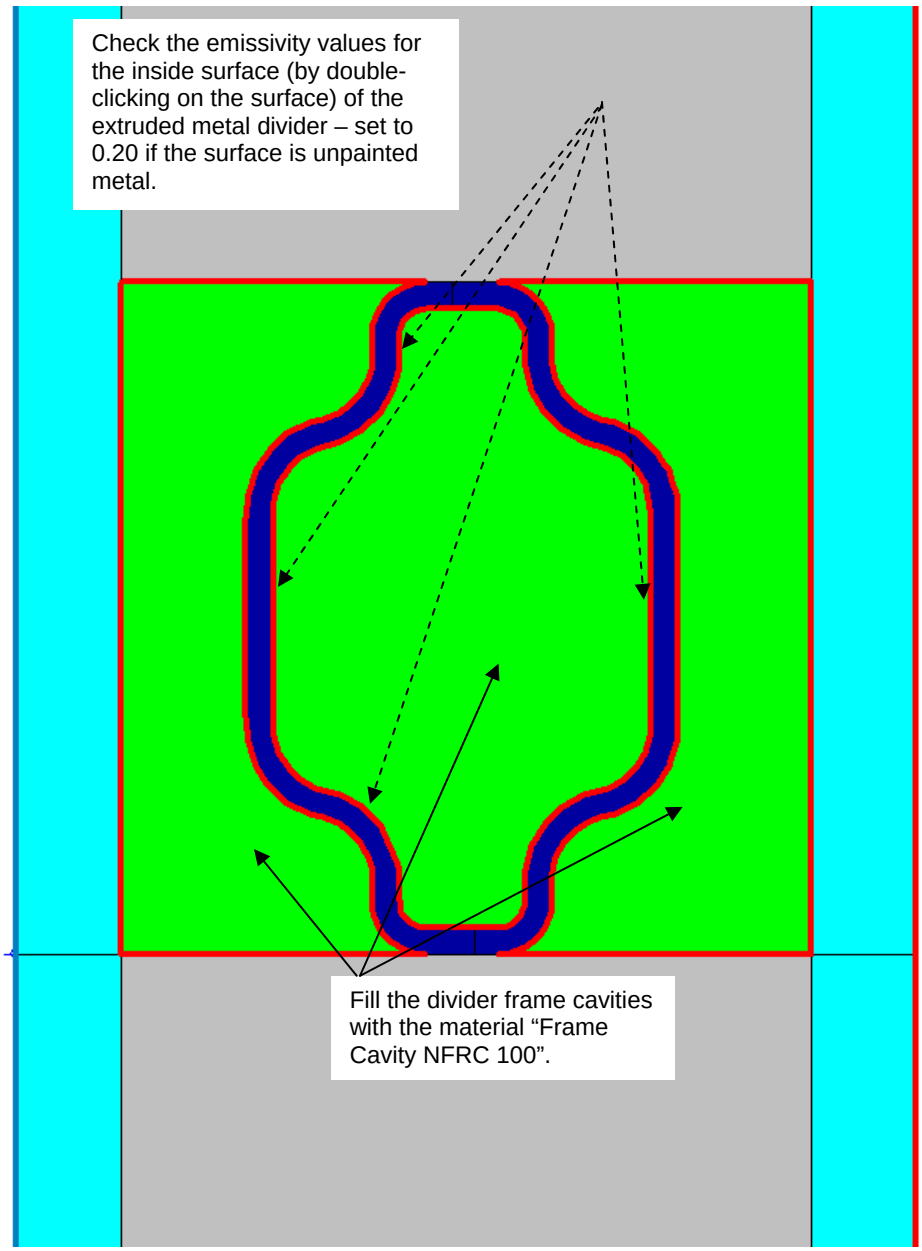


Figure 8-15 Fill the divider frame cavities with Frame Cavity NFRC 100.

6. Define the boundary conditions, using the "AutoEnclosure" choice for the Radiation Model.

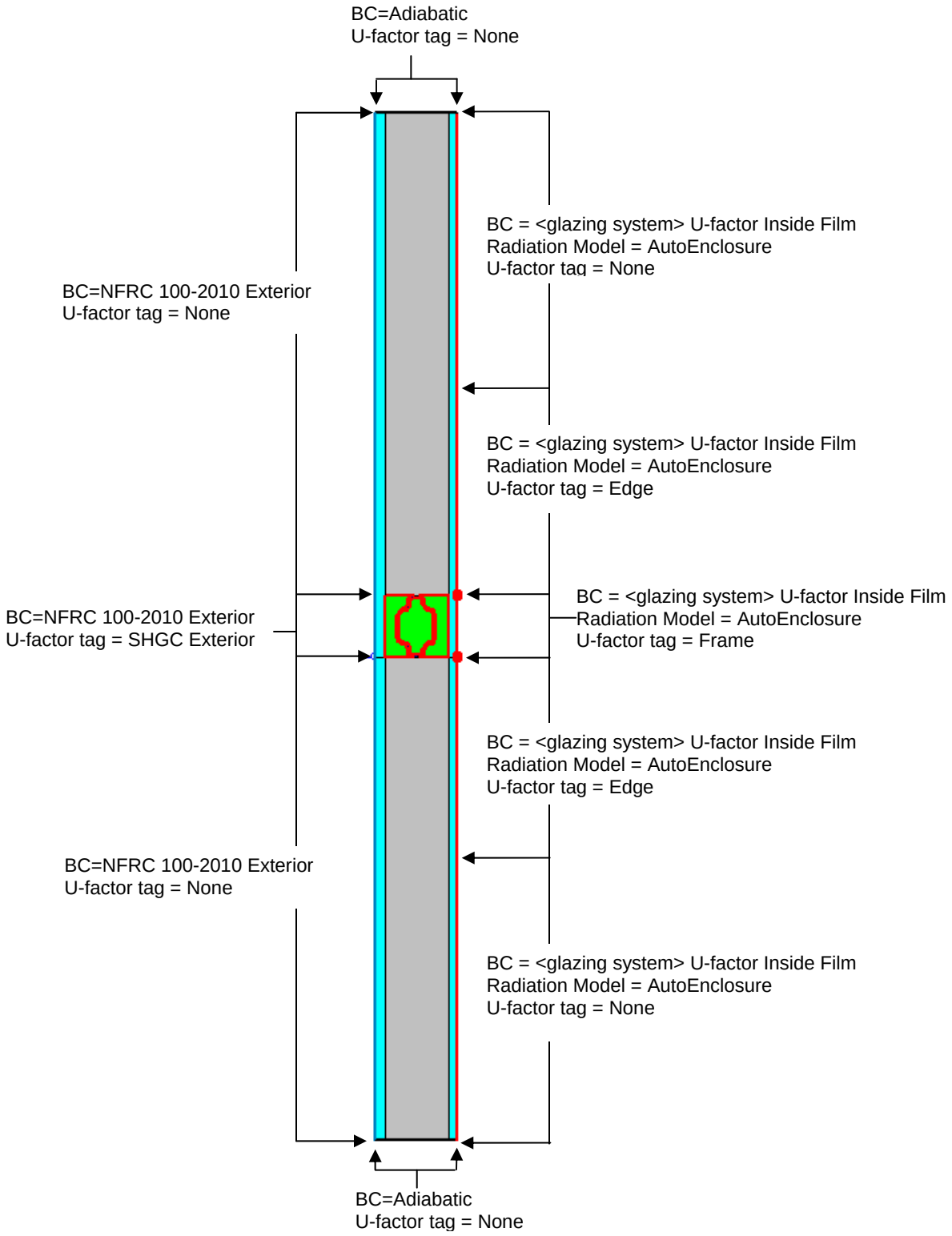


Figure 8-16 Assign the boundary conditions.

6. Calculate the results.

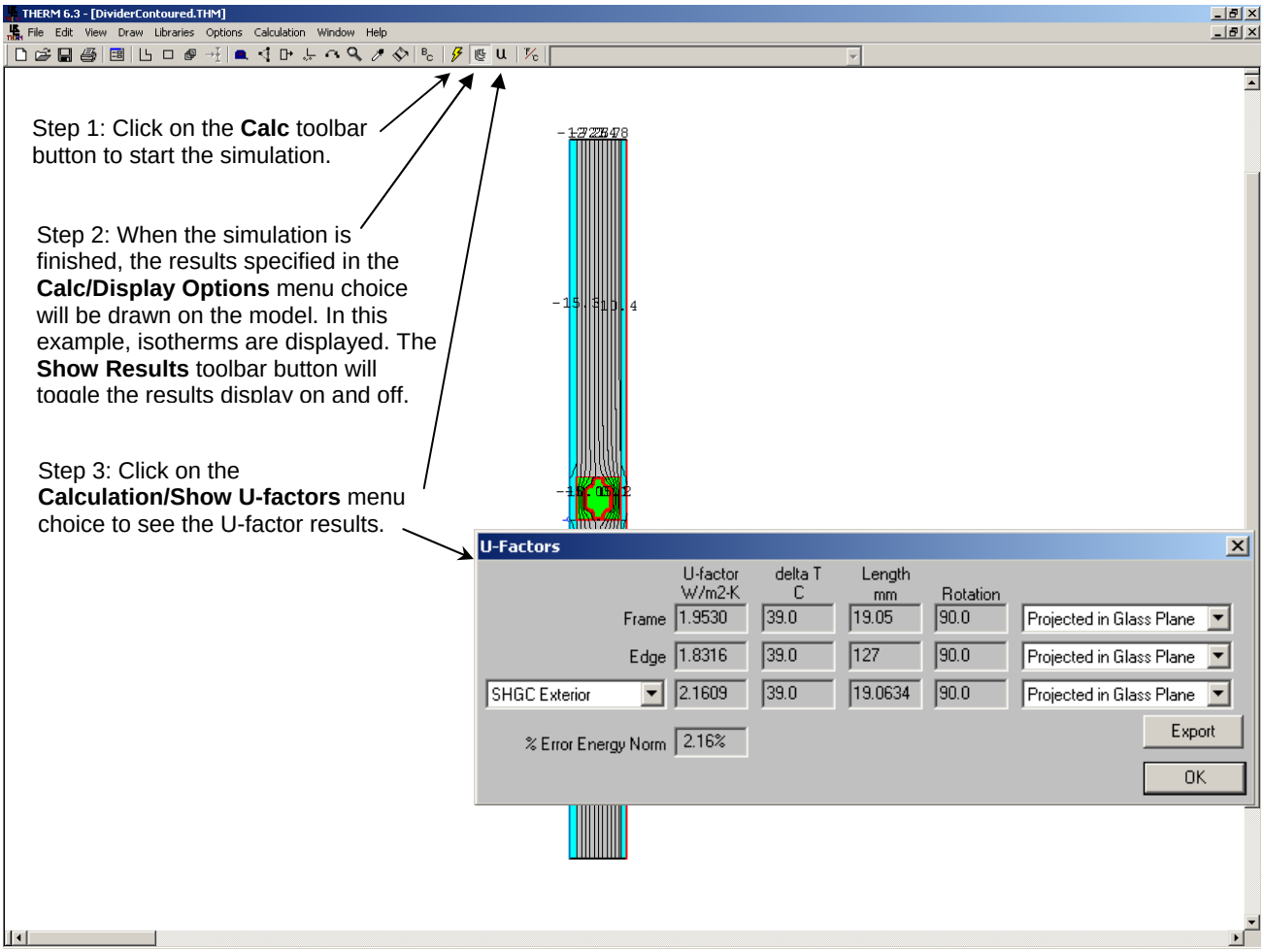


Figure 8-17 Calculate the results.

7. Save the file using the **File/Save As** menu choice.

8. Import the results to the WINDOW Divider Library, as shown below. See Section 4.7.3, "Importing THERM files" in the *WINDOW User's Manual* for more information about importing THERM files.

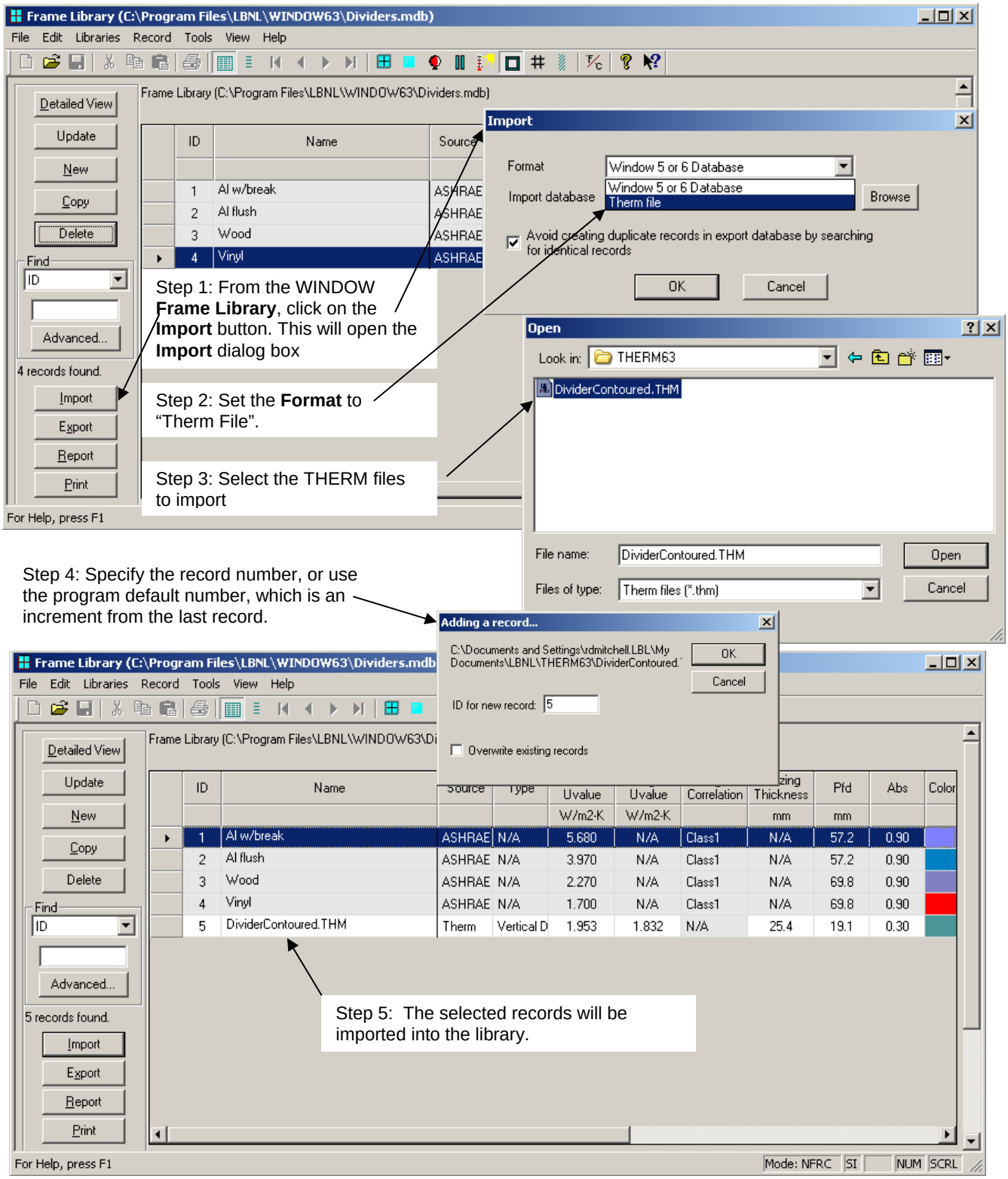


Figure 8-18 Import the THERM file into the WINDOW ***Divider Library****.*

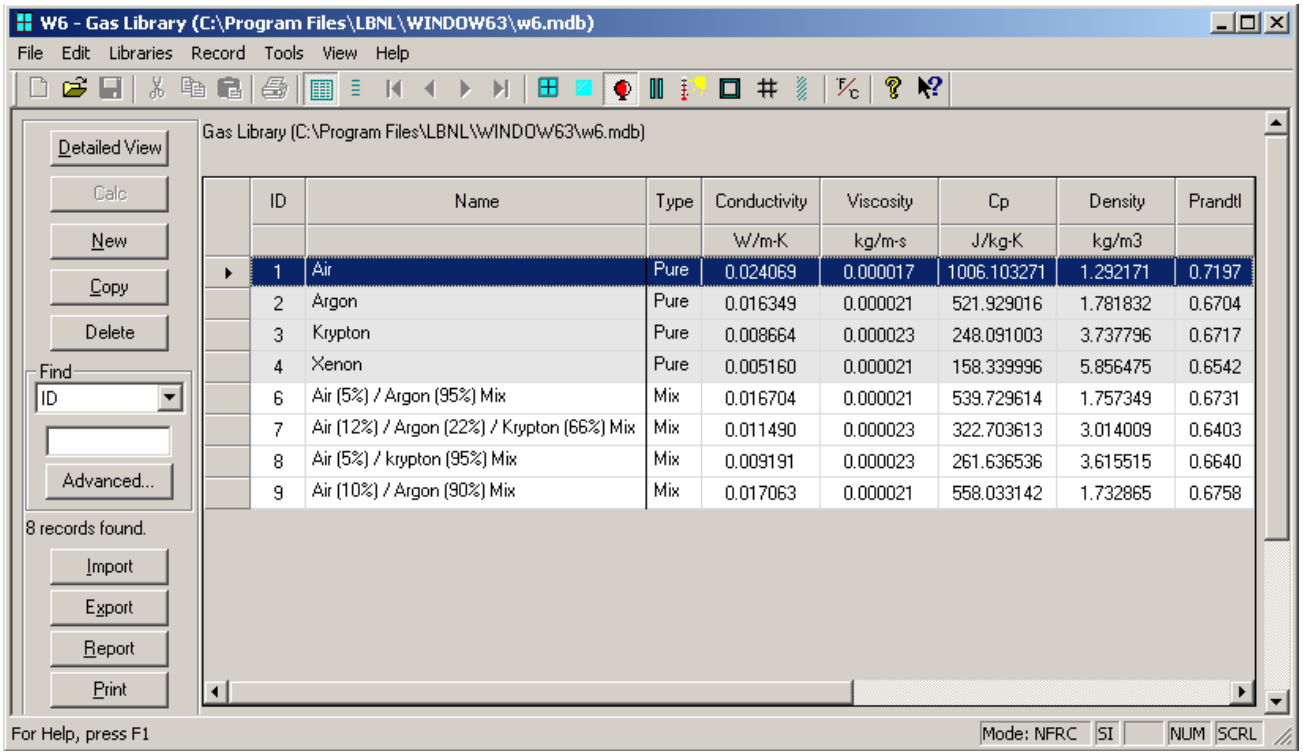
9. Use the new divider in the calculation of the complete product values in the main screen of WINDOW.

8.3.1.3. Gas Filled Glazing Systems

If the glazing system being modeled with a divider is gas-filled, it is necessary to model the divider with the same gas fill as the glazing system. This means a new material must be defined for the gas-filled frame cavities around and inside the divider.

The THERM **Gas Library** contains entries for standard gases, as well as examples of gas mixtures. These gases are not made in THERM; they are made in the WINDOW **Gas Library** and then imported into the THERM **Gas Library**. When the gas mixtures have been imported into THERM, they can be referenced from a new frame cavity material for the divider model, as shown below.

1. Create the gas mixture in the WINDOW **Gas Library**. Presumably it already exists for the product glazing system model. See Section 4.6, "Gas Library" in the *WINDOW User's Manual* for details about creating new entries in the **Gas Library**.



ID	Name	Type	Conductivity	Viscosity	Cp	Density	Prandtl
			W/m-K	kg/m-s	J/kg-K	kg/m3	
1	Air	Pure	0.024069	0.000017	1006.103271	1.292171	0.7197
2	Argon	Pure	0.016349	0.000021	521.929016	1.781832	0.6704
3	Krypton	Pure	0.008664	0.000023	248.091003	3.737796	0.6717
4	Xenon	Pure	0.005160	0.000021	158.339996	5.856475	0.6542
6	Air (5%) / Argon (95%) Mix	Mix	0.016704	0.000021	539.729614	1.757349	0.6731
7	Air (12%) / Argon (22%) / Krypton (66%) Mix	Mix	0.011490	0.000023	322.703613	3.014009	0.6403
8	Air (5%) / krypton (95%) Mix	Mix	0.009191	0.000023	261.636536	3.615515	0.6640
9	Air (10%) / Argon (90%) Mix	Mix	0.017063	0.000021	558.033142	1.732865	0.6758

Figure 8-19 Make the necessary gas mixture in the WINDOW Gas Library.

2. Import the WINDOW gas mixture into the THERM **Gas Library**, if it is not already there.

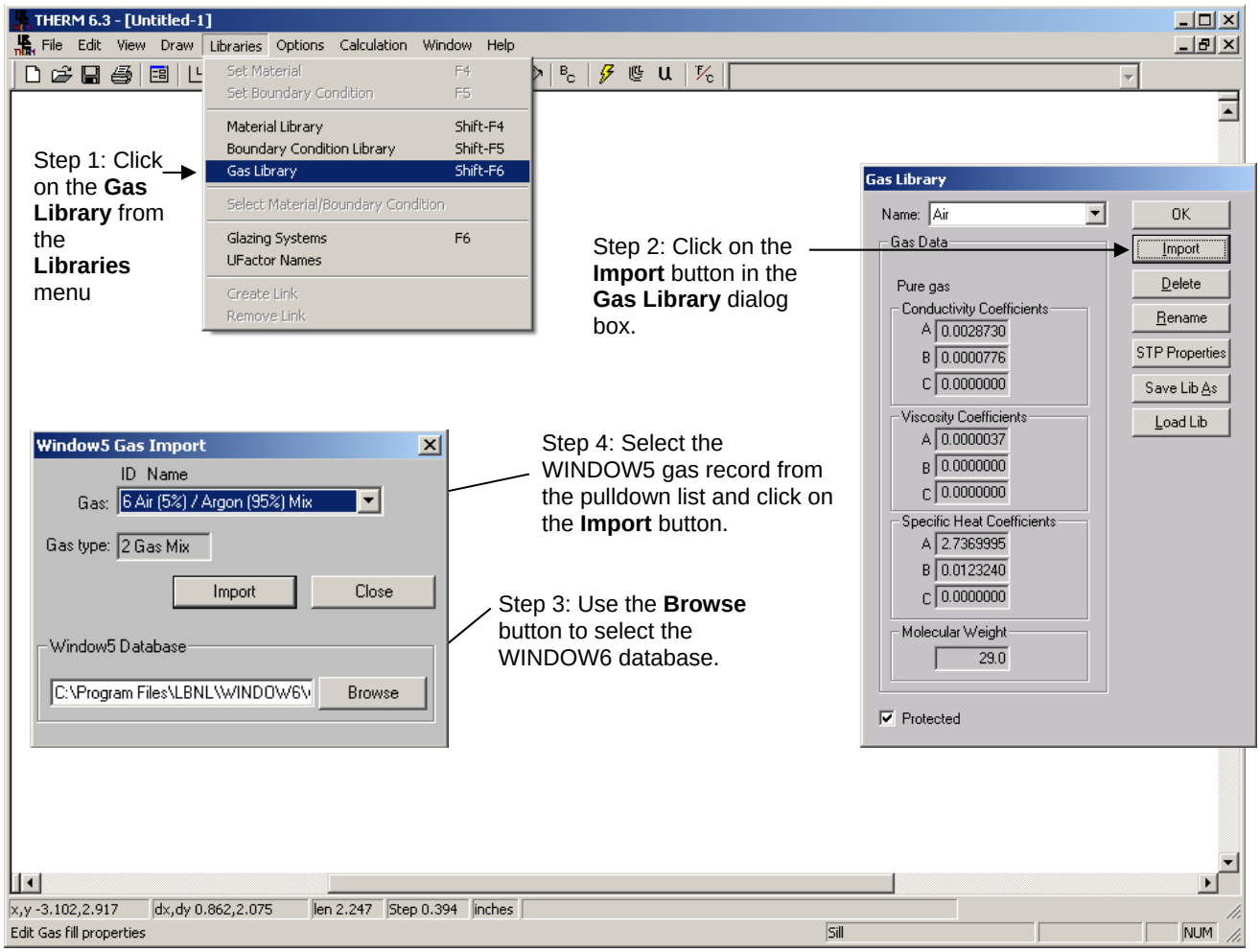


Figure 8-20 Import the gas mixture entries into the THERM Gas Library.

3. Make a new frame cavity material in the THERM **Material Library** based on "Frame Cavity NFRC 100" but with the **Gas Fill** field set to the correct gas mixture from the **Gas Library**.

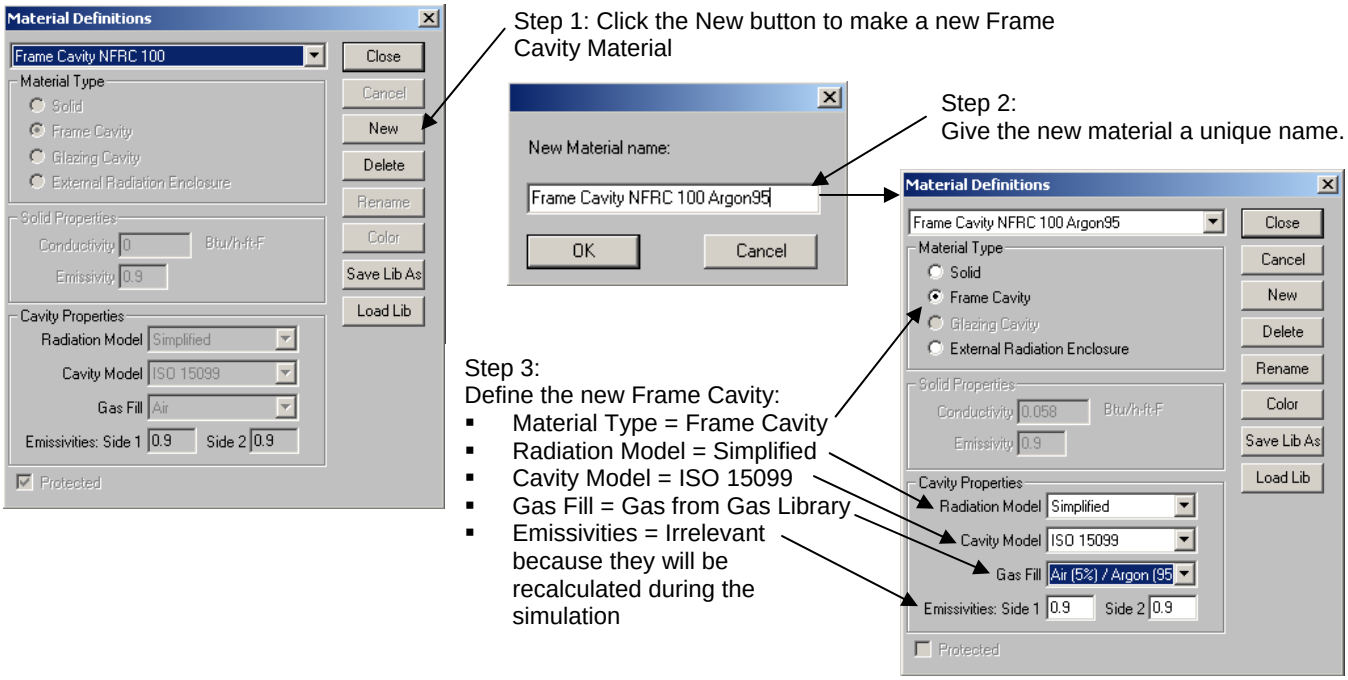


Figure 8-21 Import the gas mixture entries into the THERM Gas Library.

4. Use this new frame cavity material in the divider model cavities.

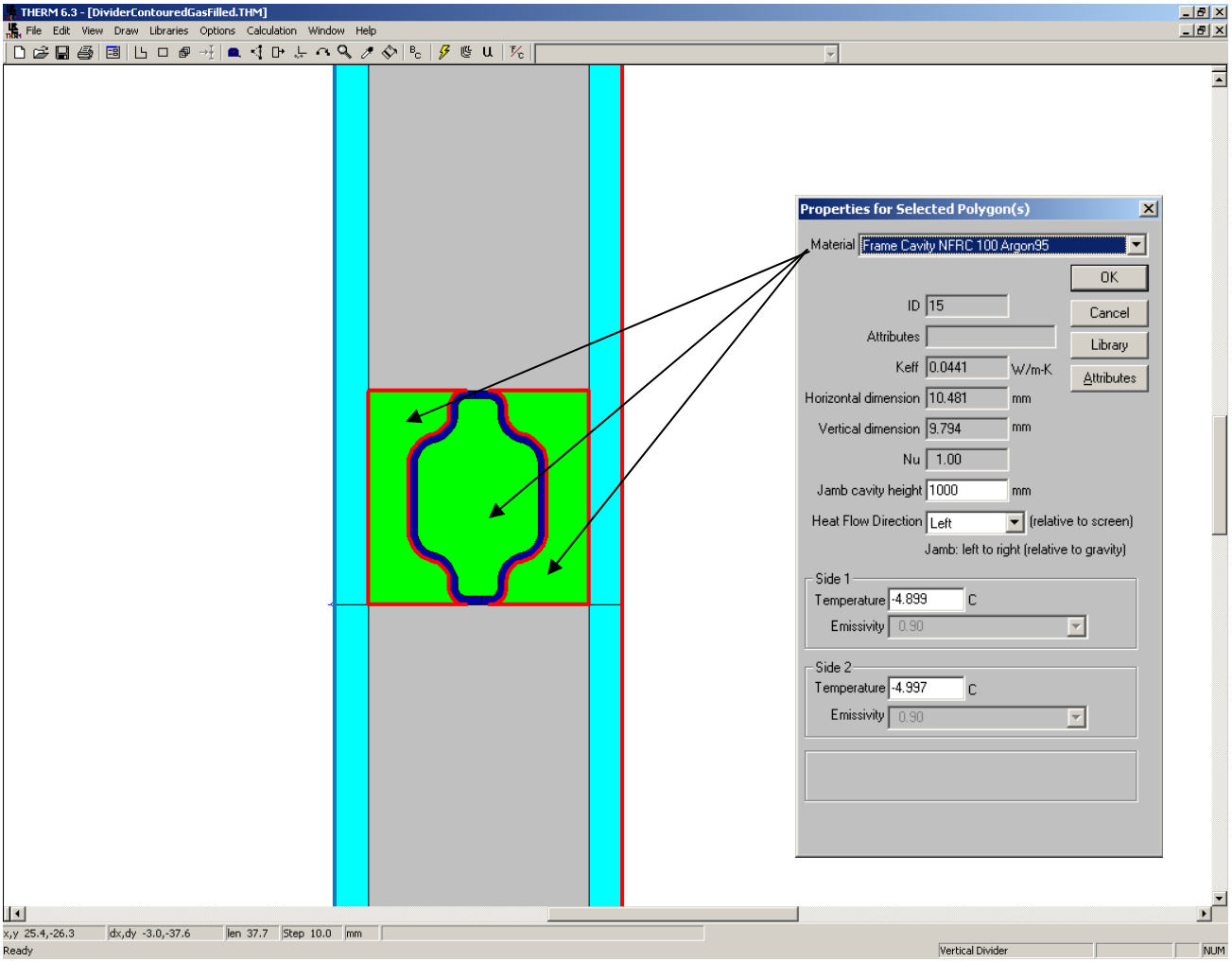


Figure 8-22. Use the new Frame Cavity material to fill the divider cavities.

8.3.2. Simulated Divided Lites

A simulated divided lite is a glazing system that has elements attached to the inside and outside of a glazing system to give the appearance of true divided lites. The glazing system has a metal internal reinforcement, but is all one system. The materials applied/adhered to the outside of the insulating glazing unit are not required to be modeled per NFRC 100. This is an option of the manufacturer and the following provides the details to model and simulate it correctly

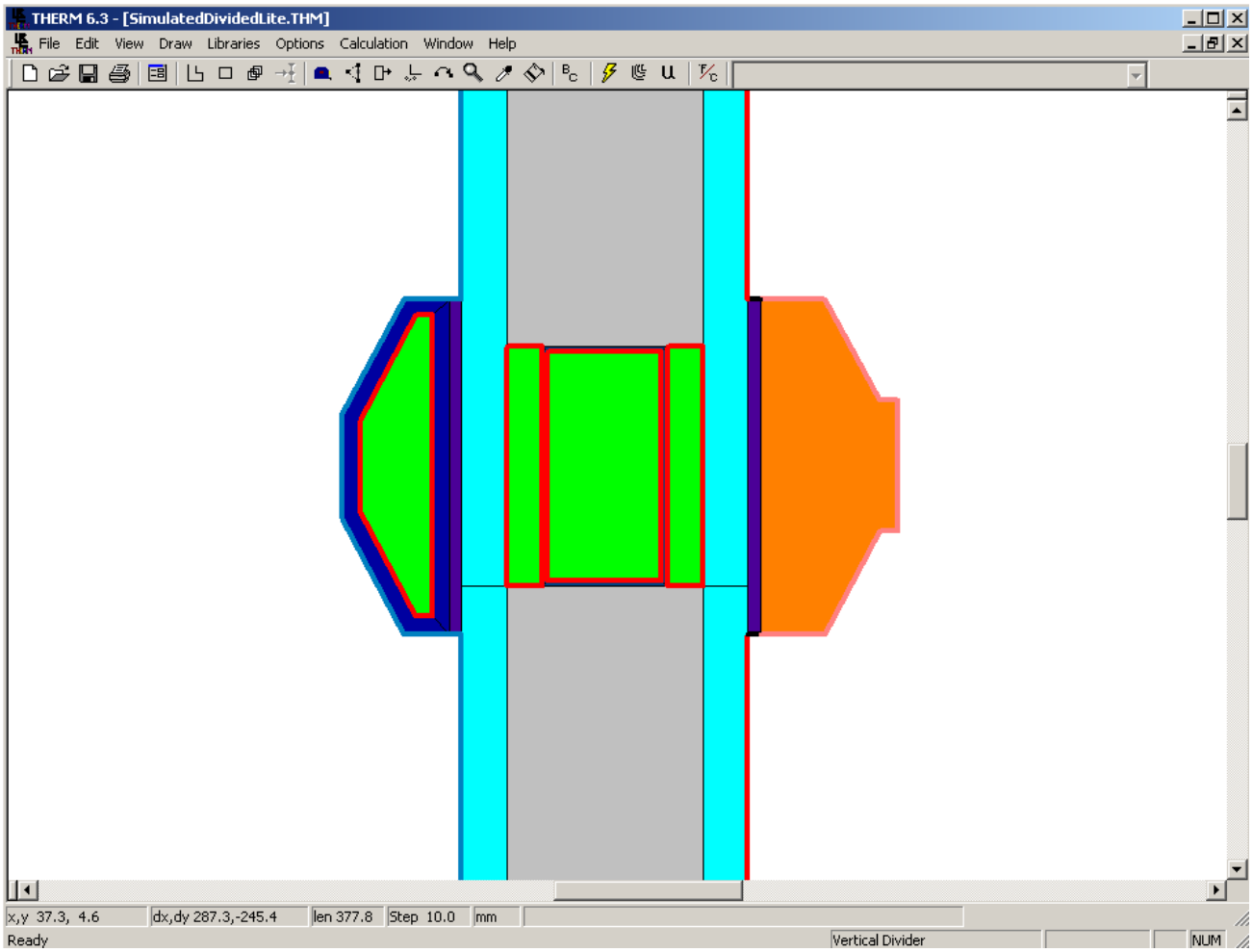


Figure 8-23. A simulated divided lite in THERM.

In THERM:

10. Set the **Cross Section Type** to "Vertical Divider".

11. Import the glazing system for the divider, which is the same glazing system as the rest of the product, with the following settings:
    - **Orientation** = Up
    - **Actual Cavity height** = 1000 mm (39 inches)
    - **Sight line to bottom of glass** = height of the divider (in this example it is 19.05 mm [0.75 inches])
    - **Spacer height** = height of the divider (in this example it is 19.05 mm [0.75 inches)
    - **Edge of Glass Dimension** = 63.5 mm (2.5 inches)
    - **Glazing System Height:** 150 mm (6.0 inches)
    - **Draw spacer** = Not checked

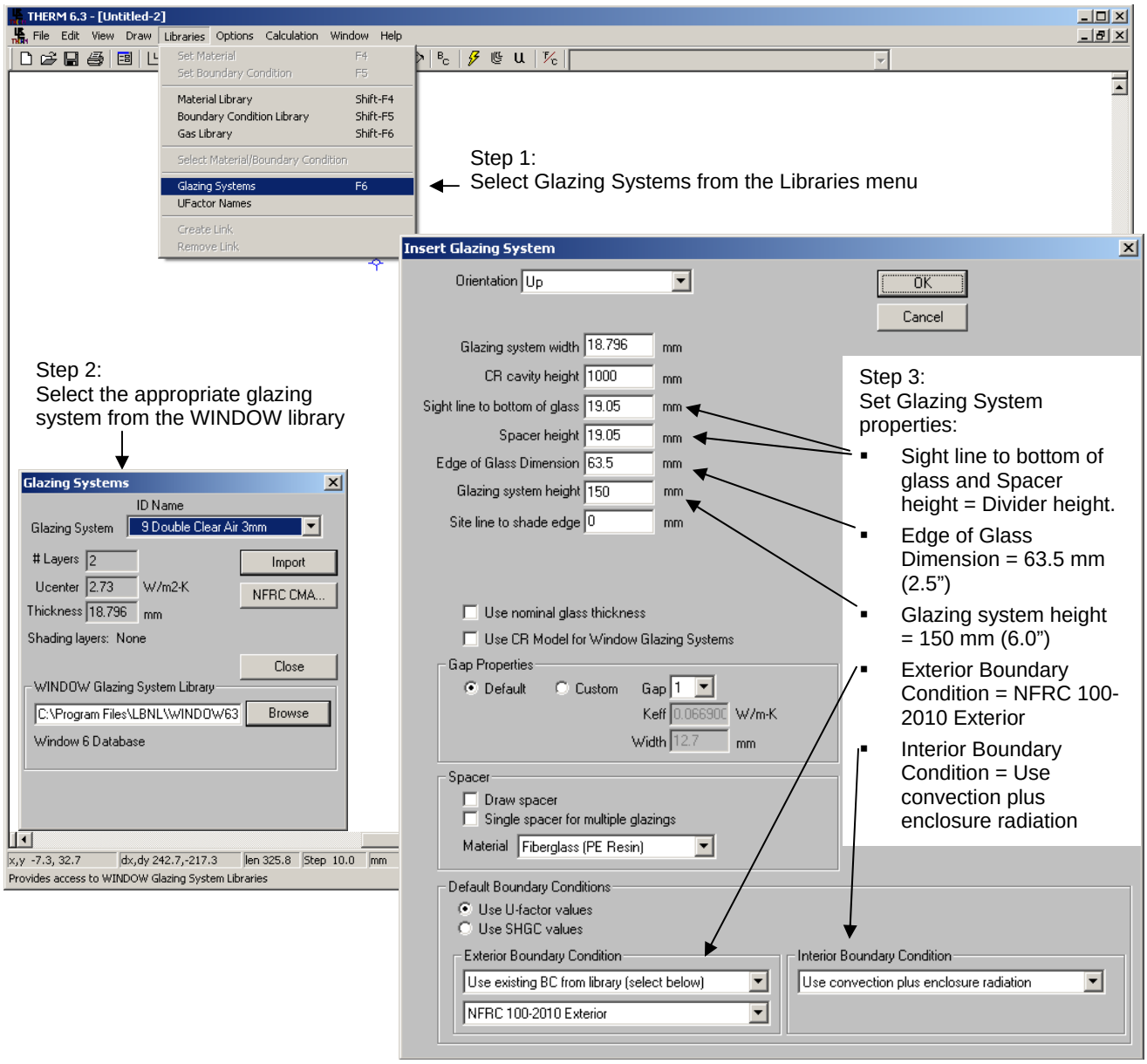


Figure 8-24. Import the first glazing system.

12. Import the glazing system again as an additional glazing system, below the first one (the locator does not have to be moved), but facing down this time. Use the following settings for this glazing system:
    - **Orientation** = Down
    - **Actual Cavity height** = 1000 mm (39 inches)
    - **Sight line to bottom of glass** = 0
    - **Spacer height** = 0
    - **Edge of Glass Dimension** = 63.5 mm (2.5 inches)
    - **Glazing System Height:** 150 mm (6.0 inches)
    - **Draw spacer** = Not checked

    Insert the glazing system as an **Additional Glazing**.

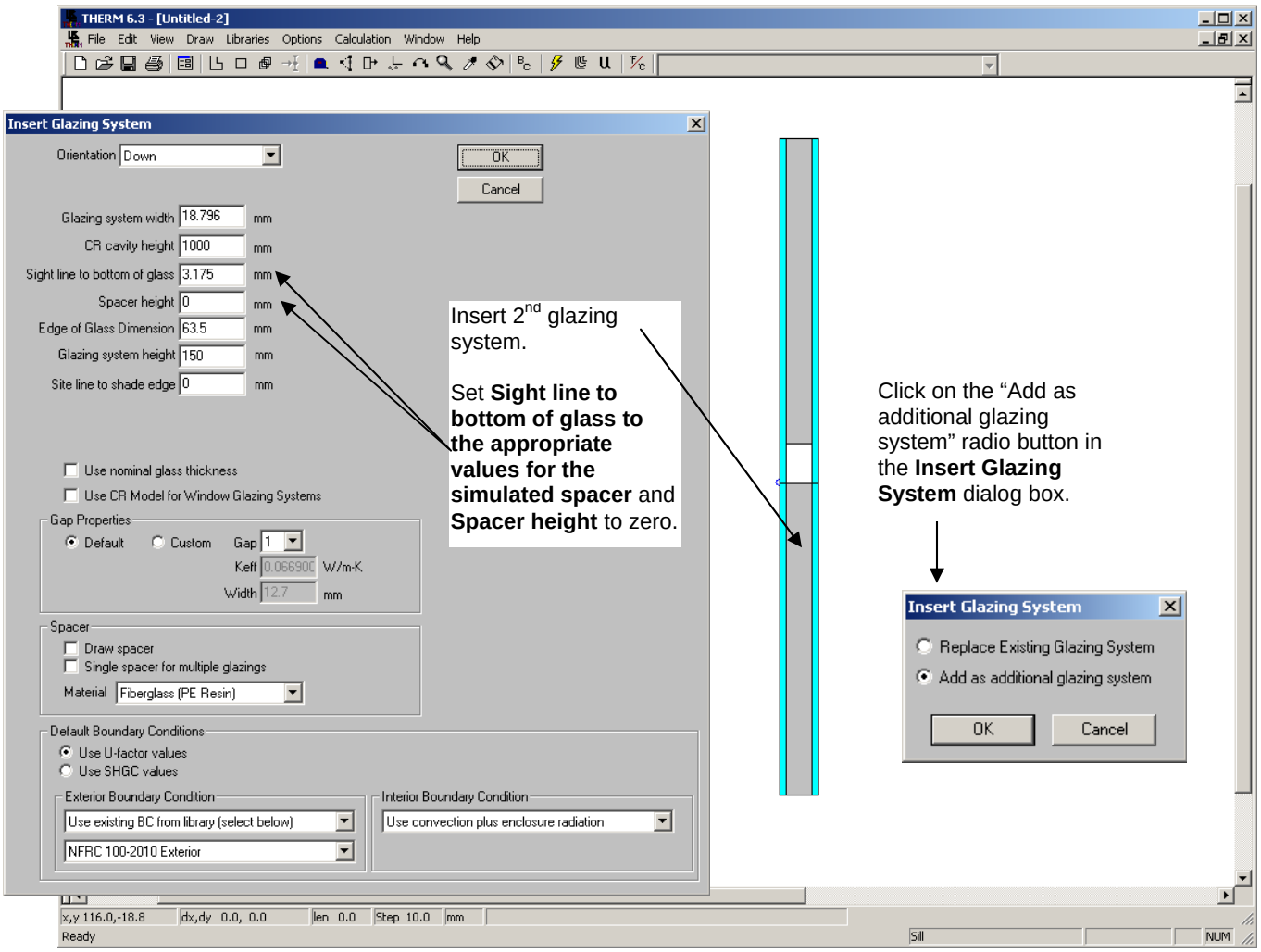


Figure 8-25. Import the second glazing system as an additional glazing system, facing down.

1. Draw (or copy and paste from another THERM file) the polygons in the cavity that represent the divider. The figure below shows the divider for this example drawn with the material set to Aluminum Alloy

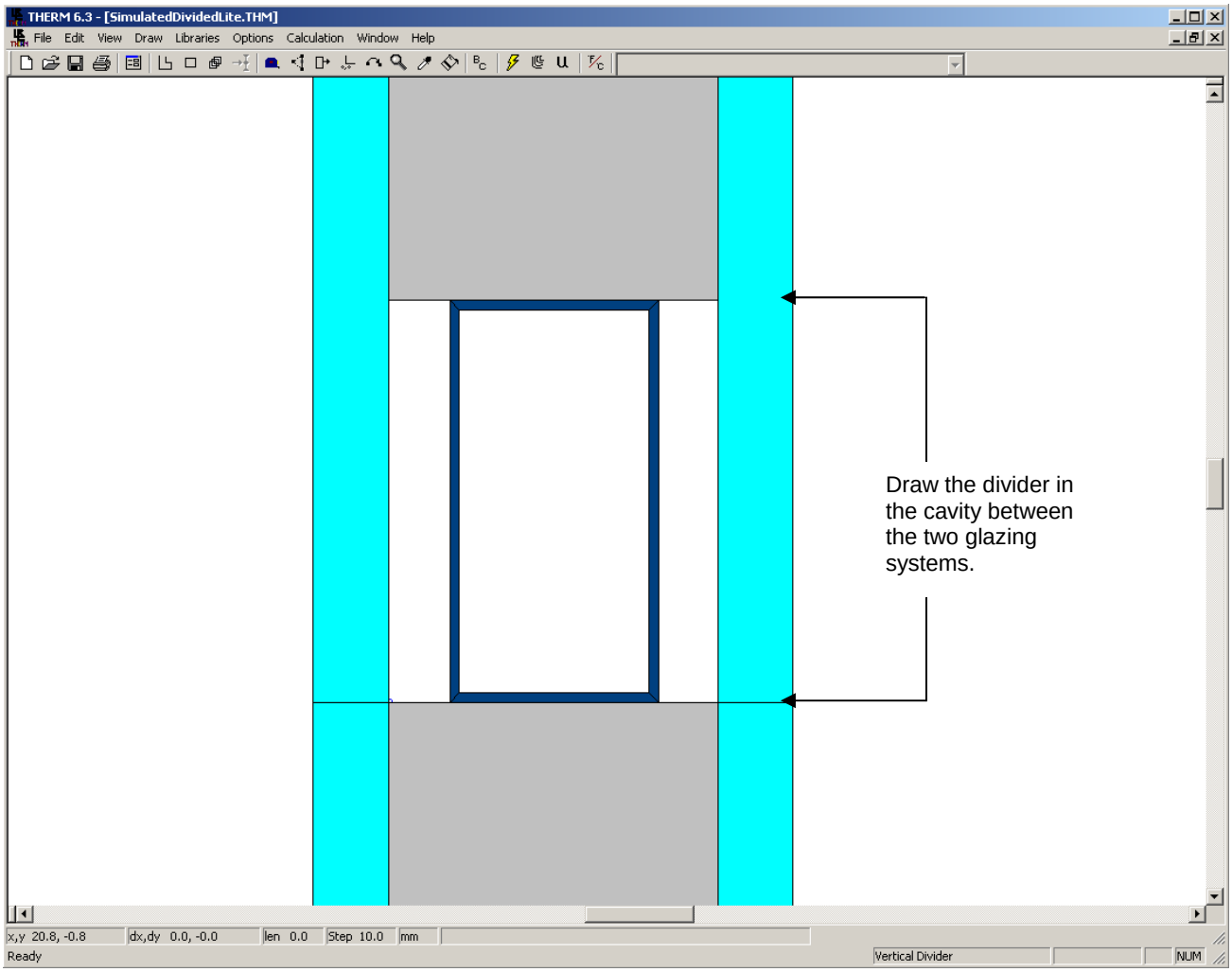


Figure 8-26. Draw the polygons to represent the divider.

2. Fill the cavities between the divider and the glass layers and inside the divider with the material "Frame Cavity NFRC 100". Divide the cavities up according to the 5 mm rule as necessary.

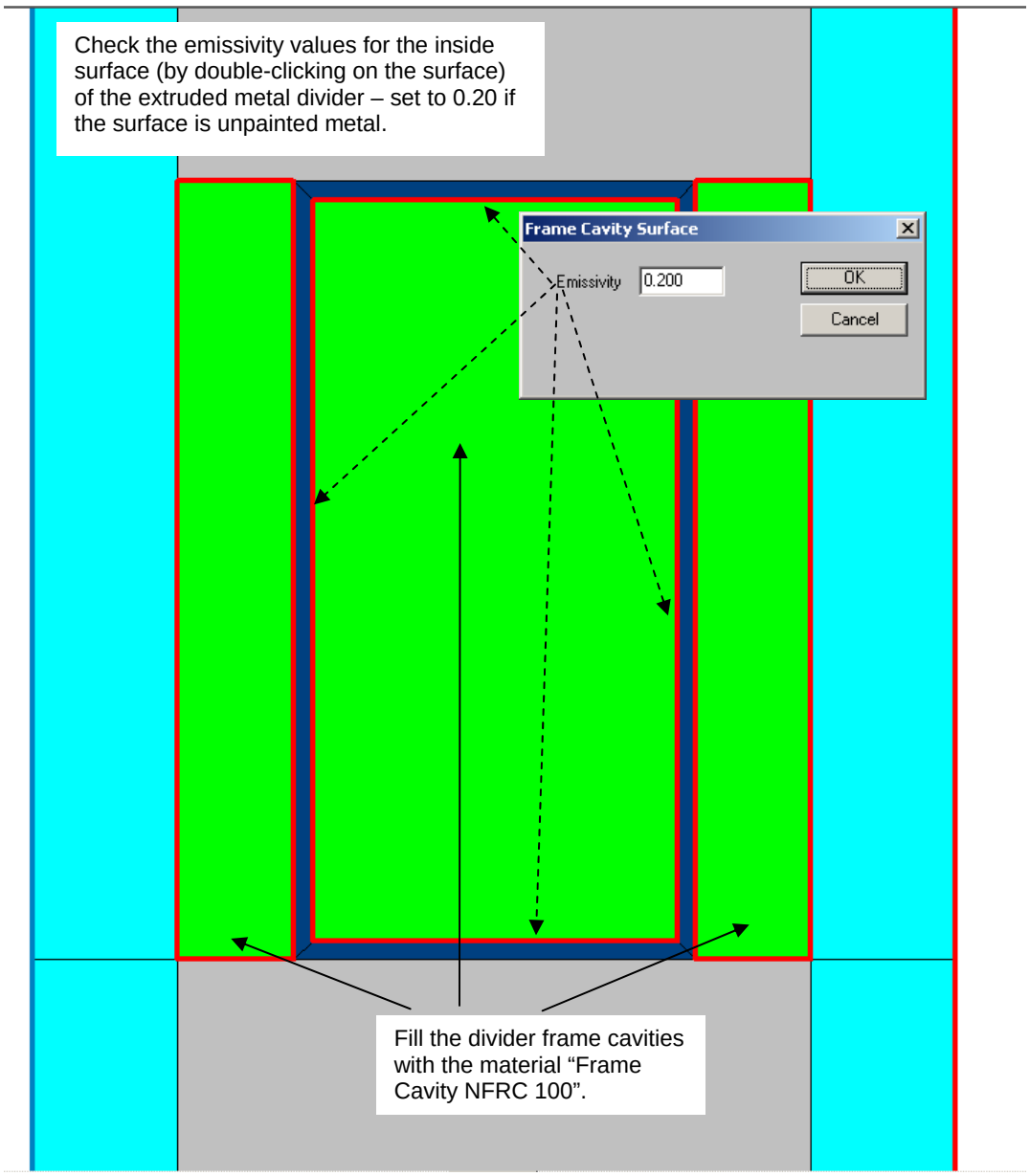


Figure 8--27 Fill the divider frame cavities with Frame Cavity NFRC 100.

7. Add the polygons for the simulated divided light elements on either side of the glazing system and assign the appropriate materials to them.

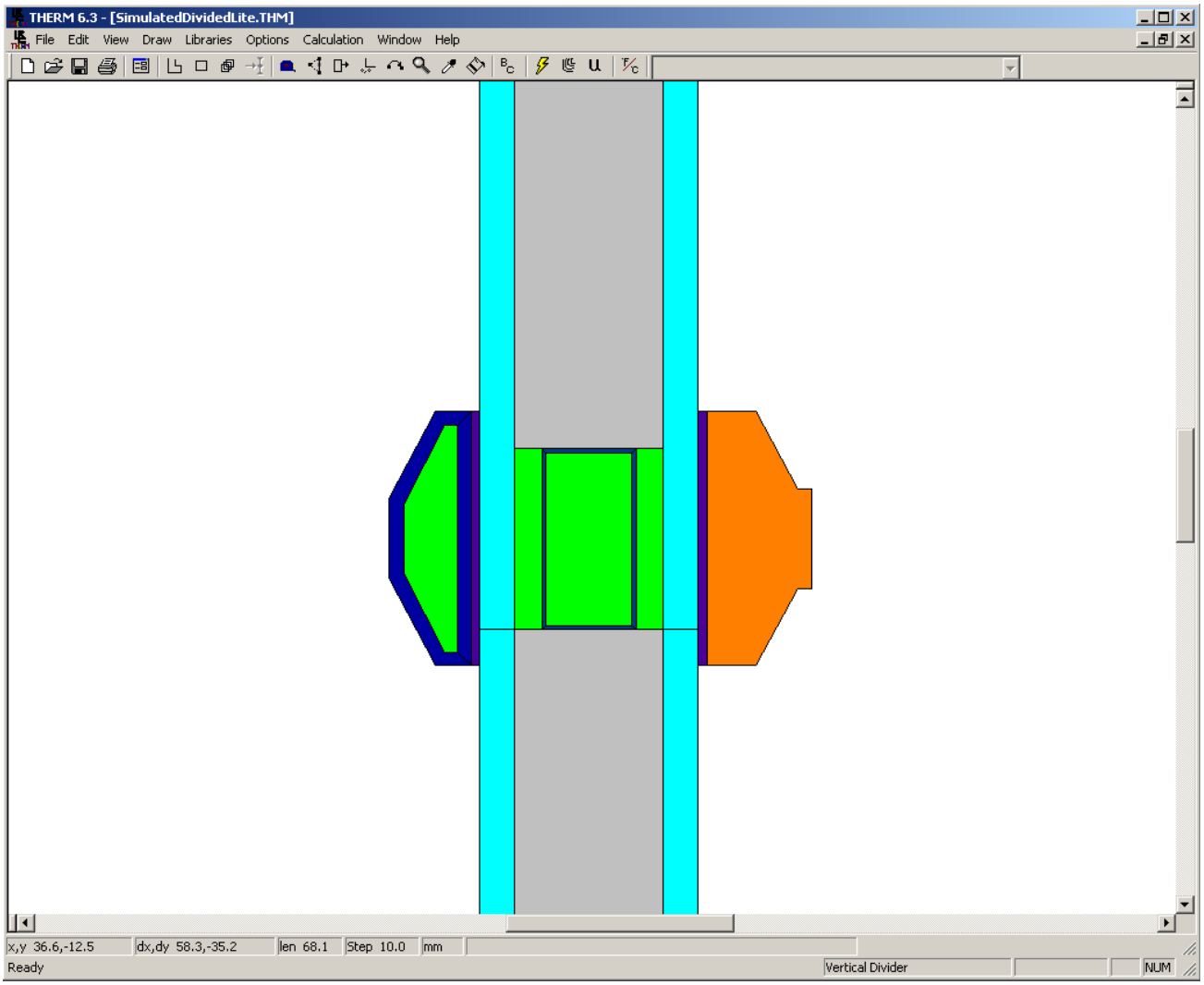


Figure 8--28 Add the polygons for the simulated divided lite elements on either side of the glazing system.

8. Define the boundary conditions, using the "AutoEnclosure" choice for the Radiation Model.

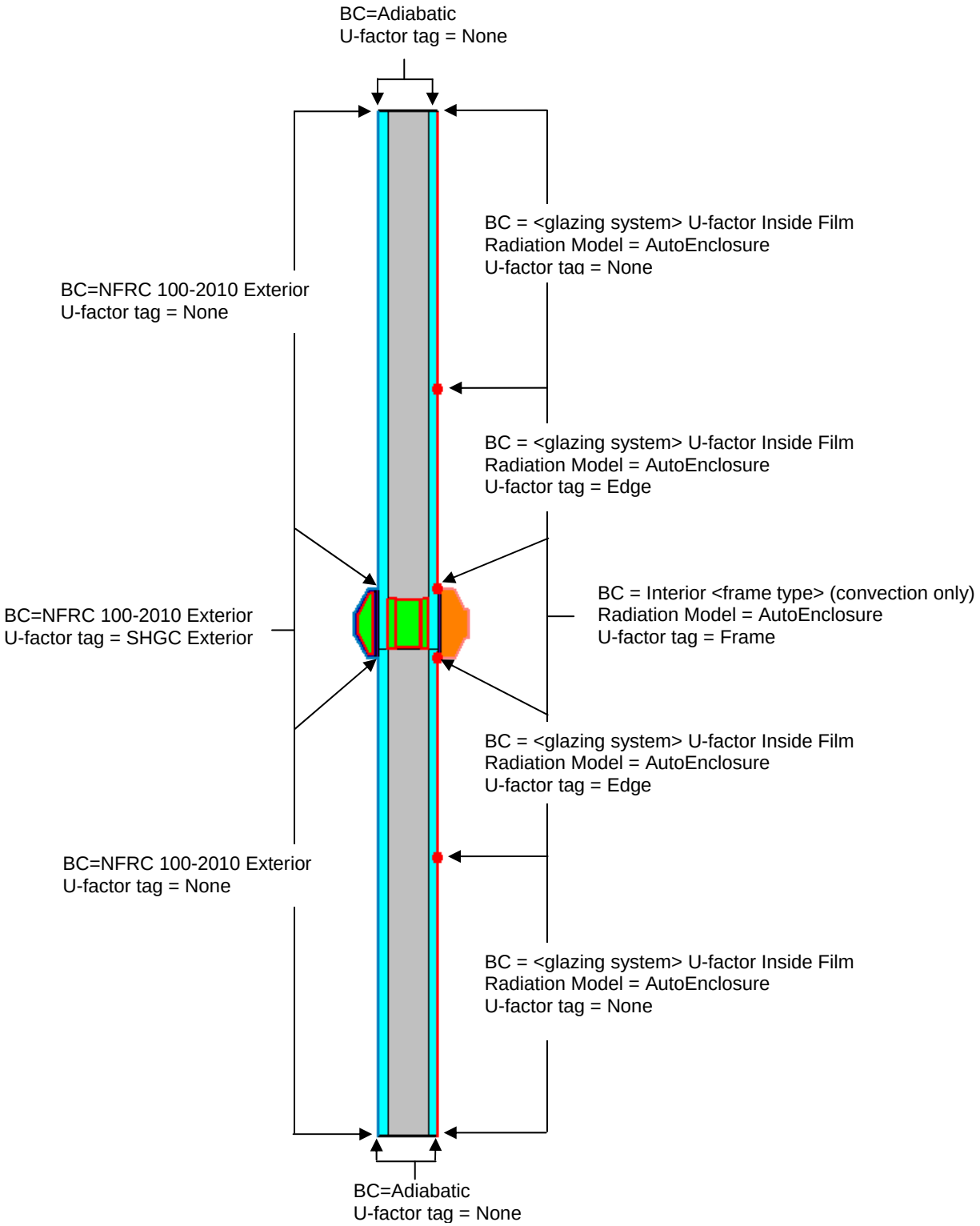


Figure 8-29 Assign the boundary conditions.

3. Calculate the results.

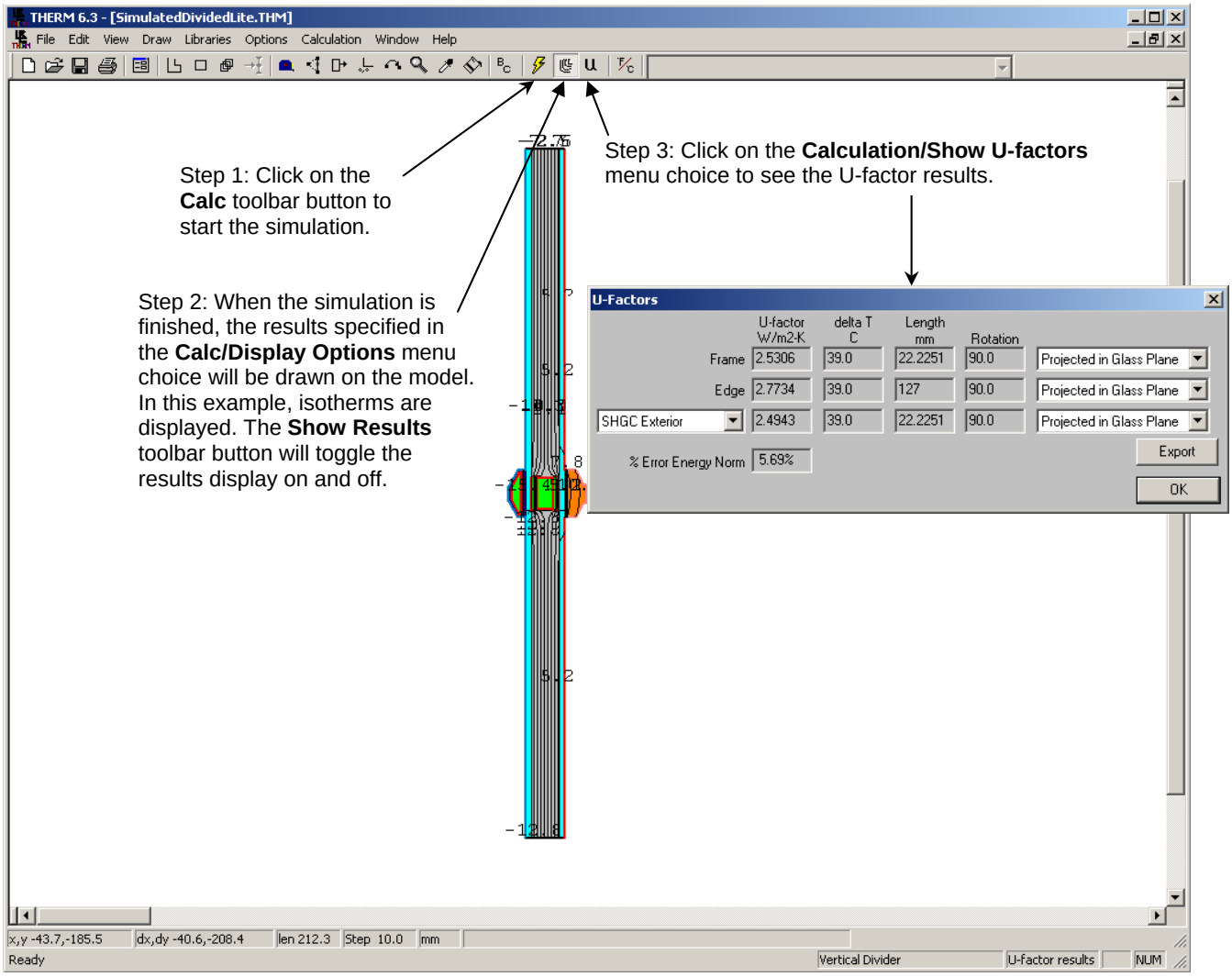
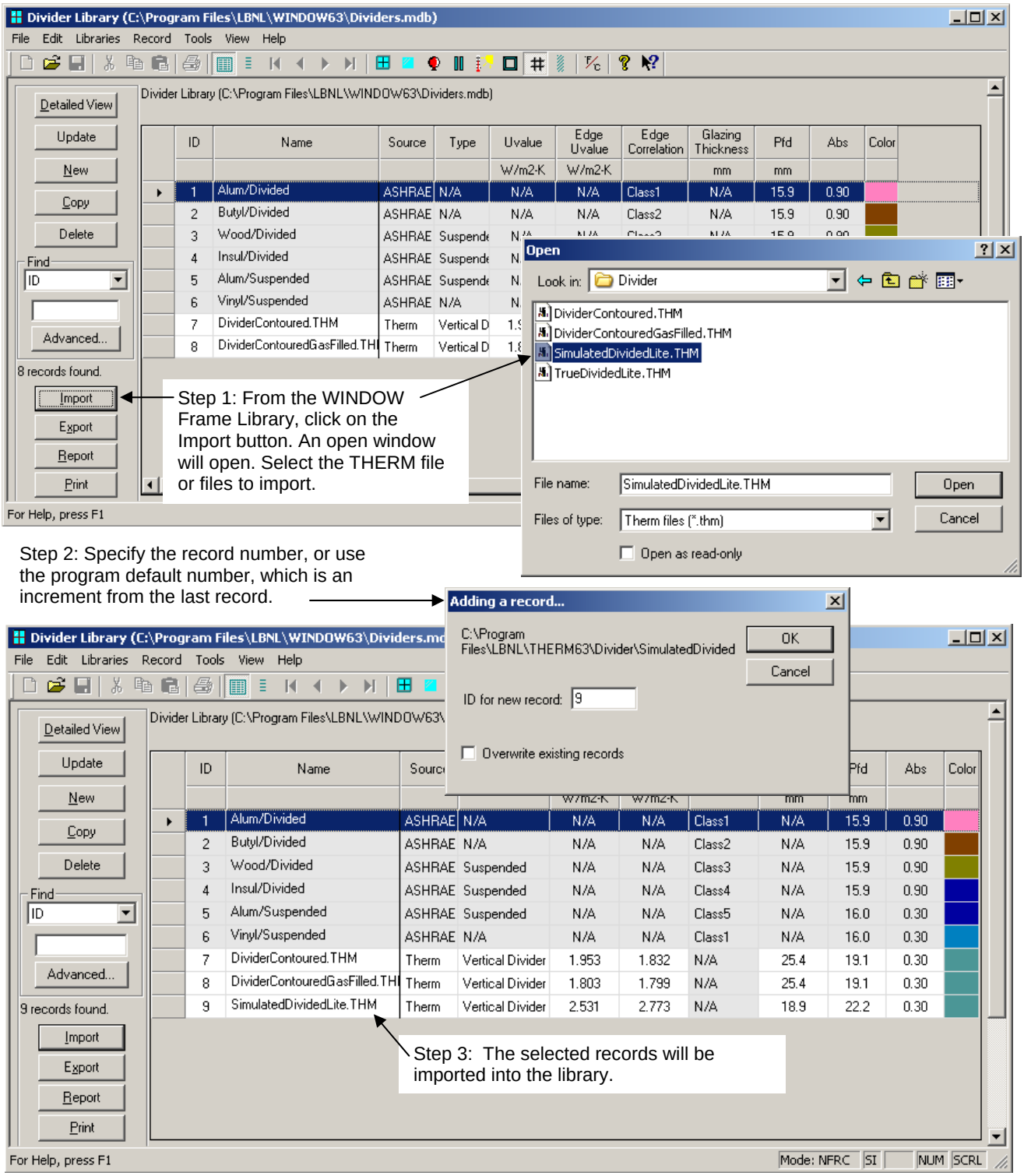


Figure 8-30 Calculate the results.

4. Save the file using the **File/Save As** menu choice.

5. Import the results to the WINDOW Divider Library, as shown below. See Section 4.7.3, "Importing THERM files" in the *WINDOW User's Manual* for more information about importing THERM files.



ID	Name	Source	Type	Uvalue	Edge Uvalue	Edge Correlation	Glazing Thickness	Pfd	Abs	Color
				W/m2-K	W/m2-K		mm	mm		
1	Alum/Divided	ASHRAE	N/A	N/A	N/A	Class1	N/A	15.9	0.90	
2	Butyl/Divided	ASHRAE	N/A	N/A	N/A	Class2	N/A	15.9	0.90	
3	Wood/Divided	ASHRAE	Suspende	N/A	N/A	Class3	N/A	15.9	0.90	
4	Insul/Divided	ASHRAE	Suspende	N/A	N/A	Class4	N/A	15.9	0.90	
5	Alum/Suspended	ASHRAE	Suspende	N/A	N/A	Class5	N/A	16.0	0.30	
6	Vinyl/Suspended	ASHRAE	N/A	N/A	N/A	Class1	N/A	16.0	0.30	
7	DividerContoured.THM	Therm	Vertical D	1.9	1.832	N/A	25.4	19.1	0.30	
8	DividerContouredGasFilled.TH	Therm	Vertical D	1.8	1.799	N/A	25.4	19.1	0.30	
9	SimulatedDividedLite.THM	Therm	Vertical Divider	2.531	2.773	N/A	18.9	22.2	0.30	

Figure 8-31 Import the THERM file into the WINDOW ***Divider Library****.*

6. Use the new divider in the calculation of the complete product values in the main screen of WINDOW.

8.3.3. True Divided Lites

The criteria for when dividers are modeled can be found in *NFRC 100*, Section 1.4.4, "Simplifications to a Product Line". The discussion below describes the methodologies in WINDOW and THERM for modeling dividers when that criteria is met.

A true divided lite means that the dividers have separate glazing systems between the divider elements, as shown in the figure below.

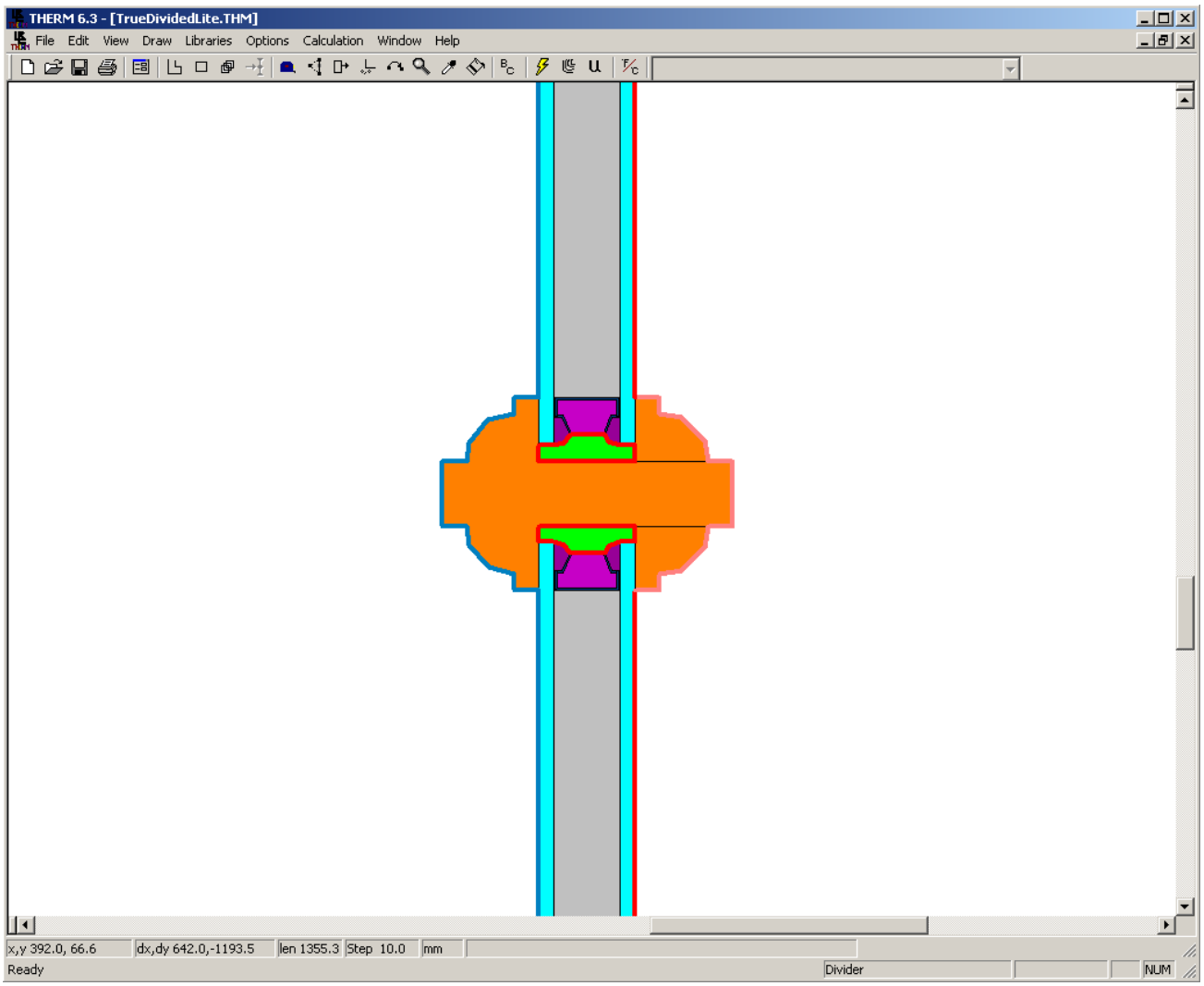


Figure 8-32. A true divided lite in THERM.

In THERM:

In this example, it is easier to start by drawing the polgyons that represent the divider, and then placing the glazing systems relative to those polygons.

1. Set the **Cross Section Type** to "Vertical Divider".
2. Draw the divider polygons as shown in the figure below.

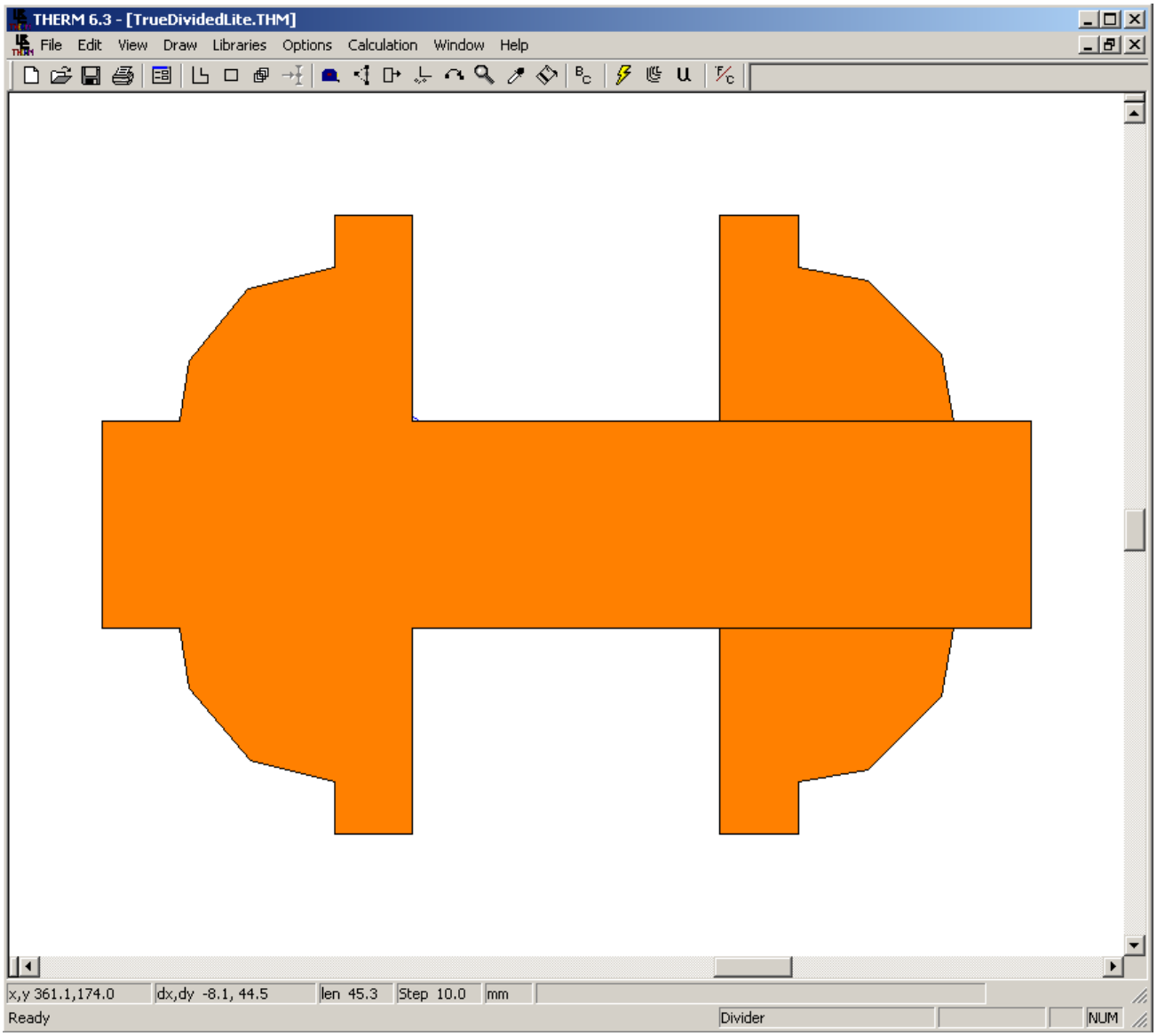


Figure 8-33. In THERM, draw the polygons for the divider elements that the glazing systems will fit into.

3. Import the first glazing system (in this case the top glazing system) for the divider, with the following settings:
   - Set the **Locator** in the appropriate location for where the glazing system will start, in this example 3.175 mm (0.125 inches) above the bottom of the divider
   - **Orientation** = Up
   - **Actual Cavity height** = 1000 mm (39 inches)
   - **Sight line to bottom of glass** = height of the divider (in this example it is 9.525 mm (0.375 inches)
   - **Spacer height** = height of the divider (in this example it is 9.525 mm (0.375 inches)
   - **Edge of Glass Dimension** = 63.5 mm (2.5 inches)
   - **Glazing System Height:** 150 mm (6.0 inches)
   - **Draw spacer** = Not checked

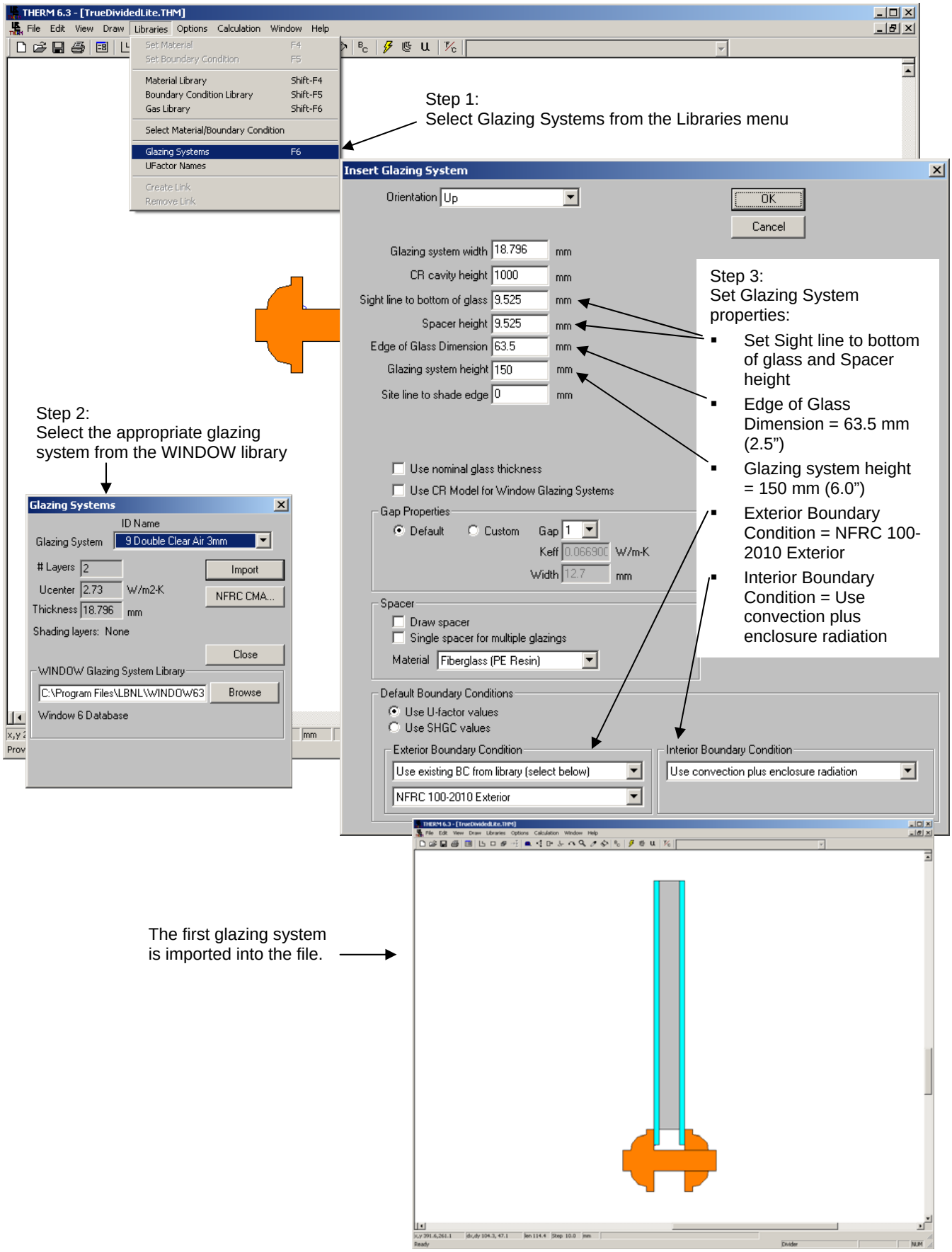


Figure 8-34. Import the first glazing system.

4. Import the glazing system again as an additional glazing system, facing down this time. Use the following settings for this glazing system:
   - Set the **Locator** in the appropriate location for where the glazing system will start, in this example 3.175 mm (0.125 inches) above the bottom of the divider
   - **Orientation** = Down
   - **Actual Cavity height** = 1000 mm (39 inches)
   - **Sight line to bottom of glass** = height of the divider (in this example it is 9.525 mm (0.375 inches)
   - **Spacer height** = height of the divider (in this example it is 9.525 mm (0.375 inches)
   - **Edge of Glass Dimension** = 63.5 mm (2.5 inches)
   - **Glazing System Height:** 150 mm (6.0 inches)
   - **Draw spacer** = Not checked

   Insert the glazing system as an **Additional Glazing**.

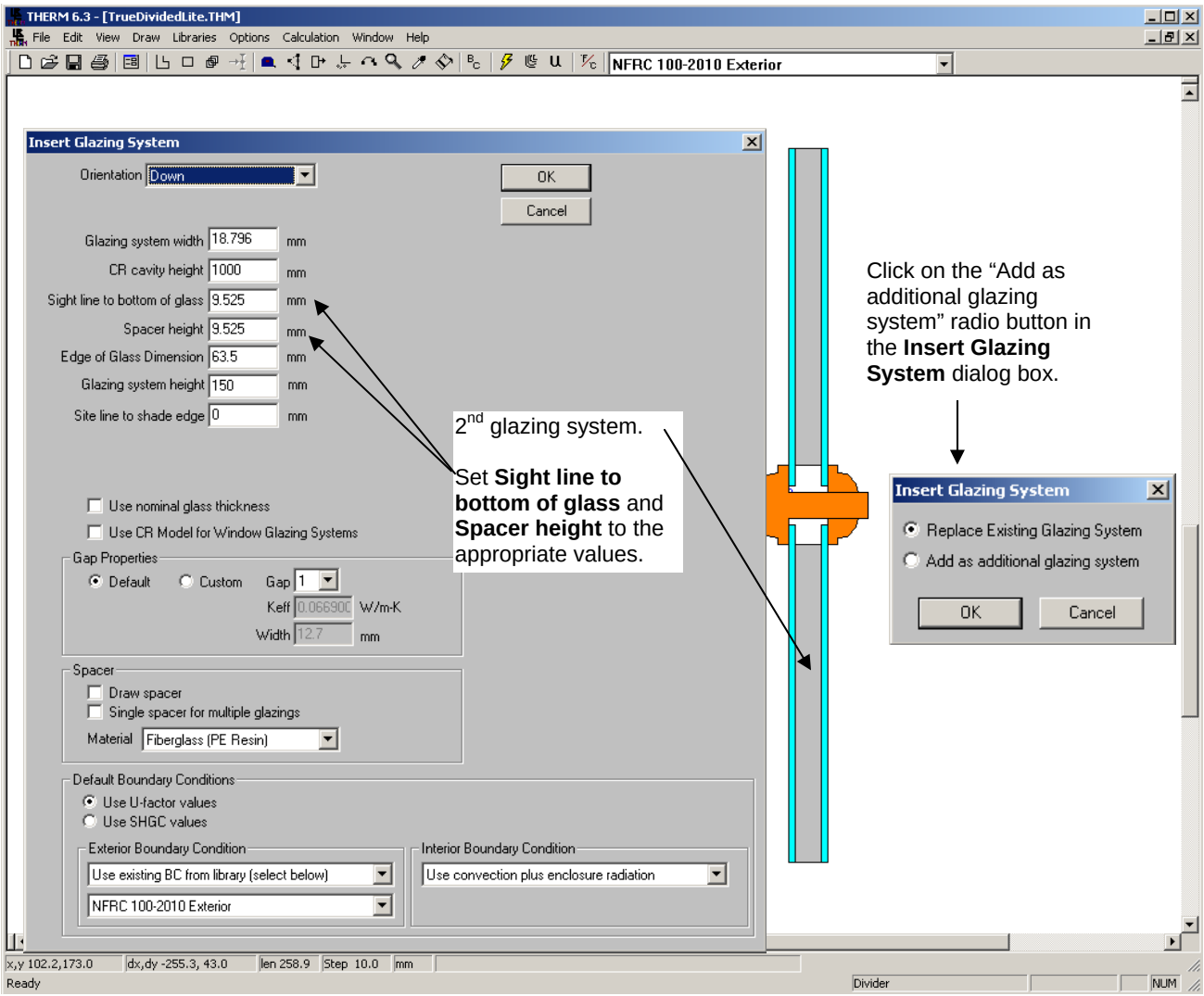


Figure 8-35. Import the second glazing system as an additional glazing system, facing down.

5. Add the spacers, sealants, desiccants, and frame cavities as appropriate.

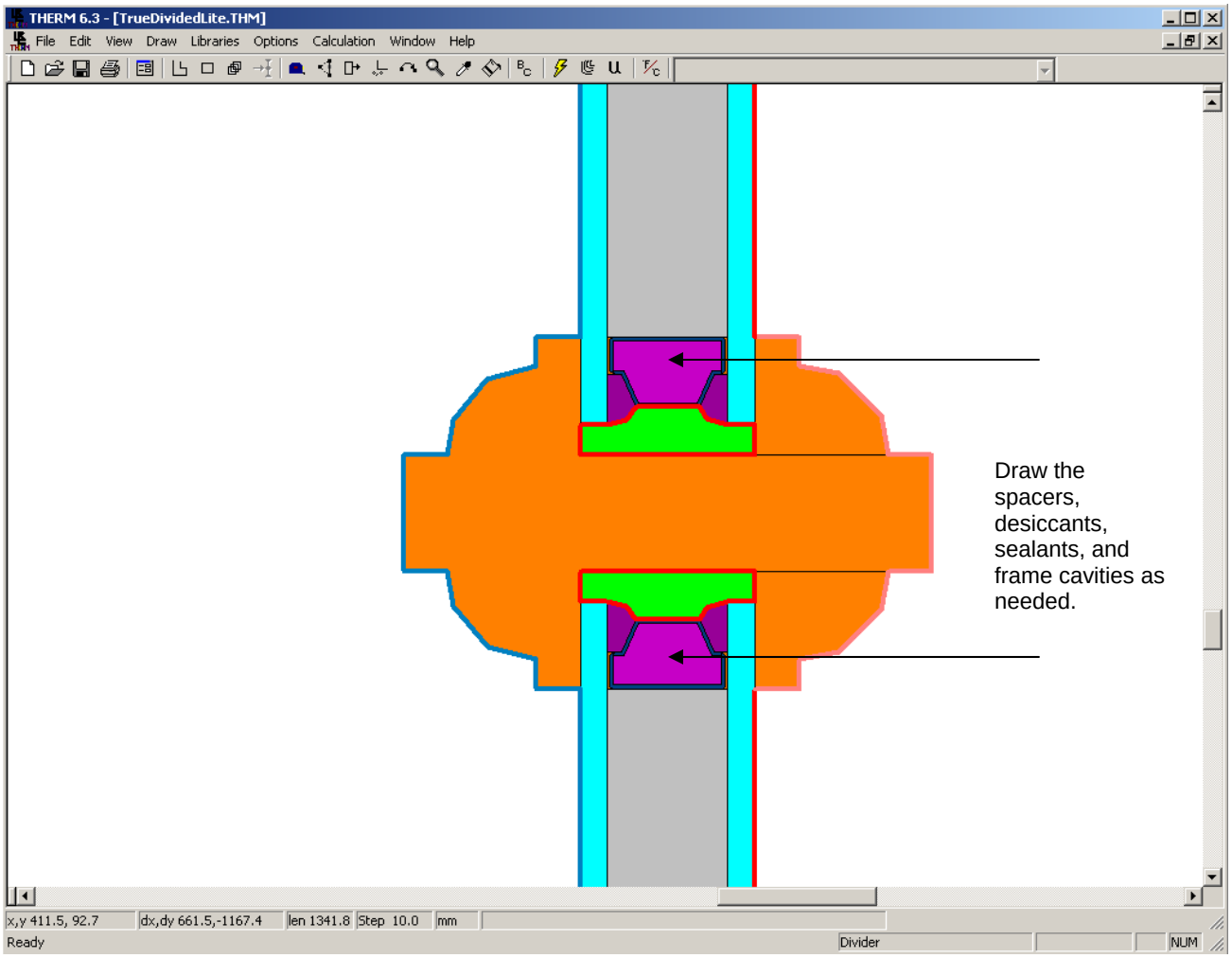


Figure 8-36. Draw the polygons to represent the divider.

6. Define the boundary conditions, using the "AutoEnclosure" choice for the Radiation Model.

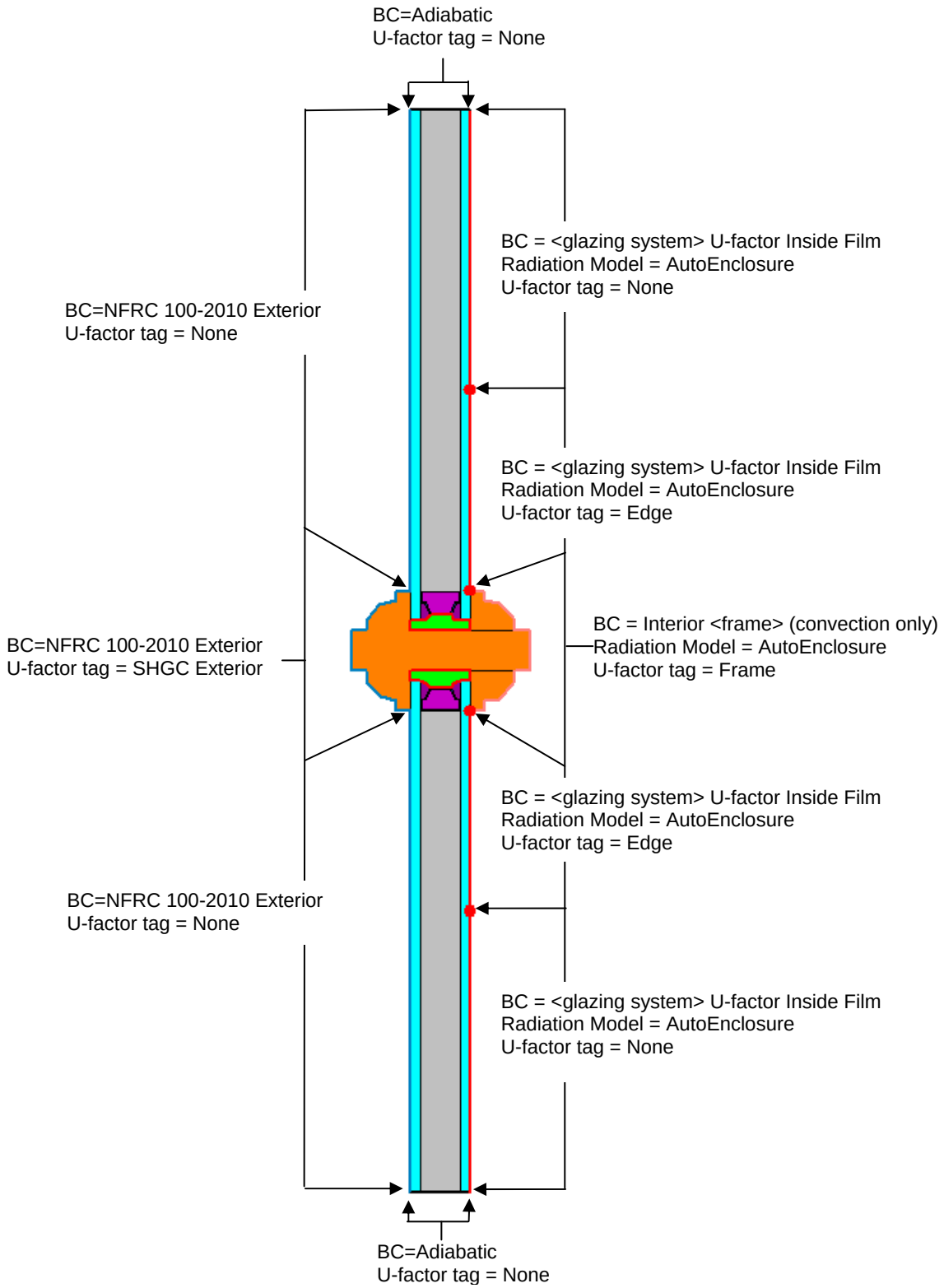


Figure 8-37. Assign the boundary conditions.

6. Calculate the results.

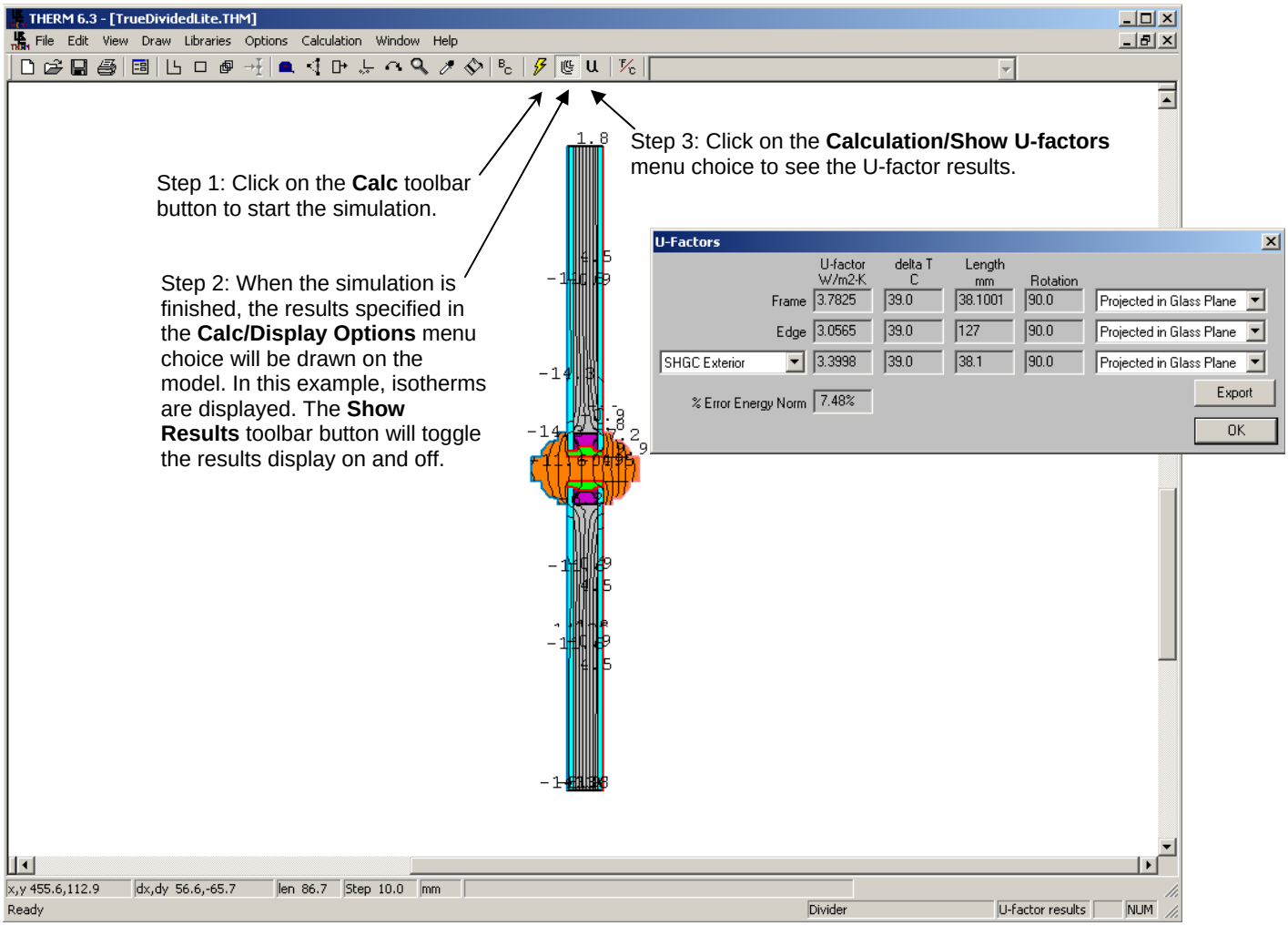
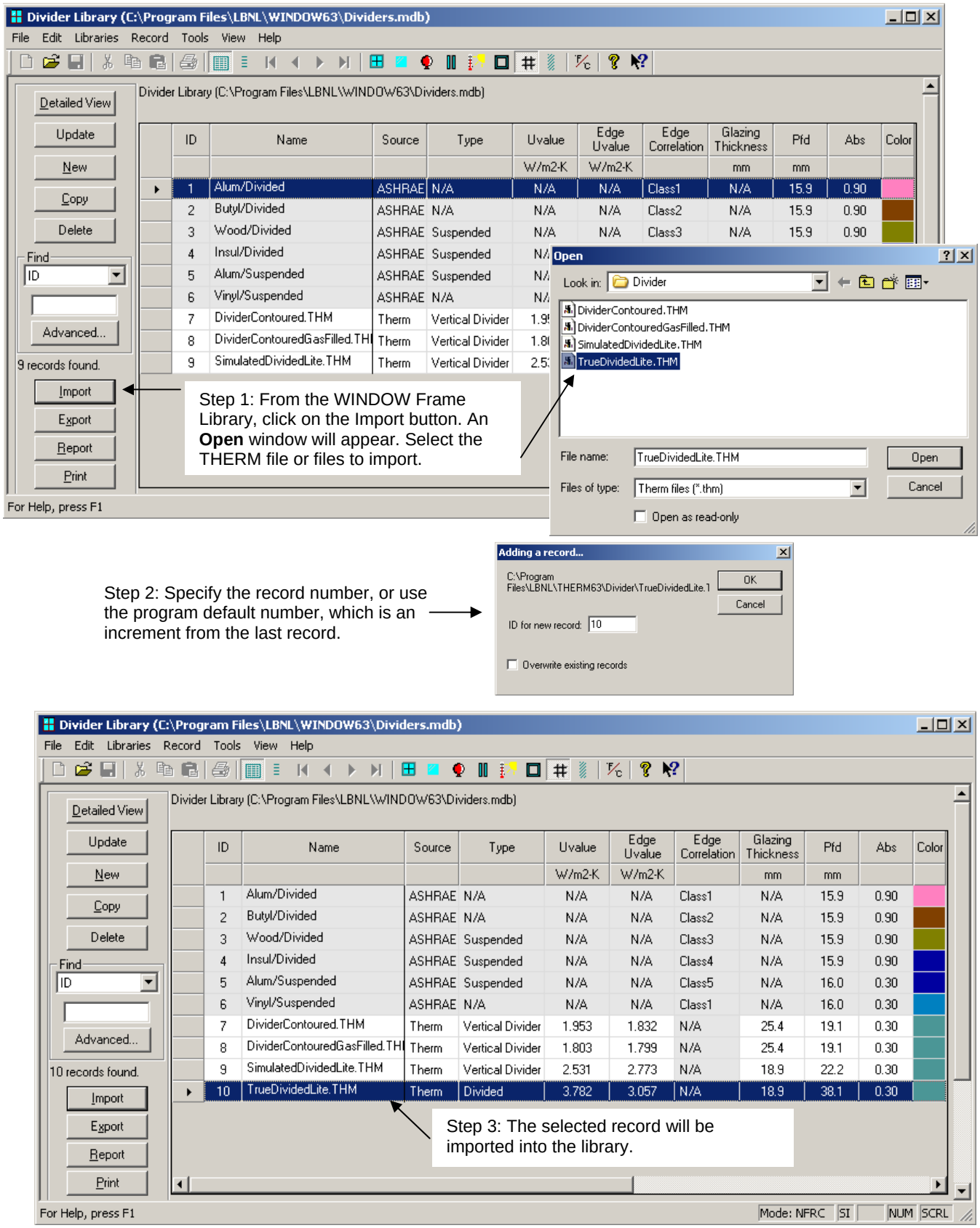


Figure 8-38. Calculate the results.

7. Save the file using the **File/Save As** menu choice.

8. Import the results to the WINDOW Divider Library, as shown below. See Section 4.7.3, "Importing THERM files" in the *WINDOW User's Manual* for more information about importing THERM files.



ID	Name	Source	Type	Uvalue	Edge Uvalue	Edge Correlation	Glazing Thickness	Pfd	Abs	Color
				W/m2-K	W/m2-K		mm	mm		
1	Alum/Divided	ASHRAE	N/A	N/A	N/A	Class1	N/A	15.9	0.90	
2	Butyl/Divided	ASHRAE	N/A	N/A	N/A	Class2	N/A	15.9	0.90	
3	Wood/Divided	ASHRAE	Suspended	N/A	N/A	Class3	N/A	15.9	0.90	
4	Insul/Divided	ASHRAE	Suspended	N/A	N/A	Class4	N/A	15.9	0.90	
5	Alum/Suspended	ASHRAE	Suspended	N/A	N/A	Class5	N/A	16.0	0.30	
6	Vinyl/Suspended	ASHRAE	N/A	N/A	N/A	Class1	N/A	16.0	0.30	
7	DividerContoured.THM	Therm	Vertical Divider	1.953	1.832	N/A	25.4	19.1	0.30	
8	DividerContouredGasFilled.THM	Therm	Vertical Divider	1.803	1.799	N/A	25.4	19.1	0.30	
9	SimulatedDividedLite.THM	Therm	Vertical Divider	2.531	2.773	N/A	18.9	22.2	0.30	
10	TrueDividedLite.THM	Therm	Divided	3.782	3.057	N/A	18.9	38.1	0.30	

Figure 8-39. Import the THERM file into the WINDOW ***Divider Library****.*

9. Use the new divider in the calculation of the complete product values in the main screen of WINDOW.

8.3.4. Door Caming

When modeling glazing options with caming, which are treated in a similar fashion to dividers, the NFRC default caming can be used. The flat caming (H-Bar) shall be used as the default shape. Brass conductivity and emissivity, per NFRC 101, Appendix B, shall be used as the default material. The caming drawing DXF file is available from the NFRC website.

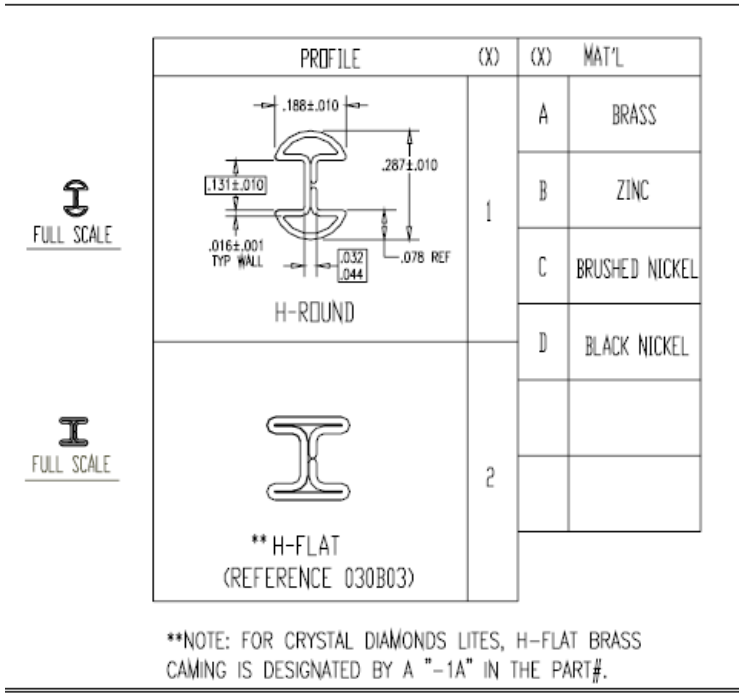


*Figure **8-40**. Standardized Caming Drawing*

In THERM:

In this example, which represents an intermediate pane in an IG unit with caming, it is easier to start by drawing the polgyons that represent the divider, and then placing the glazing systems relative to those polygons.

1. Set the **Cross Section Type** to "Vertical Divider".
2. Draw the caming polygons.

3. Insert the first glazing system (in this case the top glazing system which is a triple glazed unit made in WINDOW) for the divider, with the following settings:
   - Set the **Locator** in the appropriate location for where the glazing system will start
   - **Orientation** = Up
   - **Actual Cavity height** = 1000 mm (39 inches)
   - **Sight line to bottom of glass** =0
   - **Spacer height** = 0
   - **Edge of Glass Dimension** = 63.5 mm (2.5 inches)
   - **Glazing System Height:** 150 mm (6.0 inches)
   - **Draw spacer** = Not checked

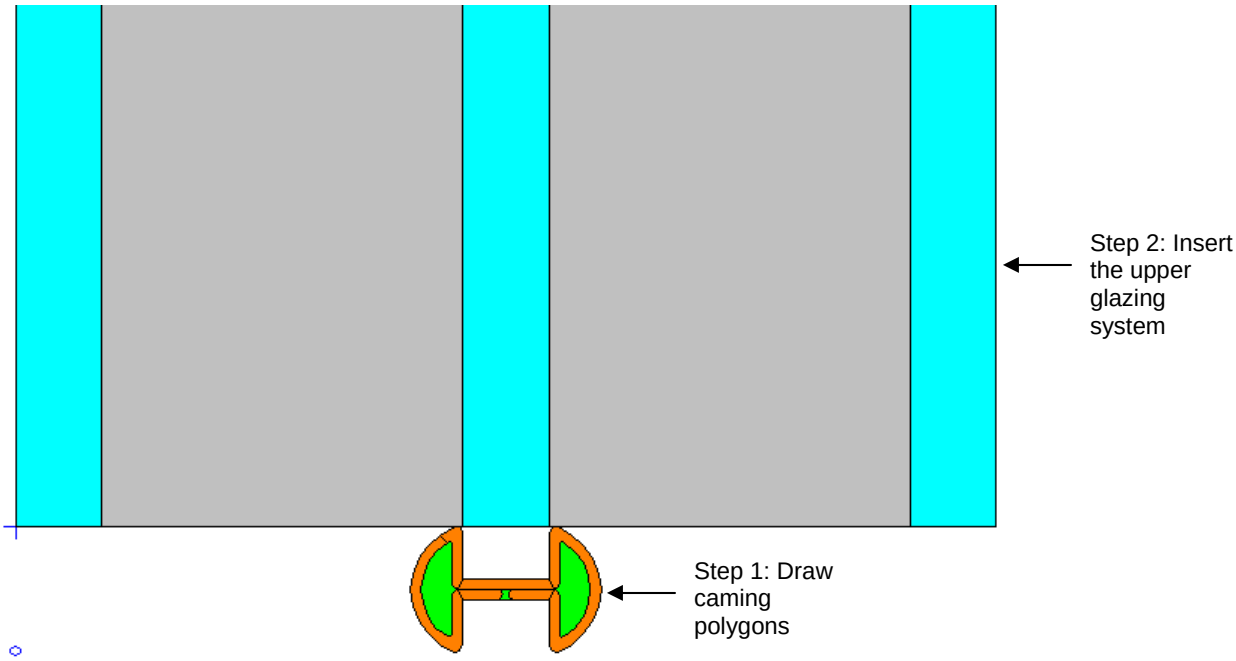


*Figure **8-41**. Draw the caming polygons and insert the upper glazing system*

4. Insert the second glazing system, with the following settings, and click the "Add as additional glazing system" radio button upon insert.
   - Set the **Locator** in the appropriate location for where the glazing system will start
   - **Orientation** = Down
   - **Actual Cavity height** = 1000 mm (39 inches)
   - **Sight line to bottom of glass** =0
   - **Spacer height** = 0
   - **Edge of Glass Dimension** = 63.5 mm (2.5 inches)
   - **Glazing System Height:** 150 mm (6.0 inches)
   - **Draw spacer** = Not checked

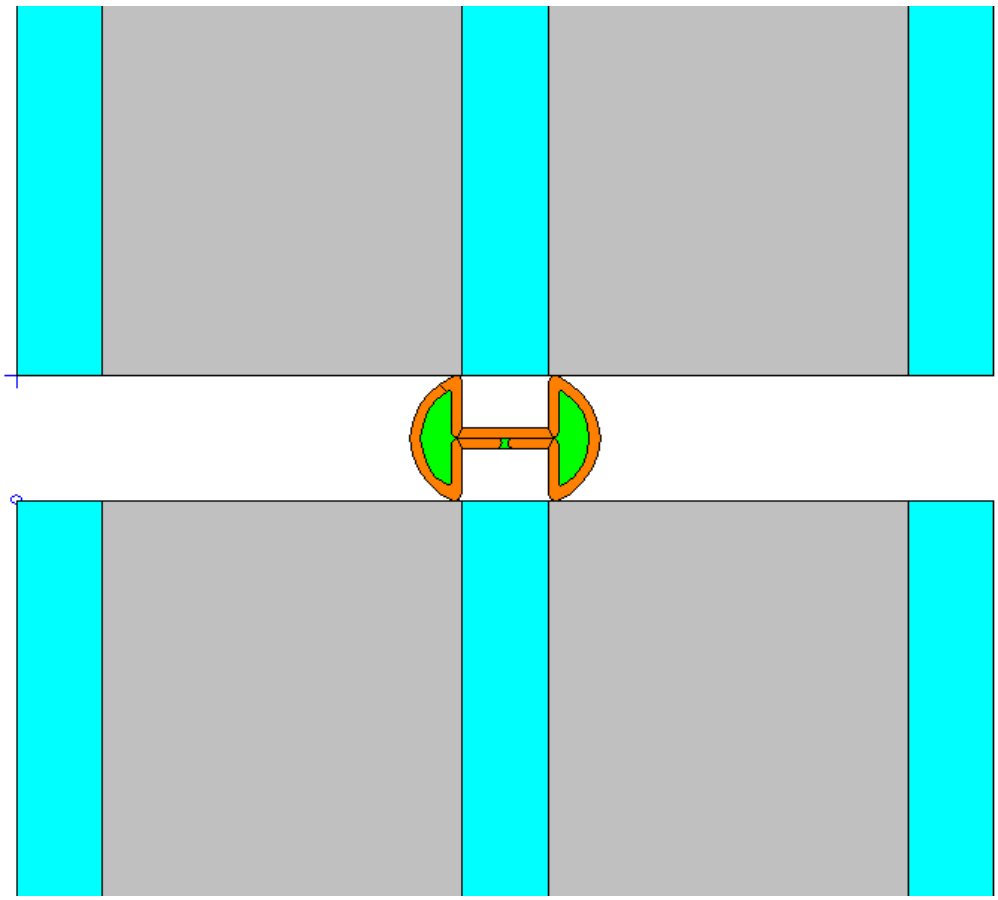


*Figure **8-42**. Insert the lower glazing system*

5. From the Options menu, select Preferences, then click on the Drawing Options tab and check "Allow editing of IG polygons" so that the glazing system geometry can be modified.
6. For both the upper and lower glazing systems, move the points of the center glass layer into the caming, as showin in the figure below.

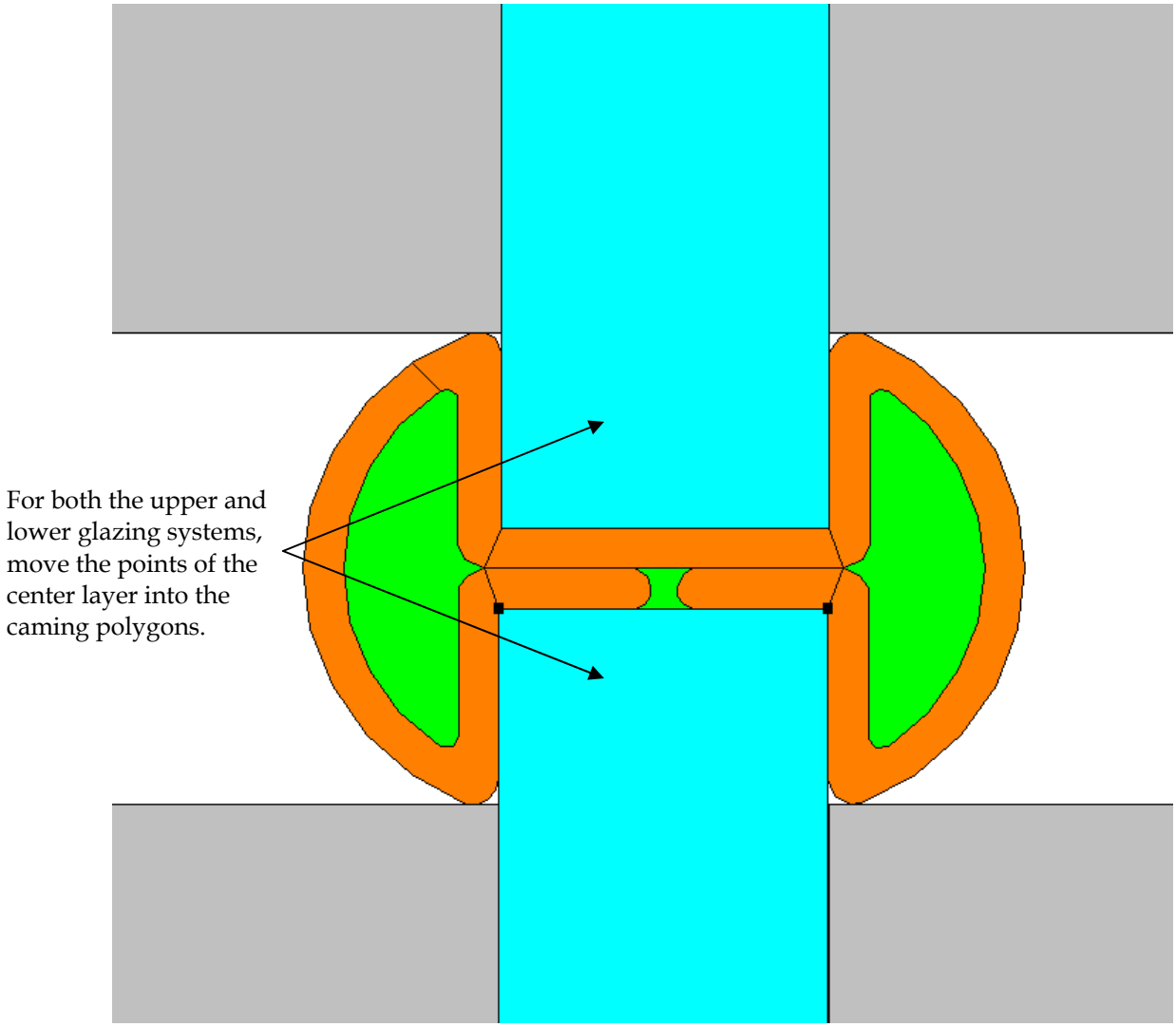


*Figure **8-43**. Move the points of the middle layer of the upper and lower glazing systems into the caming.*

7. For the either the upper or lower glazing system, move the points of the outer layers to meet the other glazing system, to enclose the IG.

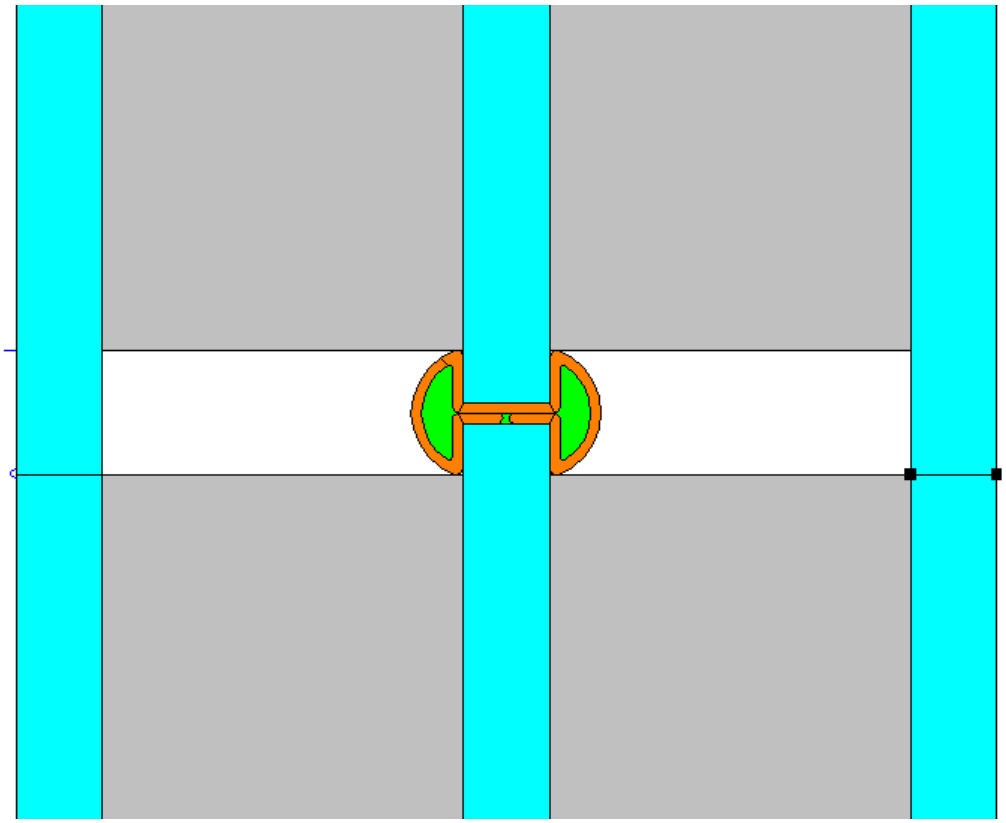


*Figure **8-44** Move the points of either the outside layers of either the upper or lower glazing system to meet the other glazing system, to enclose the IG*

8. If the IG Unit is air-filled, then fill the cavities with NFRC Frame Cavity 100, assign the normal boundary conditions, and simulate as usual. If the IG unit if gas-filled, follow the procedures for gas filling a divider per Section 8.3.1.3.

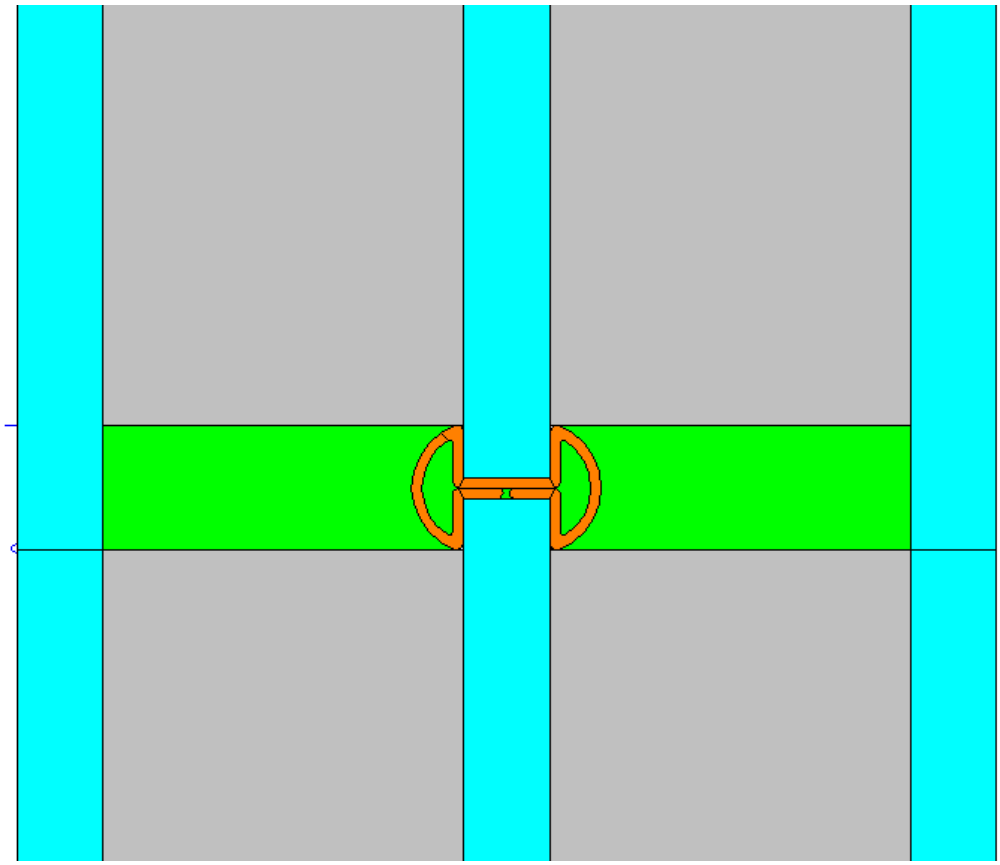


*Figure **8-45** Fill the cavities with Frame Cavity NFRC 100*

8.4 Storm Windows

Storm windows present a modeling problem different from most insulated glass (IG) units, because the spacing between the IG unit and the storm window is usually quite large, as shown in the figure below. As with all other product modeling, all relevant cross sections (head, sill, jambs, meeting rails and dividers) must be modeled in THERM.

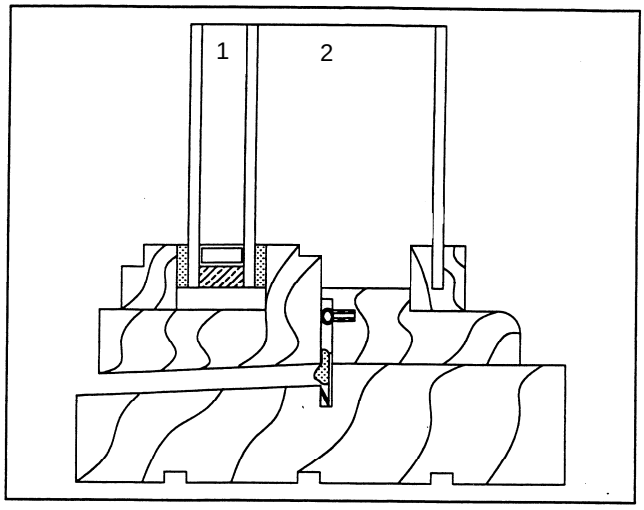


Figure 8-46 Product with an interior storm window.

8.4.1. Modeling Steps

The following steps can be used to model storm windows. These steps are discussed in more detail in the following sections.

If the product is *NOT* a single or double hung (i.e., it is a casement, fixed, picture, transom, awning, etc), do the following:

In WINDOW:

- Create a three-layer glazing system with the correct spacing between each of the glass layers in WINDOW.

In THERM

- Draw the frame components for the product in THERM.
- Import the glazing system into THERM
  Edge of Glass Dimension = 63.5 mm (2.5 inch)
  Glazing System Height = 150 mm (6.0 inch).
- Fill the air cavity below the glazing system and use the Library/Create Link feature to link that air cavity to the glazing cavity.
- Assign the boundary conditions
  Exterior Boundary Condition = **Use existing BC from library,** select "NFRC 100-2001 Exterior", and assign the **SHGC Exterior** U-factor tag to the exterior frame components
  Interior Boundary Condition = Use "convection plus enclosure radiation" for Glazing System, use appropriate "convection only" frame boundary condition for the frame components.
- Simulate the problem

If the product *IS* a hung or sliding window (i.e., a vertical or horizontal slider), where there will be a different gap width between the glazing system and the storm window for different frame profiles, do the following:

In WINDOW:

- Before starting the program, open the W6.INI file (usually found in the operating system directory – for example, in Microsoft Windows XP, that directory is c:\windows) and add the following line (if it does not already exist):
  - FrameToleranceGlazingSystemThickness=5

  Note: it is all one word, no spaces, and that it can go anywhere in the INI file. If this line already exists, but has some other value other than "5", change the value to "5". This represents the percentage tolerance between the frame and glazing system thickness. Setting it to one makes the thickness tolerance checking 500%, which should disable the WINDOW thickness tolerance checking, and therefore allowing the program to perform a calculation with glazing systems of different thicknesses.
- Create the two glazing systems with the actual thicknesses between the glazing system and the storm window, which will fit into the frame profiles that will be modeled in THERM.

In THERM

- Draw the frame components for the product in THERM.
- Import the glazing systems with the actual gap widths into the appropriate frame profiles with the following settings:
  Edge of Glass Dimension = 63.5 mm (2.5 inch)
  Glazing System Height = 150 mm (6.0 inch).
- Fill any air cavity between the bottom of the glazing system and the top of the frame profile as necessary, and use the Library/Create Link feature to link that air cavity to the glazing cavity.
- Assign the boundary conditions
  Exterior Boundary Condition = **Use existing BC from library,** select **"**NFRC 100-2001 Exterior", and assign the **SHGC Exterior** U-factor tag to the exterior frame components
  Interior Boundary Condition = Use "convection plus enclosure radiation" for Glazing System, use appropriate "convection only" frame boundary condition for the frame components.
- Simulate each model.

In WINDOW:

- Import the THERM frame profiles that have the correct geometry for the glazing systems into the Frame Library.
- In the Window Library, create the window, referencing the matching frames and glazing systems, including the meeting rail (you cannot "match" the glazing system thicknesses in the meeting rail, so just reference it).
- Calculate the overall product values from this combination of components.
- Close the program, open the W6.ini file, and do the following:
  - Delete the line FrameToleranceGlazingSystemThickness=5

  Or

  - Put a semicolon ";" in front of it which keeps it in the file, but makes it a comment instead of a command. This way it will be there the next time you need to use it.

    ; FrameToleranceGlazingSystemThickness=5

8.4.2. Storm Window Example

The following example problem, based on the product in Figure 8-23, is explained in detail in the following discussion.

8.4.2.1. Create Glazing System in WINDOW:

1. Make a glazing system consisting of three layers of glass, with the dimensions of the glazing cavity for the first gap, and the correct dimension from the glass to the storm window for the second gap.

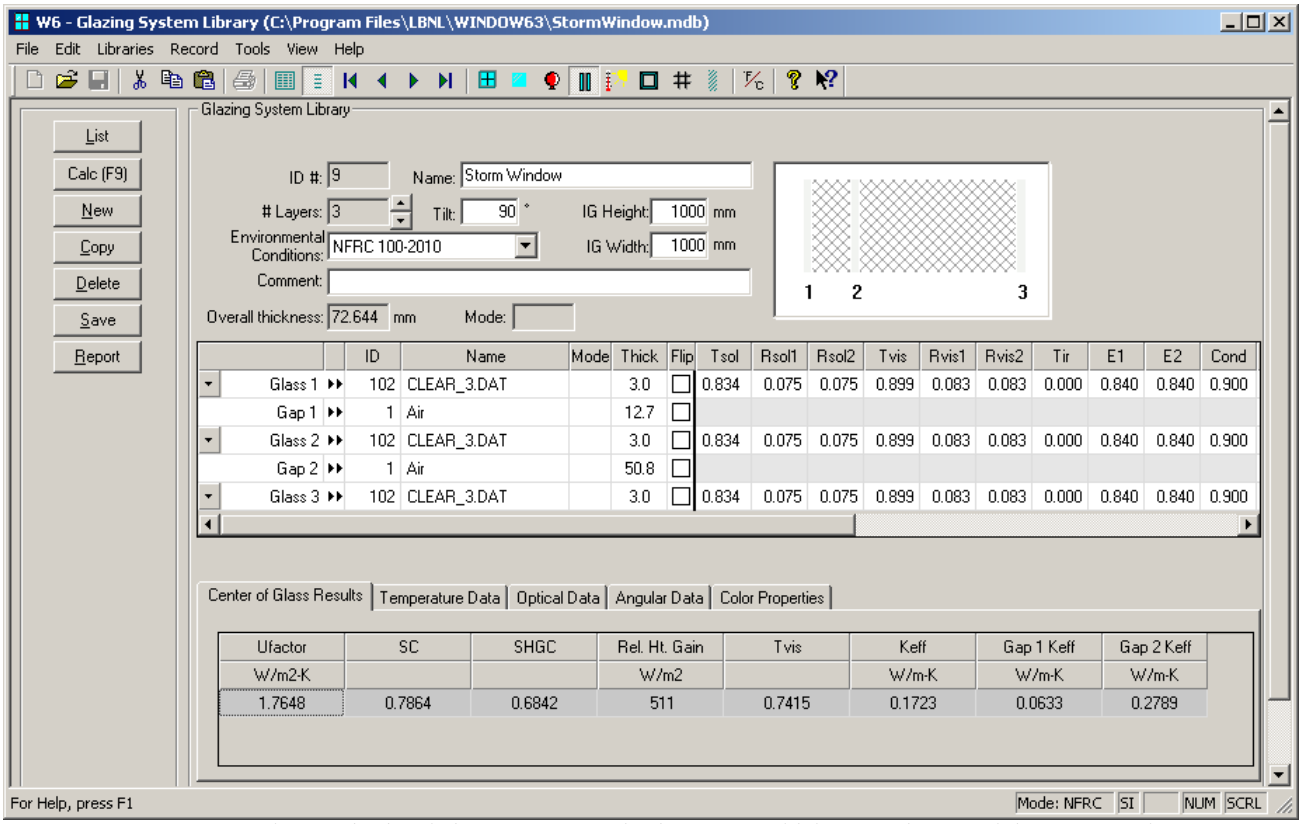


Figure 8-47 Make a triple glazed glazing system with a large gap width between the IG and the storm window.

8.4.2.2. Calculate U-factor in THERM

The steps for importing the glazing system into THERM are explained in more detail below.

1. Draw the required frame cross sections (such as head, sill, jambs, meeting rails, and dividers)
2. From the **File/Properties** menu, select the appropriate **Cross Section Type**, such as "Sill", "Head", "Jamb", and so forth.
3. Import the glazing system with the correct storm window cavity dimensions (created in WINDOW), in this case the glazing system with the 2" gap.
   Edge of Glass Dimension = 63.5 mm (2.5 inch)
   Glazing System Height = 150 mm (6.0 inch).
   Exterior Boundary Condition = **Use existing BC from library**, select "NFRC 100-2010 Exterior"
   Interior Boundary Condition = **Use convection plus enclosure radiation** for glazing system, and appropriate "convection only" boundary condition for the interior frame components.

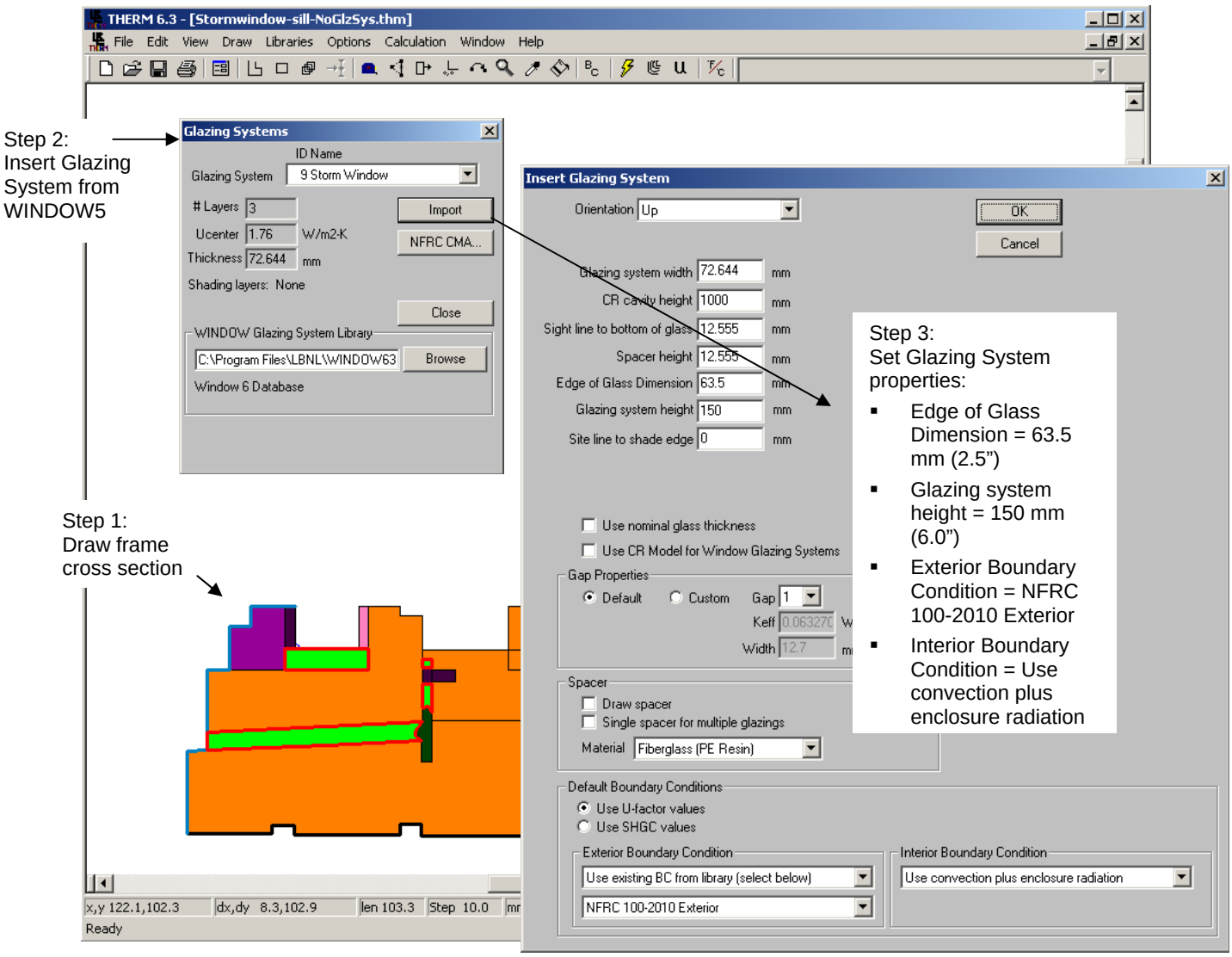


Figure 8-48 Insert the glazing system.

4. If necessary (as in this example because there is a gap between the bottom of the glazing cavity and the frame),use the material linker to create a separate polygon and link the properties to the 2″ glazing cavity.

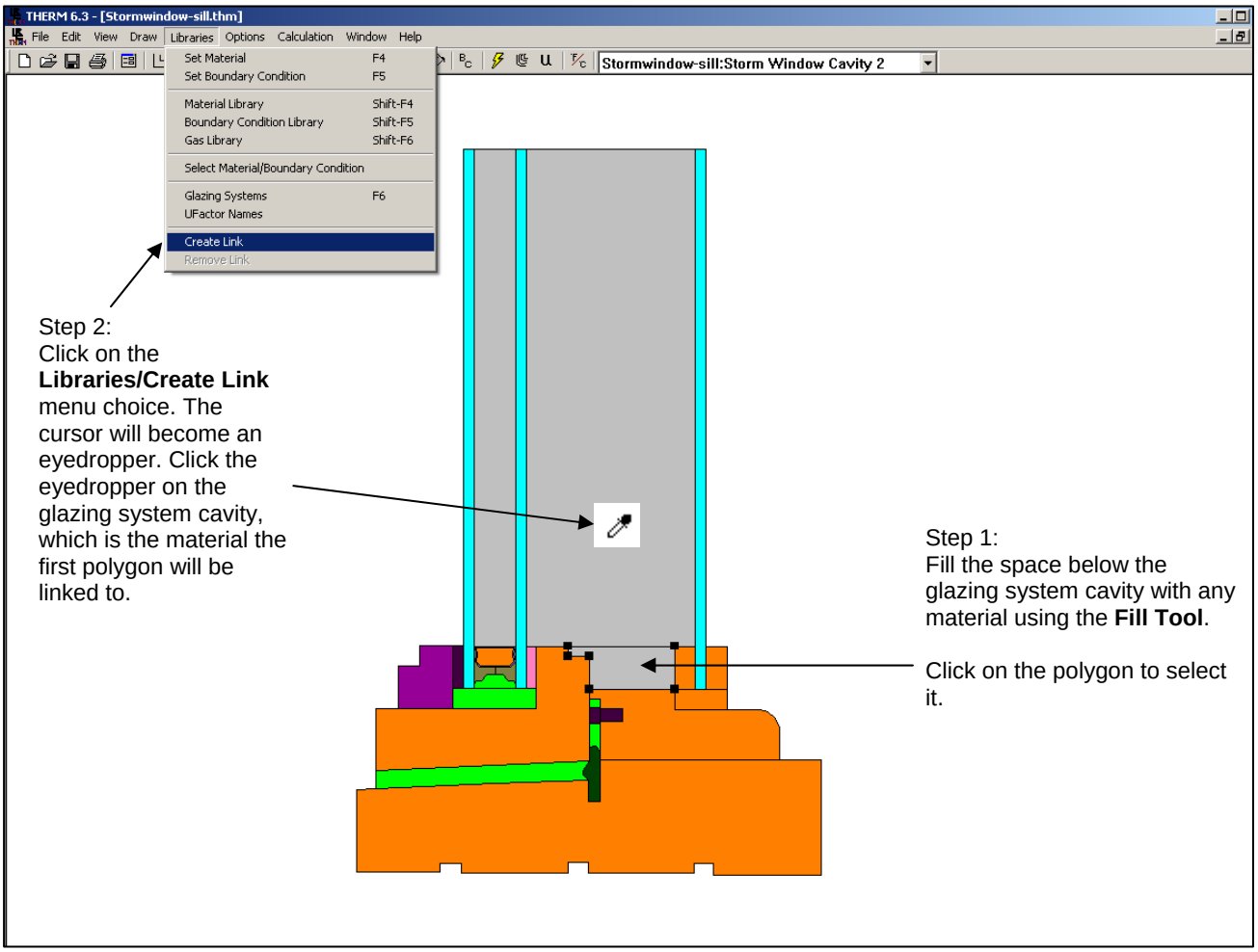


Figure 8-49 If needed, create a material link between the glazing system cavity.

5. Generate the **Boundary Conditions** by pressing the **BC** toolbar button. The figure below shows the boundary conditions for one storm window cross section. Make sure that the interior boundary conditions have the Radiation Model set to "AutoEnclosure".

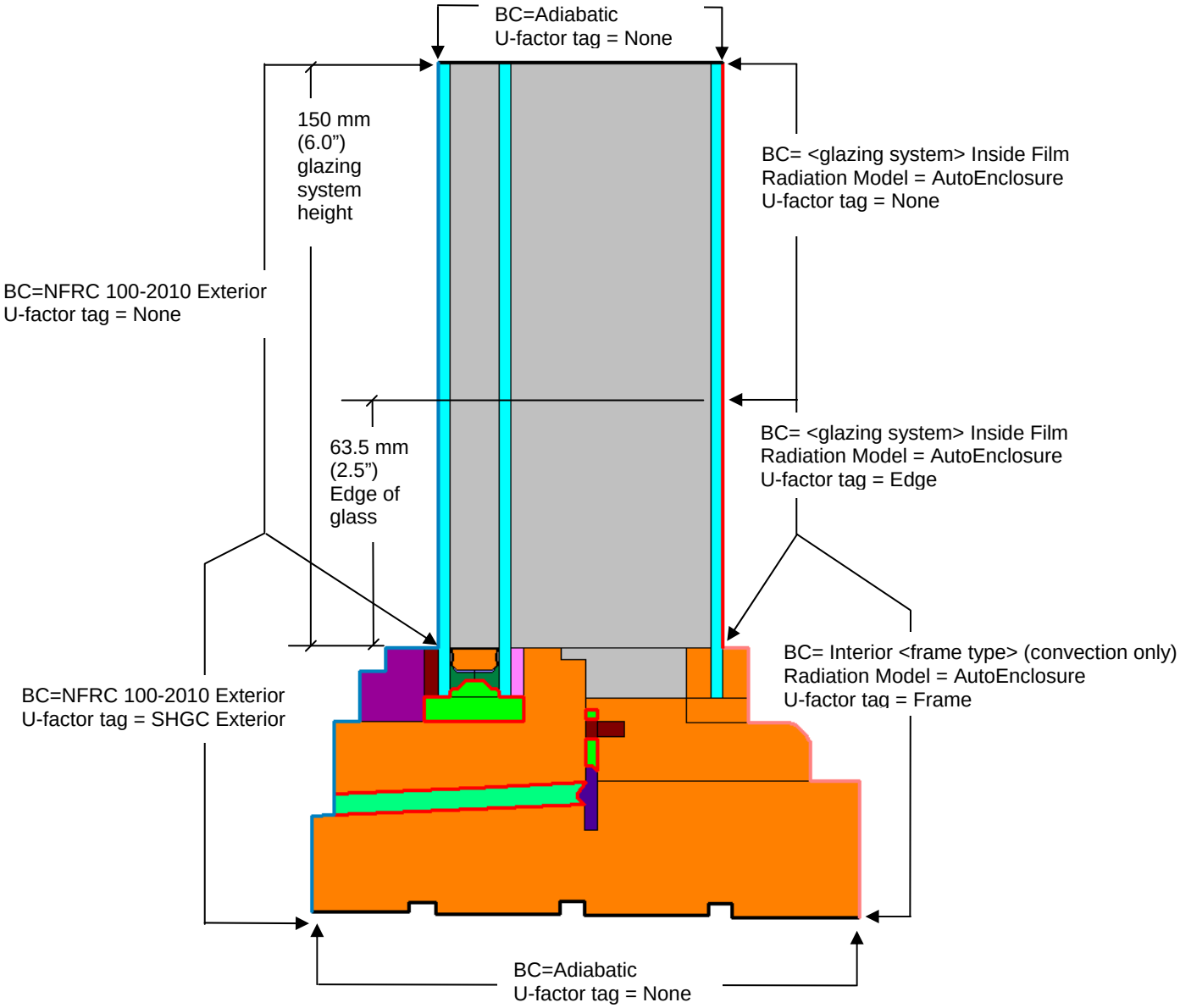


Figure 8-50 Define the boundary conditions.

6. Simulate the problem and save the file.

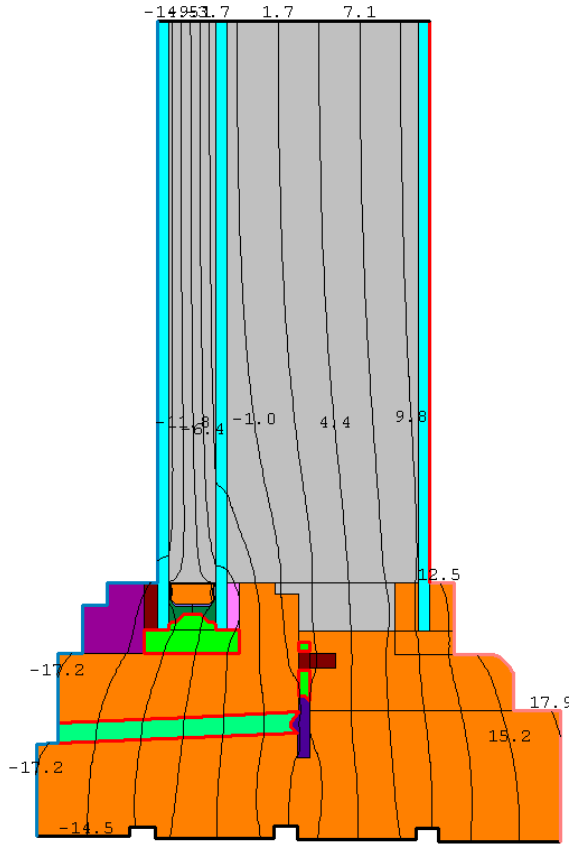


Figure 8-51 Simulate the file.

8.4.3. Steps for Storm Window Condensation Resistance Calculation

The Condensation Resistance model is only appropriate for *horizontal* frame components such as Head and Sill elements – THERM will not calculate the Condensation Resistance for a file with the **Cross Section Type** set to "Jamb" or "Vertical Meeting Rail".

There are two methods for calculating the Condensation Resistance information in THERM, which will be used in WINDOW to calculate the total Condensation Resistance of the product:

- Check the "Use CR Model for Window Glazing System" checkbox when importing a glazing system

  OR

- In the **Options** menu, **Preferences** choice, **THERM File Options** tab, check the "Use CR Model for Glazing Systems", as shown in the figure below.

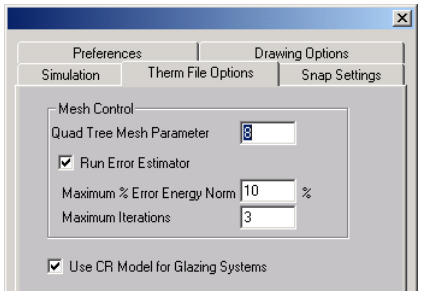


Figure 8-52 In Options/Preferences/Therm File Options, check the "Use CR Model for Glazing Systems" checkbox.

When the CR model has been "turned on", red boundary conditions will appear inside the glazing system, and the following steps should be taken to simulate the file:

1. Check the emissivities of these boundary conditions. They should be the following:
   - Emissivity of the surrounding surface, such as 0.84 for standard glass, 0.90 for painted metal and most other frame materials, 0.20 for mill finish metal, and so forth.
   - 1.0 for the adiabatic (open end) of the glazing cavity.
2. Simulate the model. The program will calculate both U-factor results and the Condensation Resistance results if the CR model is checked.
3. Import the results into the WINDOW **Frame Library** and use the file to create the whole product in the **Window Library** as applicable.

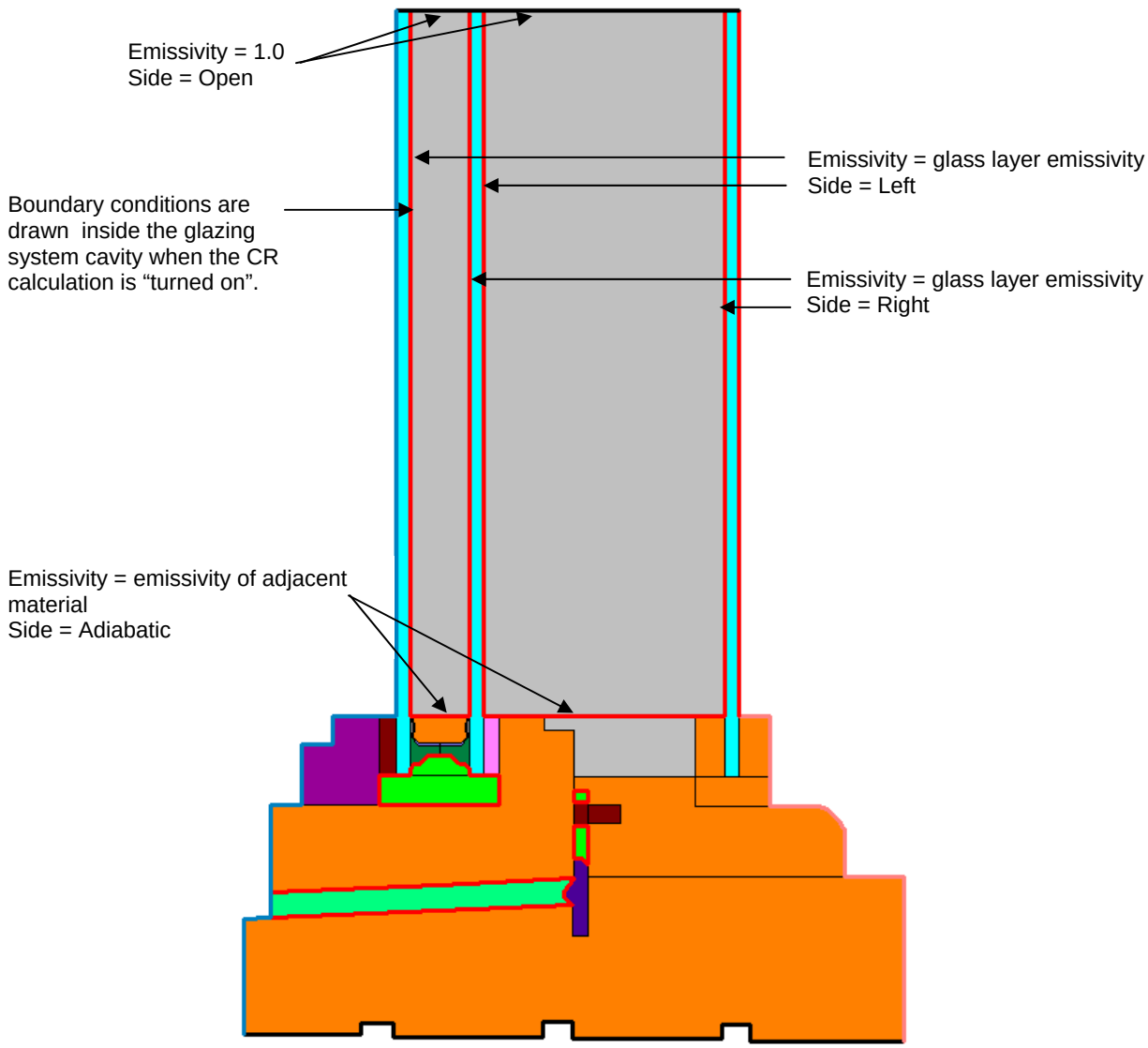


Figure 8-53 Red boundary conditions will appear inside the glazing system when the CondensationResistance option is turned on. Check the emissivities of each boundary condition.

8.4.3.3. Calculate the Total Product Values in WINDOW

The following discussion explains how to model the whole product values for the storm window in WINDOW.

- Import the THERM files into the WINDOW **Frame Library**.

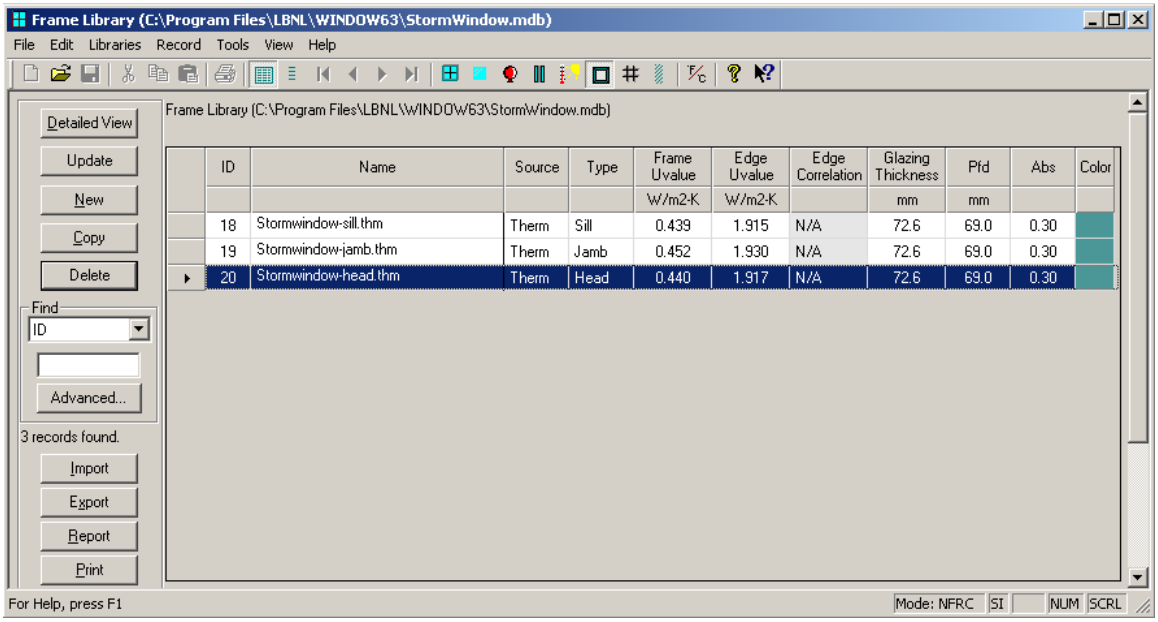


Figure 8-54 Import the storm window THERM files .

- In the WINDOW **Window Library**, construct the storm window from the THERM files and the glazing system previously defined, and calculate the total product values.

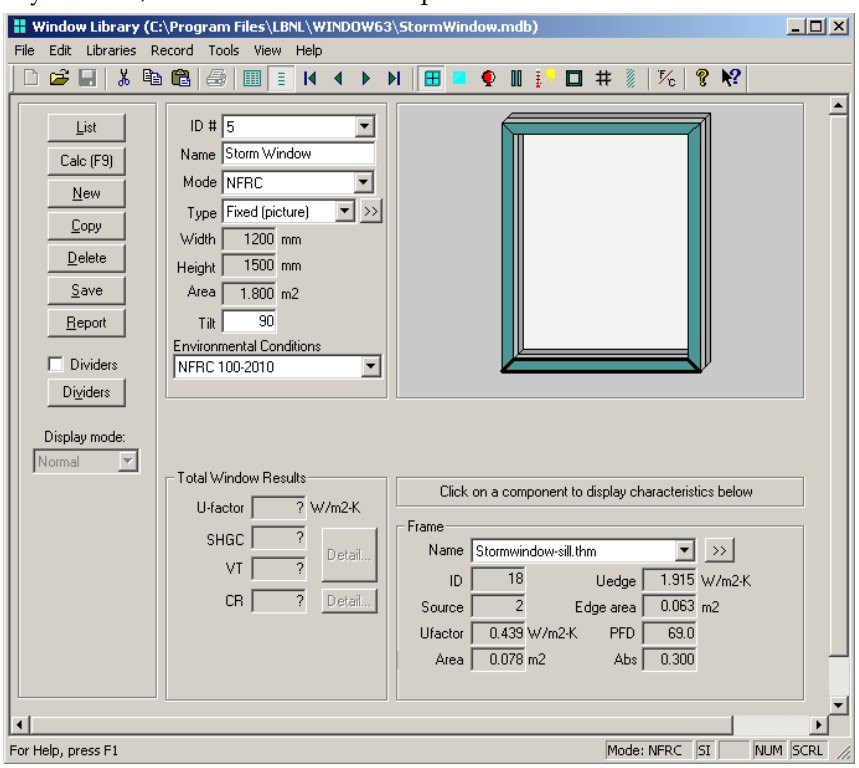


Figure 8-55 Storm window created in the Window Library to obtain total product results.

8.5 Skylights

This section discusses the modeling procedures for skylights, which are modeled in sections in a similar manner to other products. In addition, in accordance with *NFRC 100*, skylights are modeled at a 20° slope from horizontal.

8.5.1. Skylight Modeling Steps

The steps for modeling a skylight are as follows:

In WINDOW:

- Create the skylight glazing system in WINDOW:
  - Set **Tilt** to "20" degrees

In THERM:

- Draw the required frame cross sections in THERM, for example a head, sill, and jambs if they are all different, untilted. Because the tilt of the jambs will be in the z-direction, which is not possible to display in the two dimensional viewing of THERM, they will be drawn vertically and the gravity vector oriented properly to reflect the tilt in the z-direction.
- Do not use the Condensation Resistance Model on any of the THERM skylight cross sections. WINDOW will calculate the CR value based on the temperatures from the U-factor results. (Even if the THERM cross sections are modeled with CR enabled, WINDOW will use the U-factor temperature results rather than the CR temperature results when calculating the whole product CR value).
- Set the **Cross Section** value in **File/Properties** as follows:
  - For **Sill**: set **Cross Section** to "Sill", **Gravity Vector** should face "Down"
  - For **Head:** set **Cross Section** to "Head", **Gravity Vector** should face "Down"
  - For **Jambs:** set **Cross Section** to "Sill", set **Gravity Vector** to "Right"
- The Frame Cavity height is not used by the program for the skylight cross sections, as long as the Types are defined properly as shown above, so the default value of 1000 mm can be left unchanged.
- Insert the glazing system from WINDOW into the frame cross sections with the **Edge of Glass Dimension** field set to 150 mm (6.0 inches). The **CR cavity height** field can be set to any value (you can leave it set to the default of1000 mm) because the U-factor temperatures not the CR temperatures will be used in WINDOW to calculate the overall CR value).
  - Insert the **Sill** glazing system with orientation up
  - Insert the **Head** glazing system with orientation down
  - Insert the **Jamb** glazing system with orientation up
- Assign the boundary conditions. Interior Boundary conditions have the following settings:
  - **Radiation Model** set to "AutoEnclosure"
  - **Frame Boundary Conditions:** set to the appropriate "Interior (20 tilt) …" choices
- Tilt the cross section 20 degrees from horizontal:
  - For a **Sill** or **Head**, rotate the entire model 70 degrees clockwise
  - For **Jambs**, do not rotate the model at all

- Simulate the skylight cross sections and save them.
- View the U-factor for the cross section, and make sure the "Projected in Glass Plane" is selected from the Projection pulldown list, as shown in the figure below. This will ensure that the projection will be correct for the tilted cross section.

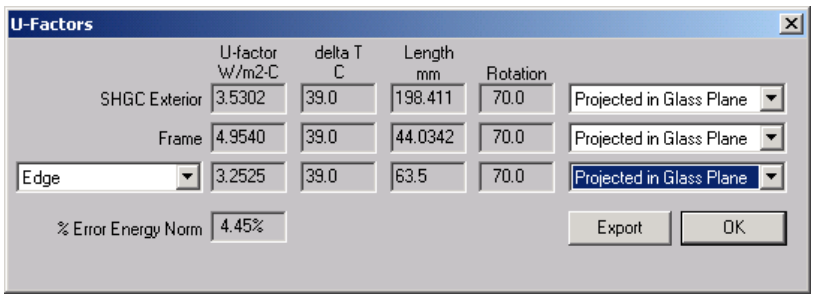


Figure 8-56 Make sure the "Projected in Glass Plane" projection option is selected for the tilted cross section.

There is a circumstance where THERM will not calculate the total frame length correctly, and it is necessary to enter a "Custom Frame Length" into the U-factor dialog box above. It occurs when a section of an adiabatic boundary "overlaps" a boundary with a U-factor tag in the projected dimension over which the length is being calculated. This is explained in detail in Chapter 6, Section 6.6.6.

- Import the components into the WINDOW Frame Library (and Divider Library if appropriate)
- Construct the whole product in the WINDOW Window Library to get the overall product results.

8.5.2. Skylight Mounting Details

There are two ways that skylights can be mounted into a roof system, either flush-mounted (also called inset-mounted) or curb-mounted. The figures below show these two different mounting styles. Each mounting style has a slightly different definition of the adiabatic boundary condition, and each will have a different projected frame length. The rules for modeling can be found in *NFRC 100* and the NFRC Technical Interpretations. To model curb mounted skylights, if the projected frame height is zero, define a Frame U-factor Surface Tag 0.25 mm (0.01 inches) up the interior of the glass, which will result in a non-zero frame height.

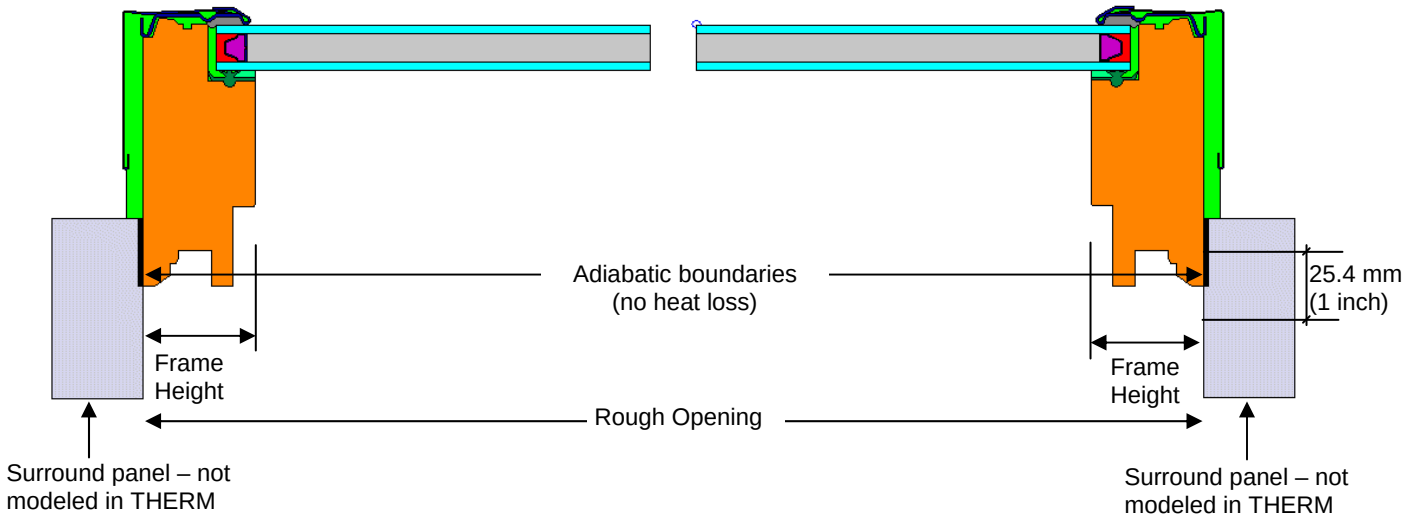


Figure 8-57 A flush-mounted (or inset-mounted) skylight.

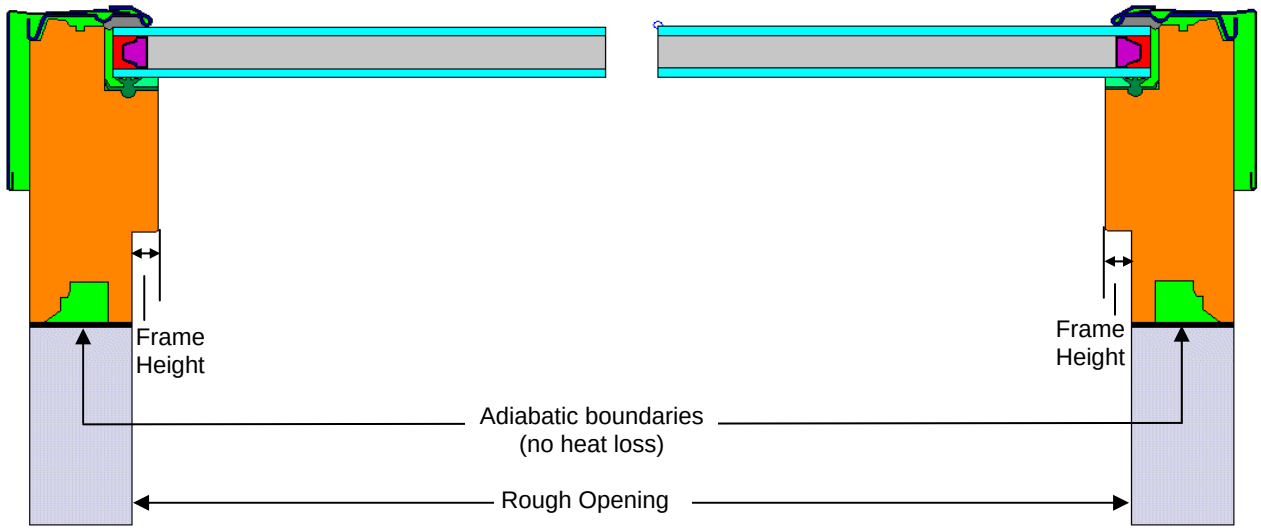


Figure 8-58 A curb-mounted skylight.

8.5.3. Example Flush Mounted Skylight Problem

This example assumes a flush-mounted skylight.

In WINDOW:

1. **Glazing System Library:** Make a glazing system with a tilt of 20° off horizontal. In this example, the glazing system is called **Skylight Double Glz** and is made up of generic glass layers.

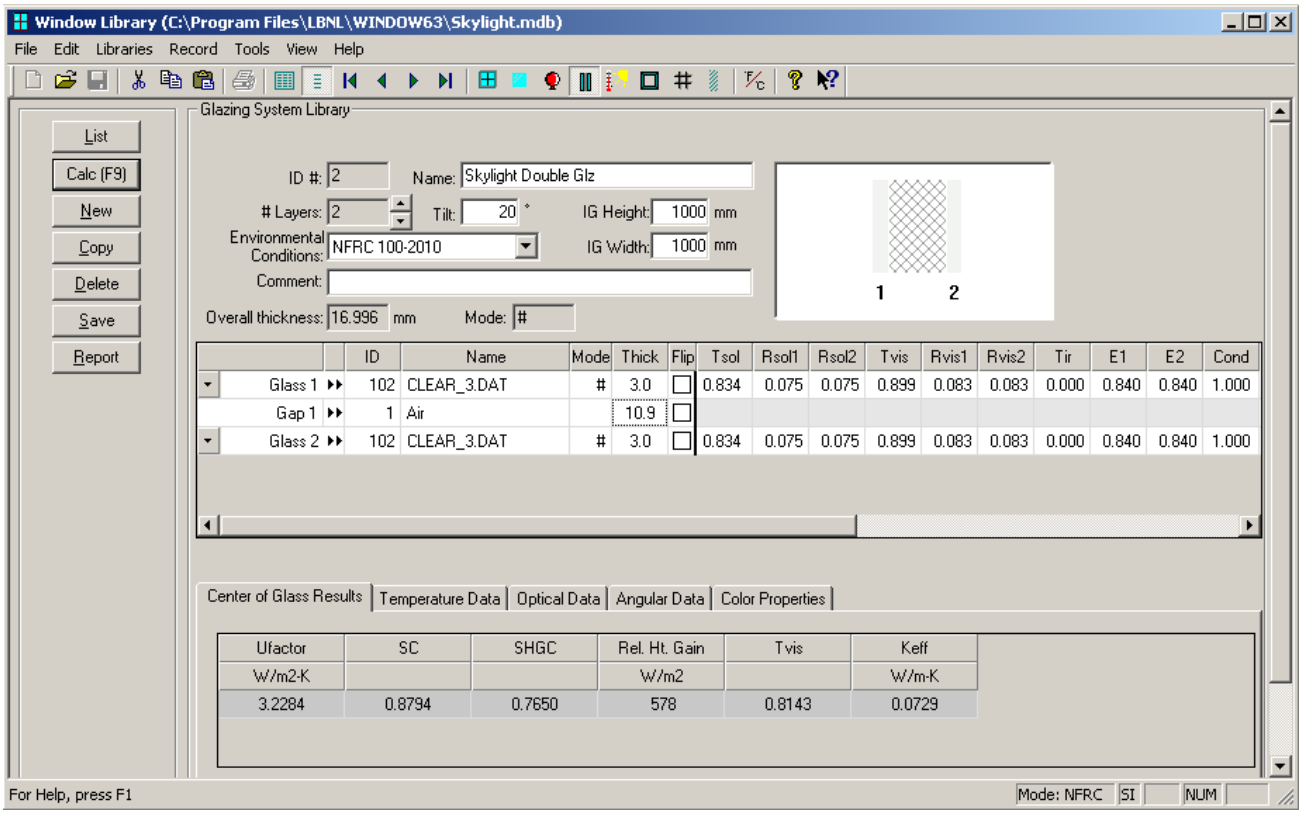


*Figure 8-59 Make new glazing system in the **Glazing System Library** with **Tilt** = 20 degrees.*

2. **Save the file:** Make sure to save the glazing system (**Record** menu**, Save** choice**.**).

In THERM, for Sill:

1. Draw the appropriate cross sections for the Sill.

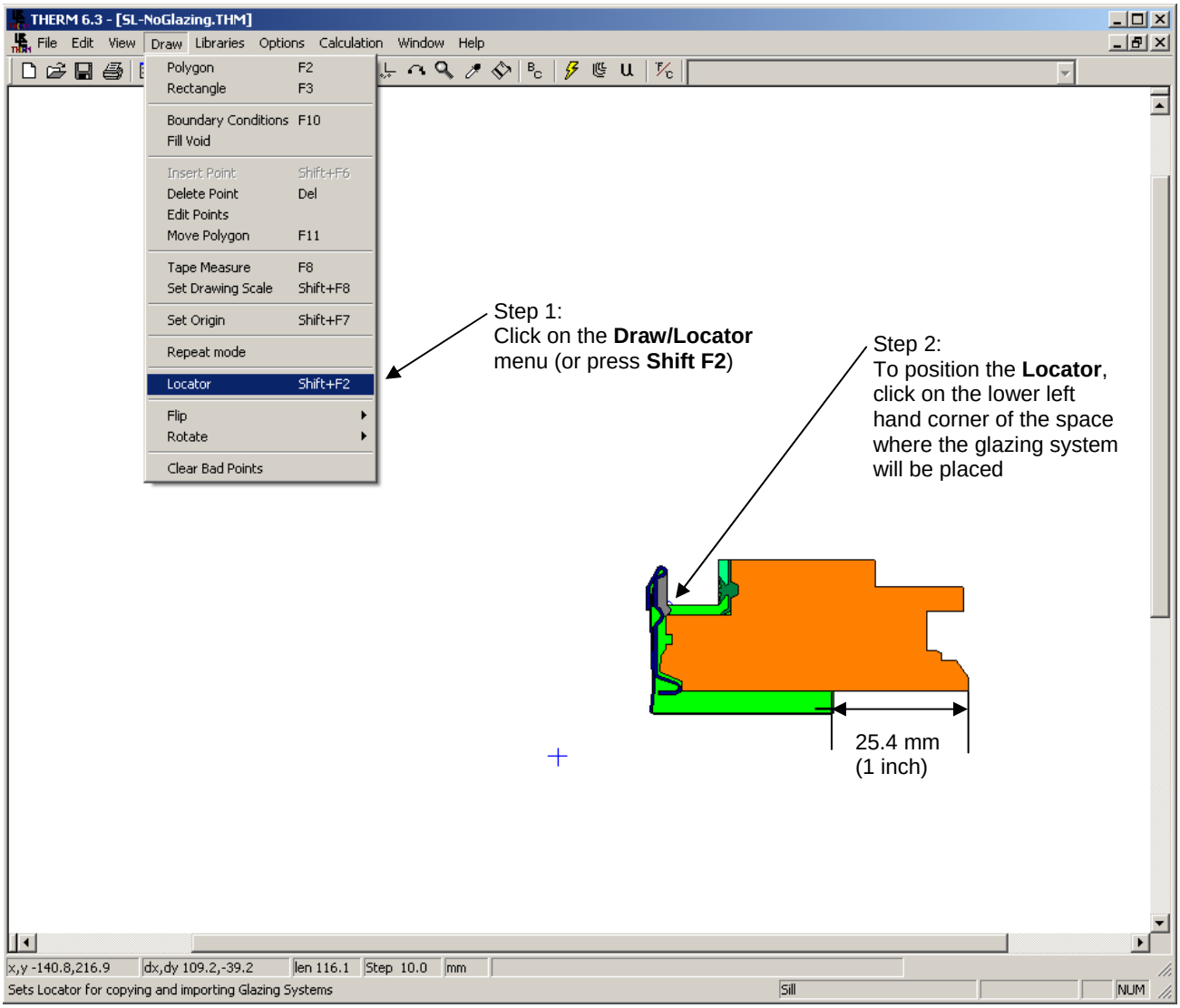


Figure 8-60 Position the locator so that the first glazing section can be inserted.

2. Insert the glazing system for the Sill, with the following settings:
   - **Orientation** = Up
   - **Cavity height** = 1000 mm
   - **Sight line to bottom of glass** = measure this value with the tape measure or get from dimensioned drawings
   - **Spacer height** = measure this value with the tape measure or get from dimensioned drawings
   - **Edge of Glass Dimension** = 150 mm (6.0 inches)
   - **Draw spacer** = not checked

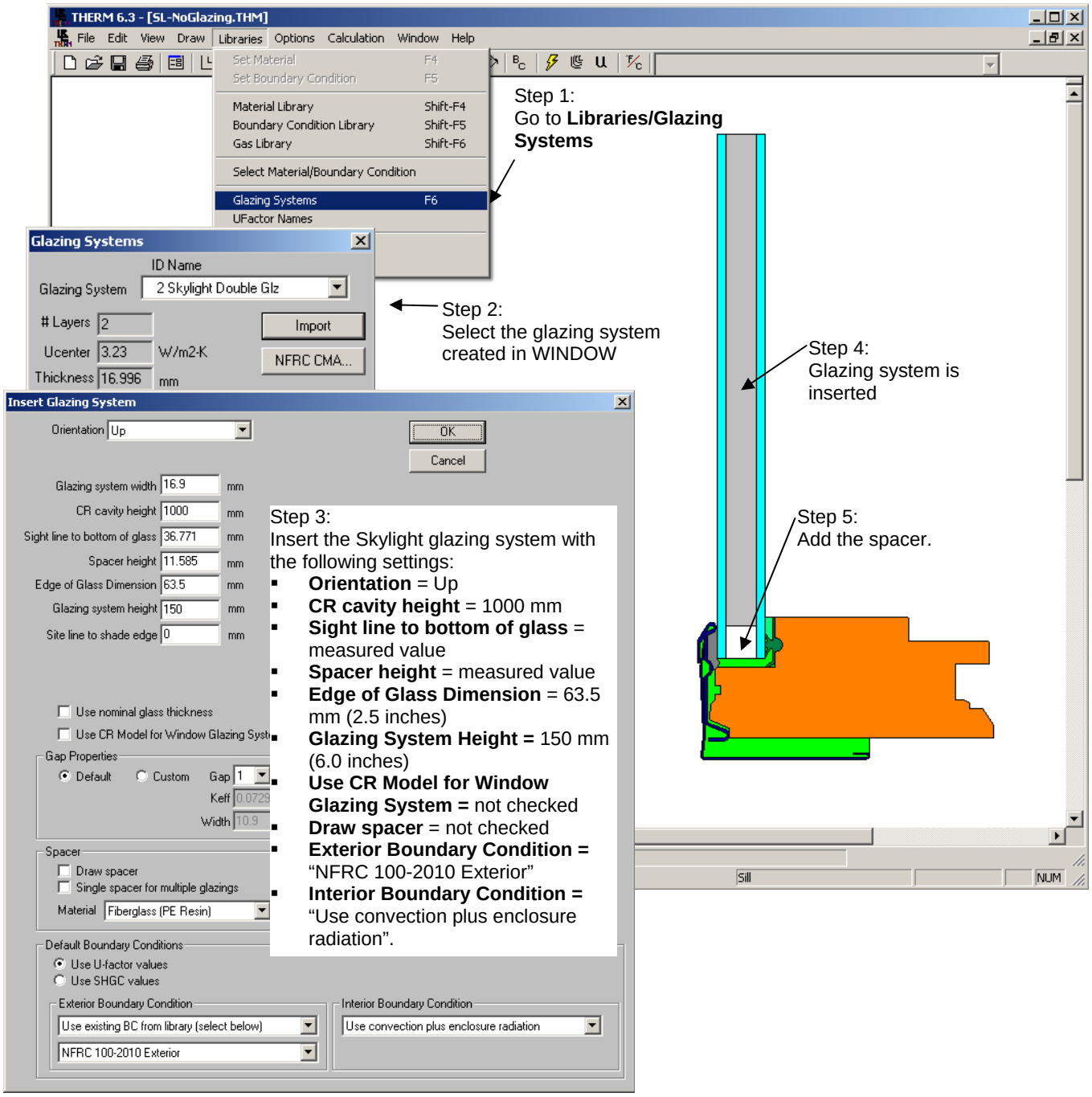


Figure 8-61 Insert the glazing system .

- Note: If using the Multiple Glazing Options feature of THERM, set up the multiple glazing options before tilting the profile, so that all the Boundary Conditions become defined automatically for the glazing options by THERM. Then tilt the cross-section.

3. **Assign Boundary Conditions and U-factor tags:** Click on the Boundary Conditions (BC) toolbar button and correct any problems encountered with the geometry (see Section 6.5.3, "Voids, Overlaps, and Bad Points" in this manual).

4. Tilt the cross section to be 20 degrees off the horizontal plane. For this example sill cross section, click on the **Draw** menu, **Rotate/Degree** choice, and enter **70** degrees **Clockwise**.

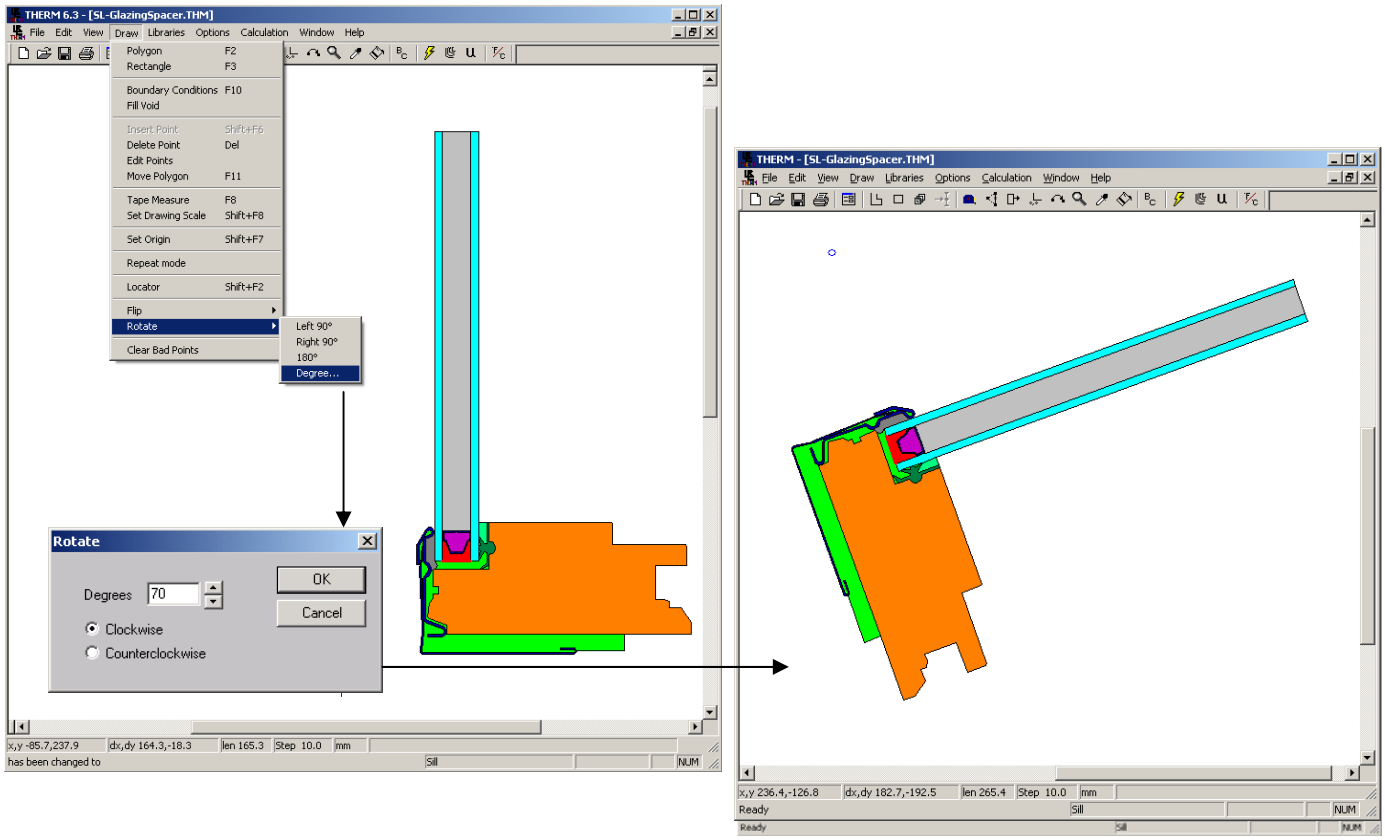


Figure 8-62 Rotate the sill cross section AFTER assigning Boundary Conditions.

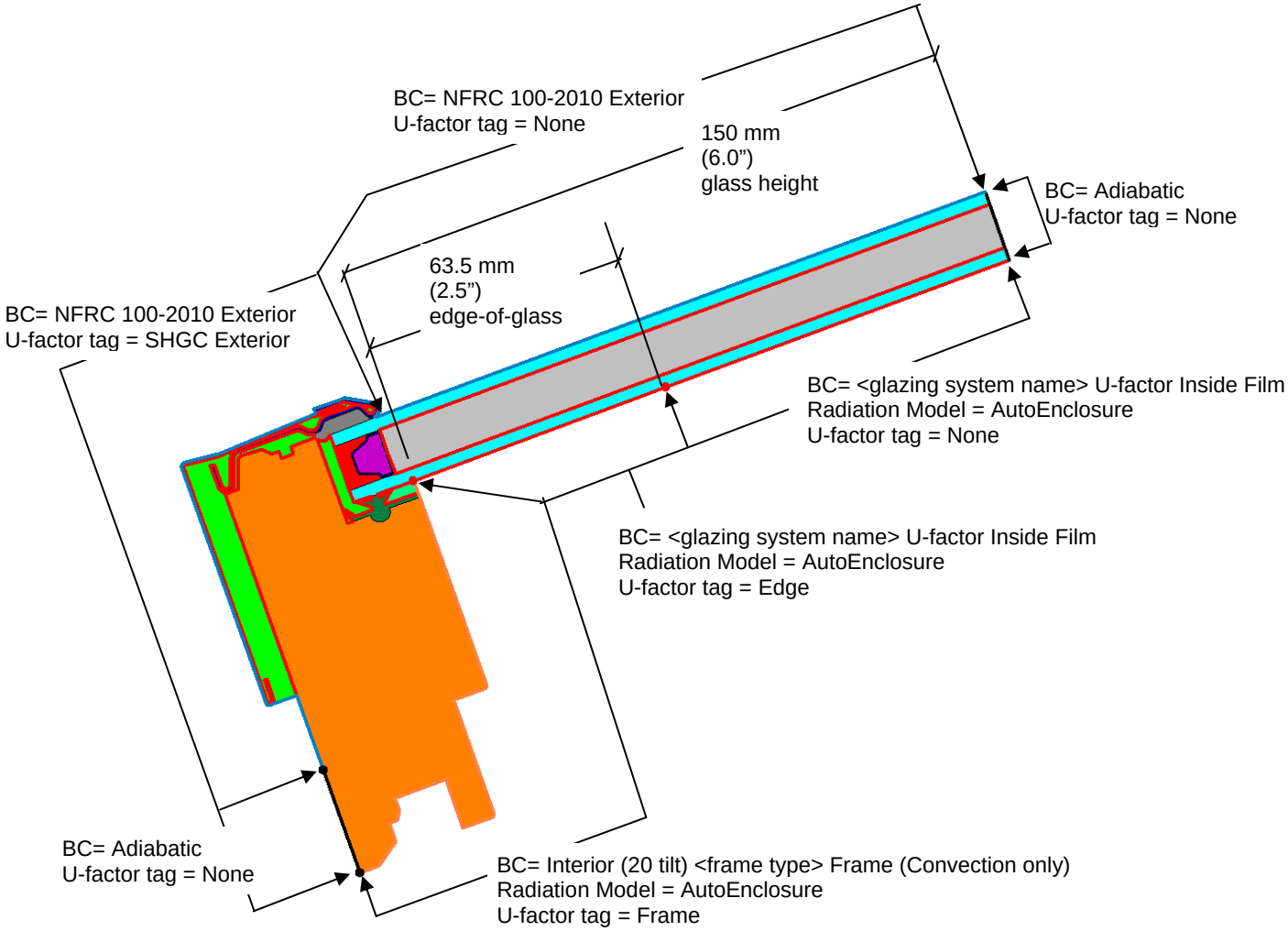


Figure 8-63 Boundary condition and U-factor tag settings for skylight Sill example.

6. Check the **Gravity Vector** for the Sill cross section (**View/Gravity Arrow**), which should point down.

7. Simulate the file.

8. Click on the Show U-factors button to view the U-factors dialog box. Make sure that the projection is set to "Projected in Glass Plane" which will allow the program to calculate the correct projected frame dimensions with a tilted cross section.

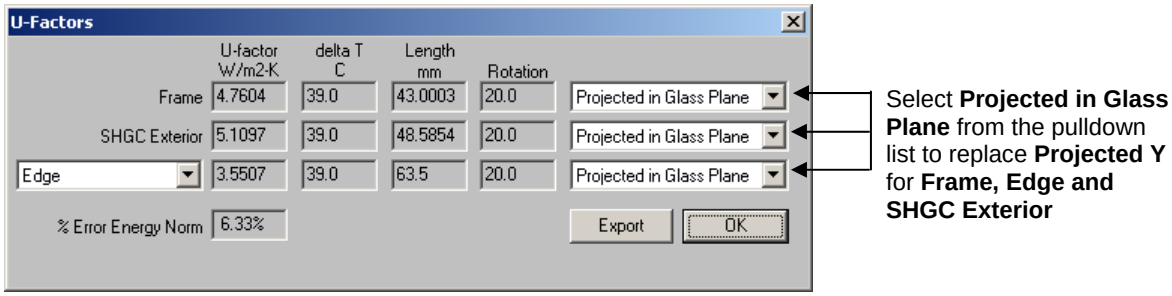


Figure 8-64 Select the Projected in Glass Plane for the projected frame dimension calculation.

In THERM, for Head:

1. Create the cross section for the Head, set the **Cross Section Type** to "Head", and import the glazing system facing **Down** (in order to get the Gravity Vector pointing in the proper direction).
2. Assign the Boundary Conditions as shown in the figure below.
3. Tilt the Head cross section so that it is 20 degrees off horizontal (click on the **Draw** menu, **Rotate/Degree** choice, and enter **70** degrees **Clockwise)**.
4. Check the Gravity Vector (**View/Gravity Arrow**), which should be pointed down.

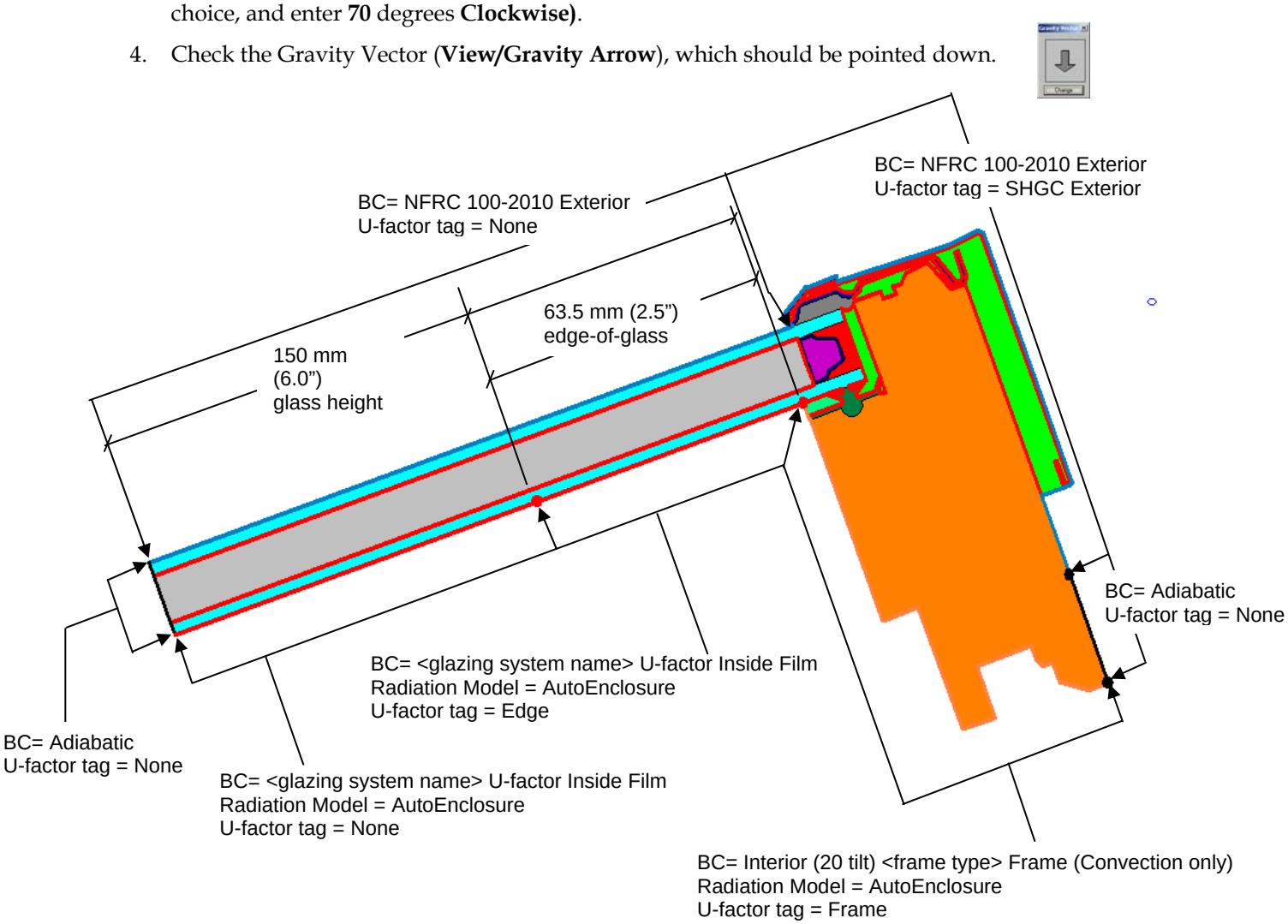


Figure 8-65 Boundary condition and U-factor tag settings for skylight Head example.

5. Simulate the file.

6. Click on the Show U-factors button to view the U-factors dialog box. Make sure that the projection is set to “Projected in Glass Plane” which will allow the program to calculate the correct projected frame dimensions with a tilted cross section.

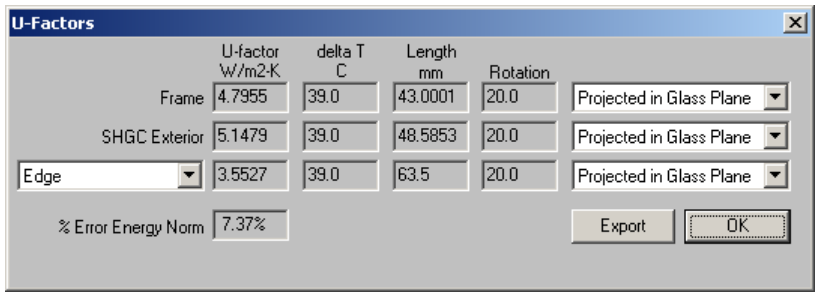


Figure 8-66 Select the Projected in Glass Plane for the projected frame dimension calculation.

In THERM, for Jamb:

1. Create the cross-section for the Jamb. The steps are similar to modeling the head and sill, except for the following:
   - Jambs are modeled in the vertical direction
   - The Cross Section Type is set to “Sill”
   - The glazing system is oriented “Up”
   - The gravity vector is set by hand to “Right”

2. Simulate the file.
   Because the cross section is not rotated, the projection in the U-factor dialog box can be set to either “Projected Y” or “Projected in Glass Plane”; both settings will result in the same answer.

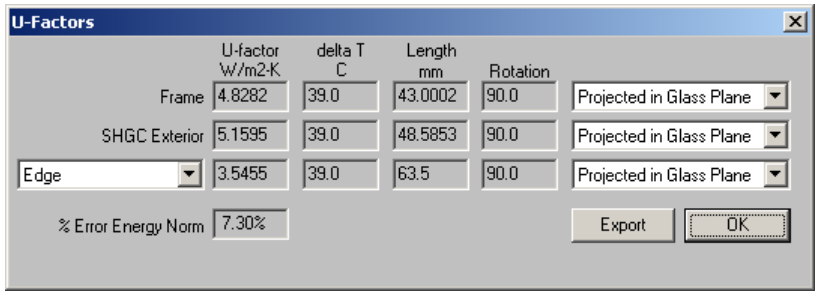


Figure 8-67 The projection can be set to either “Projected Y” or “Projected in Glass Plane”; both will result in the same answer.

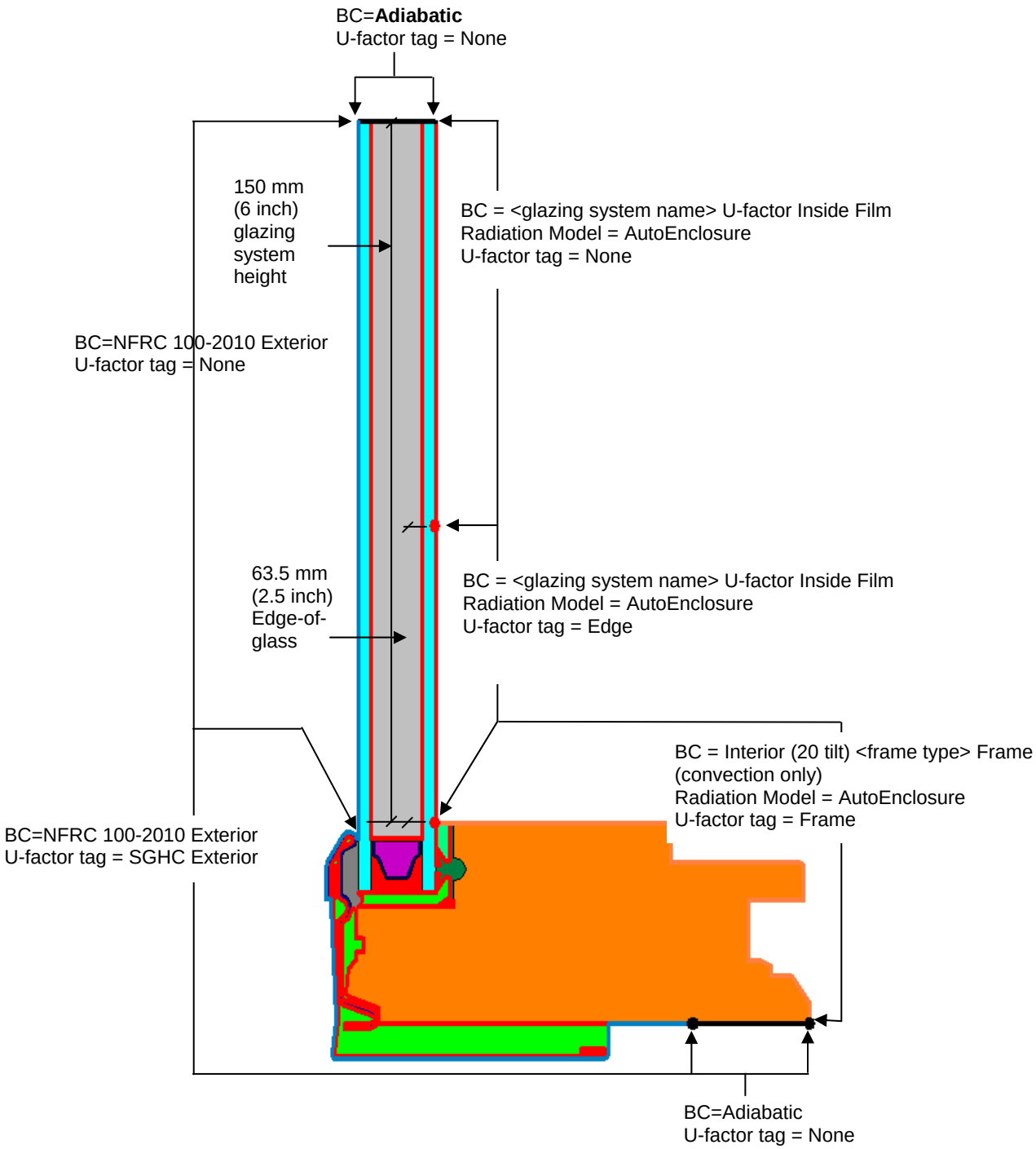


Figure 8-68 Boundary condition and U-factor tag settings for skylight jamb example.

In WINDOW, Calculate the Total Product U-factor:

1. In the WINDOW **Frame Library**, import the THERM files for the Head, Sill, Jamb and any other needed cross sections that were modeled.

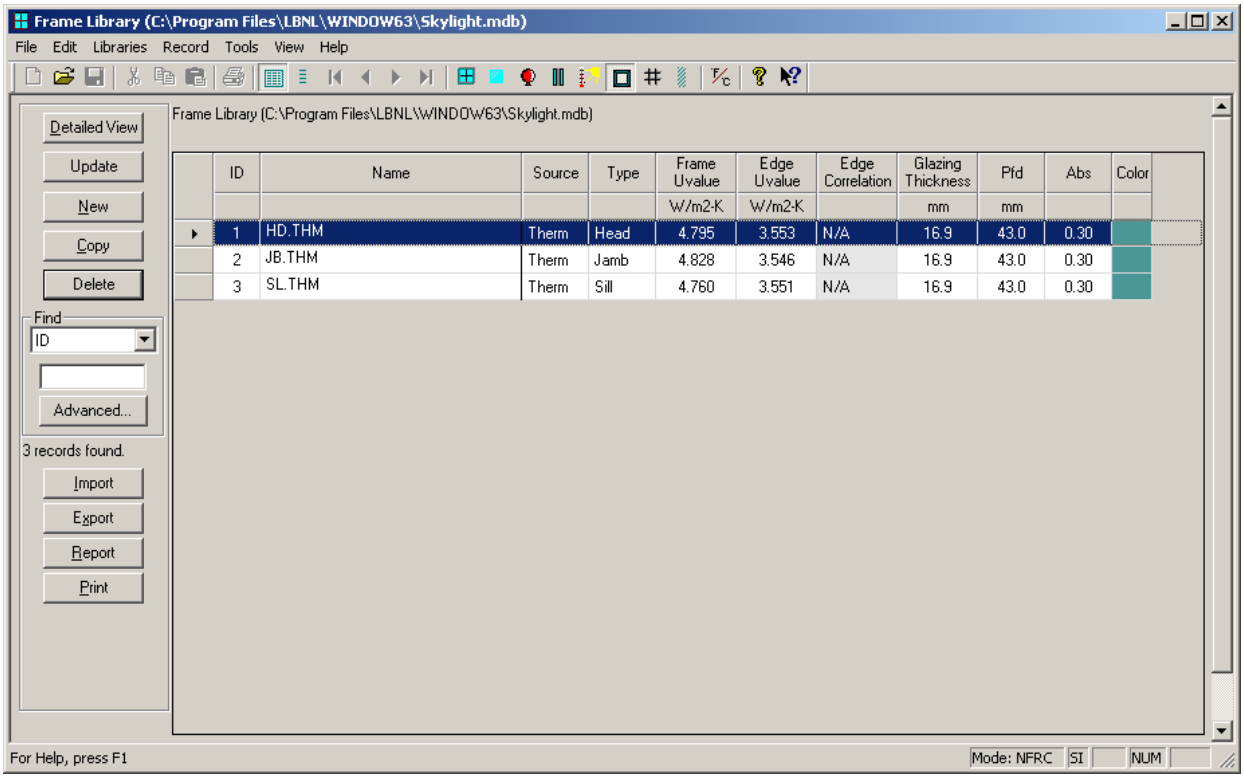


Figure 8-69 Import the skylight THERM files into the WINDOW Frame Library.

2. Construct the whole skylight in the WINDOW **Window Library** by using the THERM files for the frame components and the glazing system for the center of glass. Make sure that Type = Skylight and Tilt = 20.

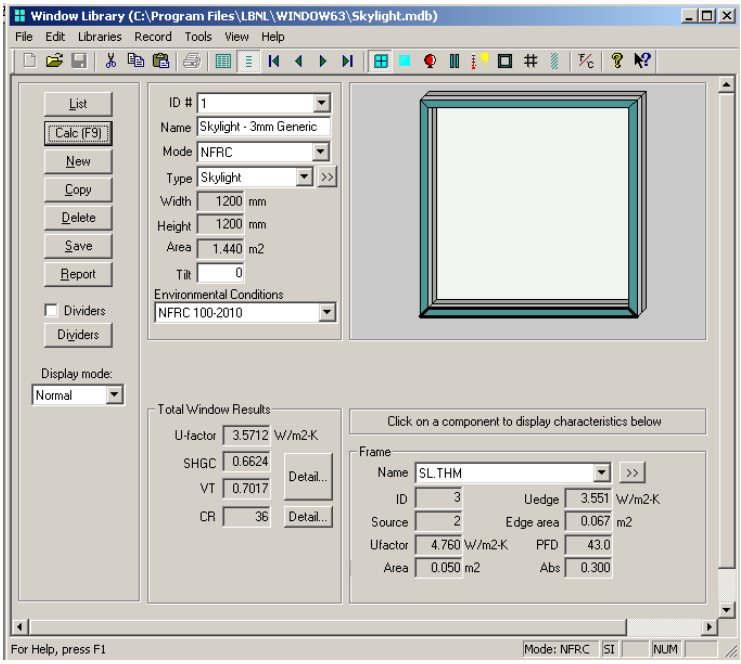


Figure 8-70. Create the whole skylight in the Window Library.

8.5.4. Domed Skylights / Glass Block

The following describes the steps for simulating a domed skylight or glass block product to obtain the total product U-factor.

1) Determine the glazing components conductance, Cs, per ASTM C1363.
2) Calculate the effective conductivity (to 3 significant figures) in Btu/h/ft/°F by the following formula:

   Keffglass = Cs * t / 12,

   Where:

   Cs = Conductance of glass as determined per ASTM C1363 test
   T = thickness of sample in inches
   12 = conversion factor from conductance to conductivity (Btu-in/hr/ft2/°F to Btu/h/ft/°F)

3) Make a new a glass layer in the Glass Library, and set the conductance to the calculated Keffglass value.
   a. Enter the thickness of the sample
   b. If the sample is glass, enter 0.84 for the emissivity of the front and back surfaces
   c. If the sample is not glass, then the emissivity of the material shall be determined per the applicable ASTM standard.
   d. The solar, visible, and Tir spectral data values shall not be used and therefore the default values shown do not need to be modified.
4) Build the glazing system to be used in the THERM model in the Glazing System Library
5) Import the glazing system into the applicable THERM model.

Glass Block Example

1) The Cs value from the ASTM C1363 test = 0.635 Btu/hr-ft2-°F. The glass = 1.008" thick.
2) Keffglass = 0.635 * 1.008 / 12 = 0.0533 Btu/hr-ft-°F = 0.092 W/m-K
3) In the Glass Library, make a new record, and set the Conducivity to 0.092 W/m-K. Set the front and back emissivity to 0.84.

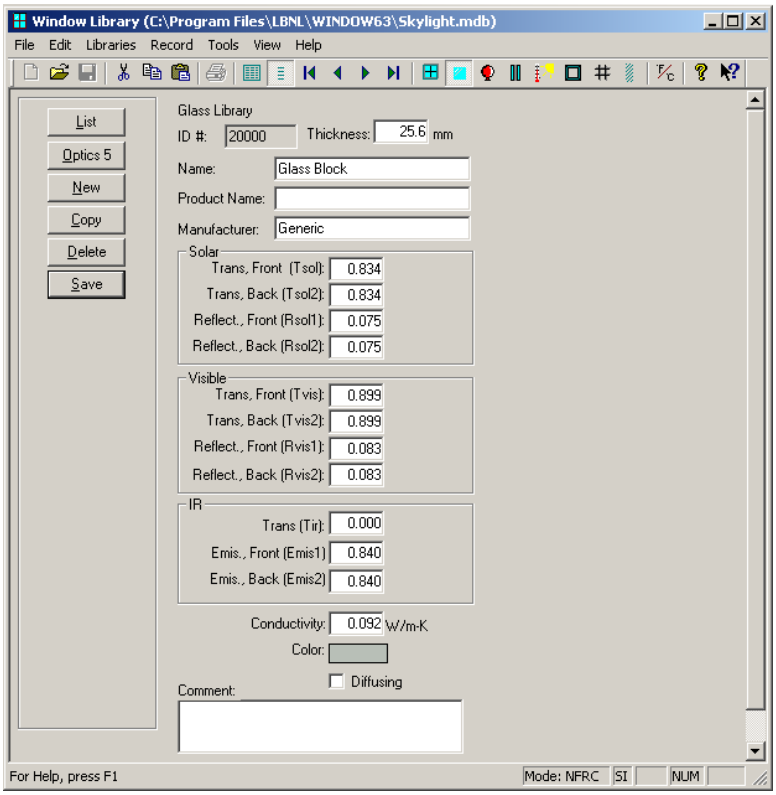


Figure 8-71. Create a new record in the Glass Library for the Glass Block tested value.

4) In the Glazing System library, create a record for, in this example, a glass block glazing system using the new glass layer created in the Glass Library, and calculate the properties.

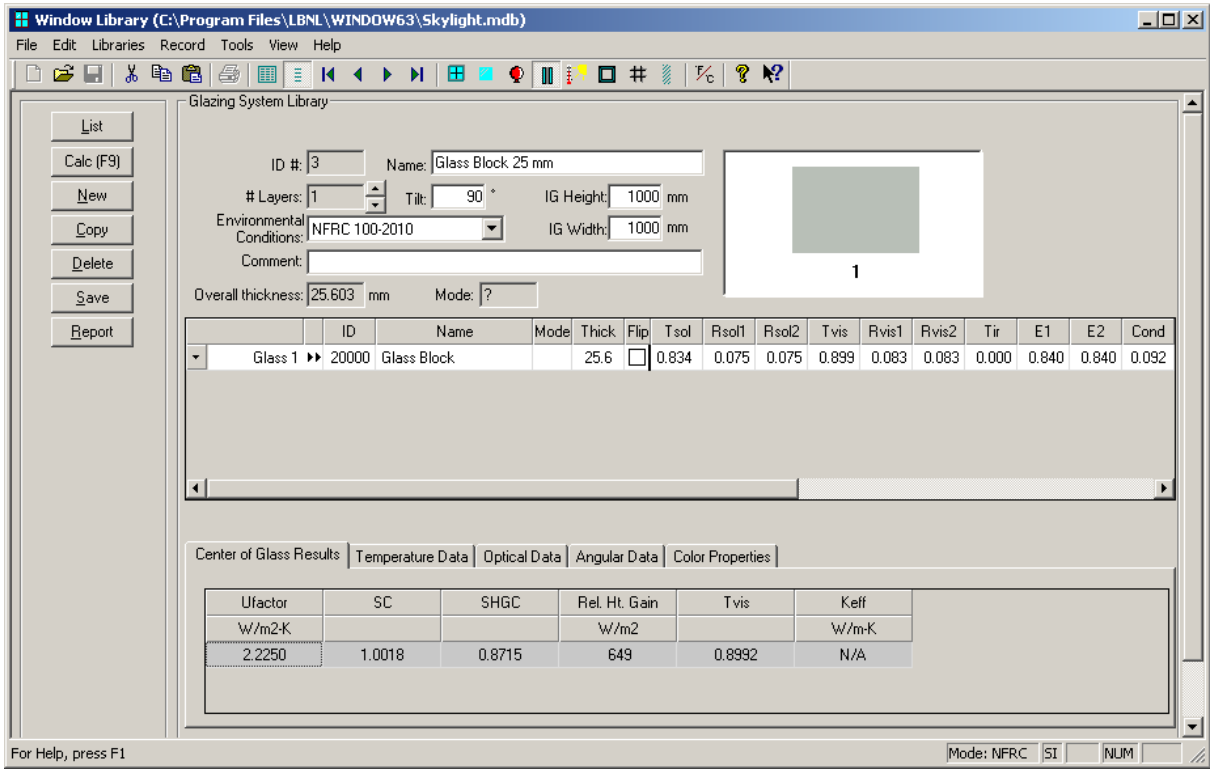


Figure 8-72. Create a new record in the Glazing System Library using the Glass Block layer.

5) Import the glazing system into the applicable THERM model and simulate the product.
6) Calculate the total product U-factor using a spreadsheet, rather than in WINDOW.

8.5.5. Sloped Glazing Systems with Large Gaps:

WINDOW6 cannot calculate the Center-of-Glass values for gap widths equal to or greater than 30 mm (1.17") on a 20° slope.

In order to model this situation, follow these steps:

In WINDOW:

- In the Glazing System Library, make the IG unit to be modeled except define the gap width as 29.5 mm (or some other value less than 30 mm) with a 20° slope.
- Obtain the effective conductivity (keff) of the gap from the "Keff" field in the "Center of Glass Results" tab in the Glazing System Library
- Multiply by the ratio of the actual gap width divided by the gap width used in the Glazing System model. This result is a new keff that will be used in the Therm model.

In THERM:

- Insert the glazing system and check "allow editing of IG polygons"
- Move one of the glass layers so that the gap width is the actual gap width of the product.
- Make a new material with a conductivity equal to the
- Assign this new material to the glazing system gap width.
- Simulate the file as usual.

8.6 Tubular Daylighting Devices

Tubular skylights are a group of products that can loosely be defined as non-standard skylight products. Their primary purpose is to provide daylighting, and not view to the outside. For this reason, there are some arguments whether these products can be considered fenestration at all. However, because they penetrate the building envelope and provide some of the essential functionality of a fenestration system (i.e., daylight) they are considered to be a fenestration product.

The NFRC Executive Committee has decided that the simulation method for determining a U-factor for TDD and HTDD products is effective until March 19, 2012. Effective March 20, 2012, TDD and HTDD product U-factors can only be achieved by physical testing per NFRC 102.

The assumptions and methodology for modeling these products differs considerably from typical fenestration products. The following is a list of standardized assumptions to be used when modeling tubular daylighting devices:

- D = Shaft Diameter = 350 mm (14 in.)
- L = Shaft Length = 750 mm (30 in.)
- Standard dome mounted on 350 mm (14 in.) shaft
- Exterior boundary conditions are applied on the exterior side of the dome
- Standard ASHRAE Attic boundary conditions are applied to the exposed surfaces of the shaft,
- Bottom of the shaft is mounted in a 250 mm (10 in.) thick surround panel (standard surround panel material, such as EPS),
- Bottom of tubular skylight is covered with light diffusing plate (manufacturer supplied).

The first step is to draw the geometry of the tubular daylighting device in THERM, per the manufacturers' drawings and using the assumptions above (see Figure 8-46). Material properties, other than frame cavities, should be assigned from the THERM material library.

Next calculate the effective conductivity of the shaft and dome cavity. The set of equations and assumptions required to calculate effective conductivity of this cavity is detailed in Curcija (2001). A custom spreadsheet is also designed to facilitate this calculation and is available on request from NFRC (tubes_keff.xls). The information necessary to calculate k_{eff} of this cavity are the average temperatures and emissivities of the inside surface of the diffuser plate at the bottom of the cavity, and inside surface of the dome at the top of the cavity. Initially these temperatures need to be estimated, a reasonable starting point being -2°C (28.4 °F) for the diffuser plate and –17°C (1.4 °F) for the dome (when the dome is single glazed). After the THERM simulation is calculated with the keff determined from these estimated temperatures, find the average temperatures for the diffuser plate and dome surfaces using the THERM tape measure tool. If the resulting average temperatures differ by more than 1° C (2 °F) from the estimated values, a new keff shall be calculated and the THERM simulation repeated with the new keff. This process should be repeated until the criterion of 1 ° C (2 °F) temperature difference is satisfied. In many cases, one iteration is enough, but the temperatures shall be checked to make sure that this has been met for the particular case. In the THERM file, fill the shaft/dome cavity with a solid material which has the conductivity equal to the calculated k_{eff}. Fill the other small frame cavities with the "Frame Cavity NFRC 100" frame cavity material, which will automatically calculate effective conductivity of them.

Next the boundary conditions need to be defined and assigned as shown in Figure 8-47. The exterior and adiabatic boundary conditions can be used from the THERM library, while the attic and indoor side of the diffuser plate must be defined in the THERM Boundary Condition Library. The following values should be used for the boundary conditions:

- Exterior: **NFRC 100-2010 Exterior**
  h_o = 30 W/m² ·K; T_o = -18 °C
  (h_o = 5.3 Btu/hr ·ft² ·°F; T_o = 0 °F)
- Adiabatic**: Adiabatic**
  q = 0 W/m²
  (q = 0 Btu/hr ·ft²)
- Attic: **User defined**
  h_a = 12.5 W/m² ·K; T_a = -18 °C
  (h_a = 2.2 Btu/hr ·ft² ·°F; T_a = 0 °F)
- Indoor Side of diffuser plate: **User defined**
  h_i = 9 W/m² ·K; T_i = 21 °C (1.582 Btu/hr ·ft² ·°F; T_i = 70 °F)

Note: The height of the shaft/dome cavity represents area weighted equivalent height, L_{eqv}, and is set to 1.041 m (41 in.) for domed top diffuser products and 750 mm (30 in.) for flat top diffuser products.

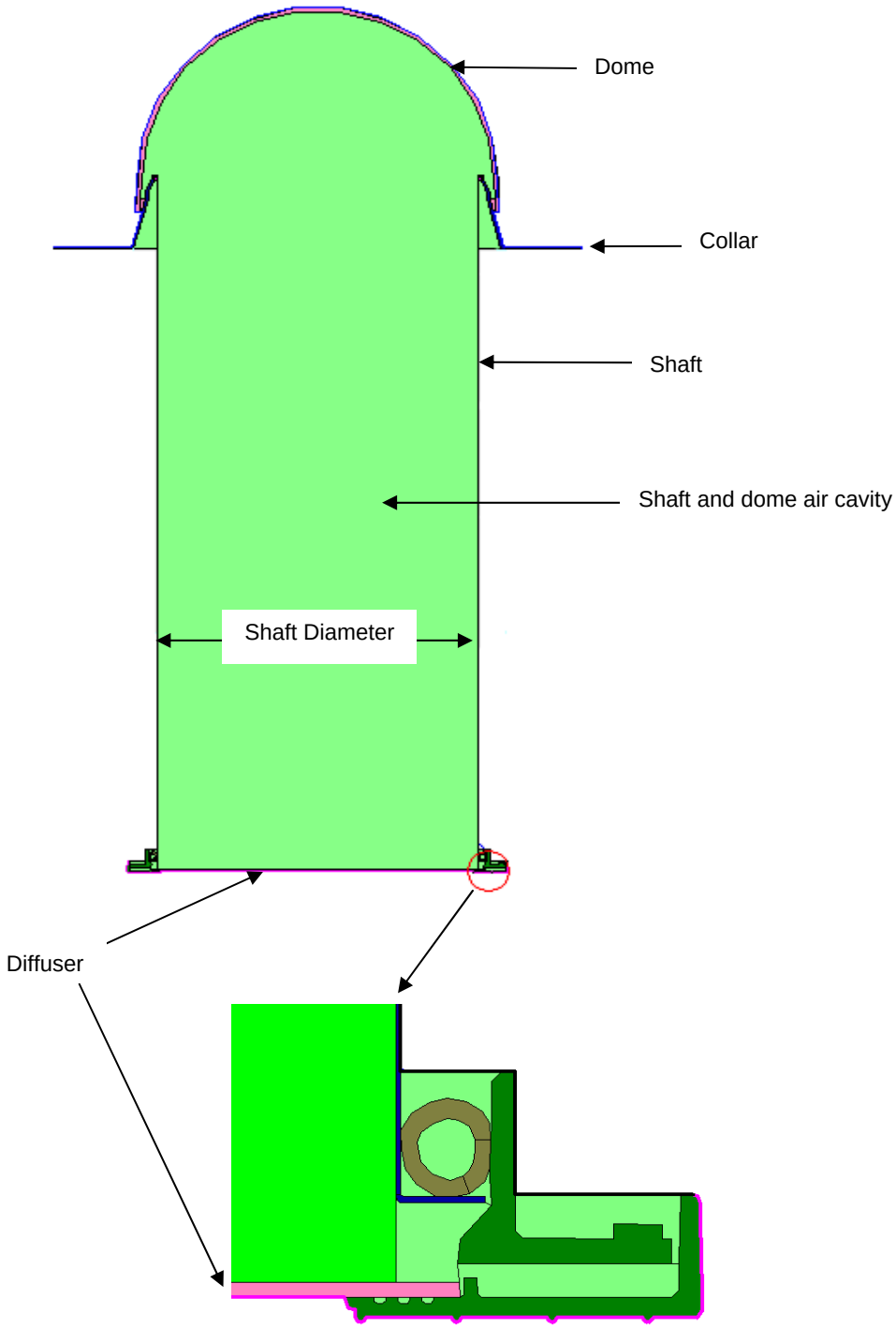


Figure 8-73 Tubular Daylighting Device Geometry drawn in THERM.

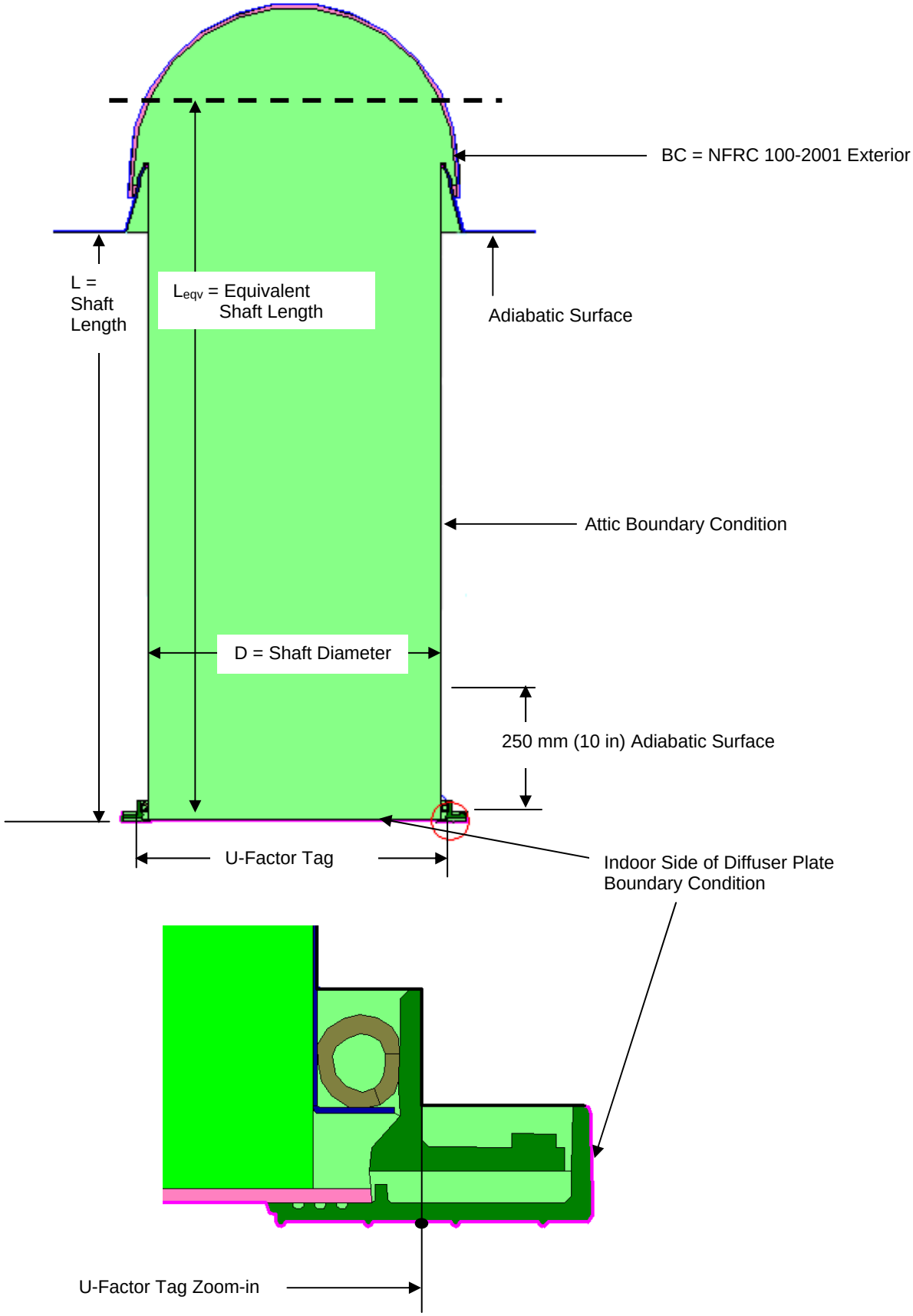


Figure 8-74 Boundary Conditions and location of U-factor tag for Tubular Daylighting Device.

The last step before simulating the problem is to define the U-factor tag. This tag is defined as shown in Figure 8-57. After the calculation is done, the U-factor obtained represents the total product performance.

8.6.6. Example Tubular Devices Problem

This example assumes that the bottom diffuser plate is made up of a single layer. For multiple layer plates, additional instructions are given at the end of this example. For single layer plates, it is not necessary to do calculations with WINDOW.

Begin by drawing geometry in THERM either by using DXF file underlay as shown below or by using a dimensioned drawing.

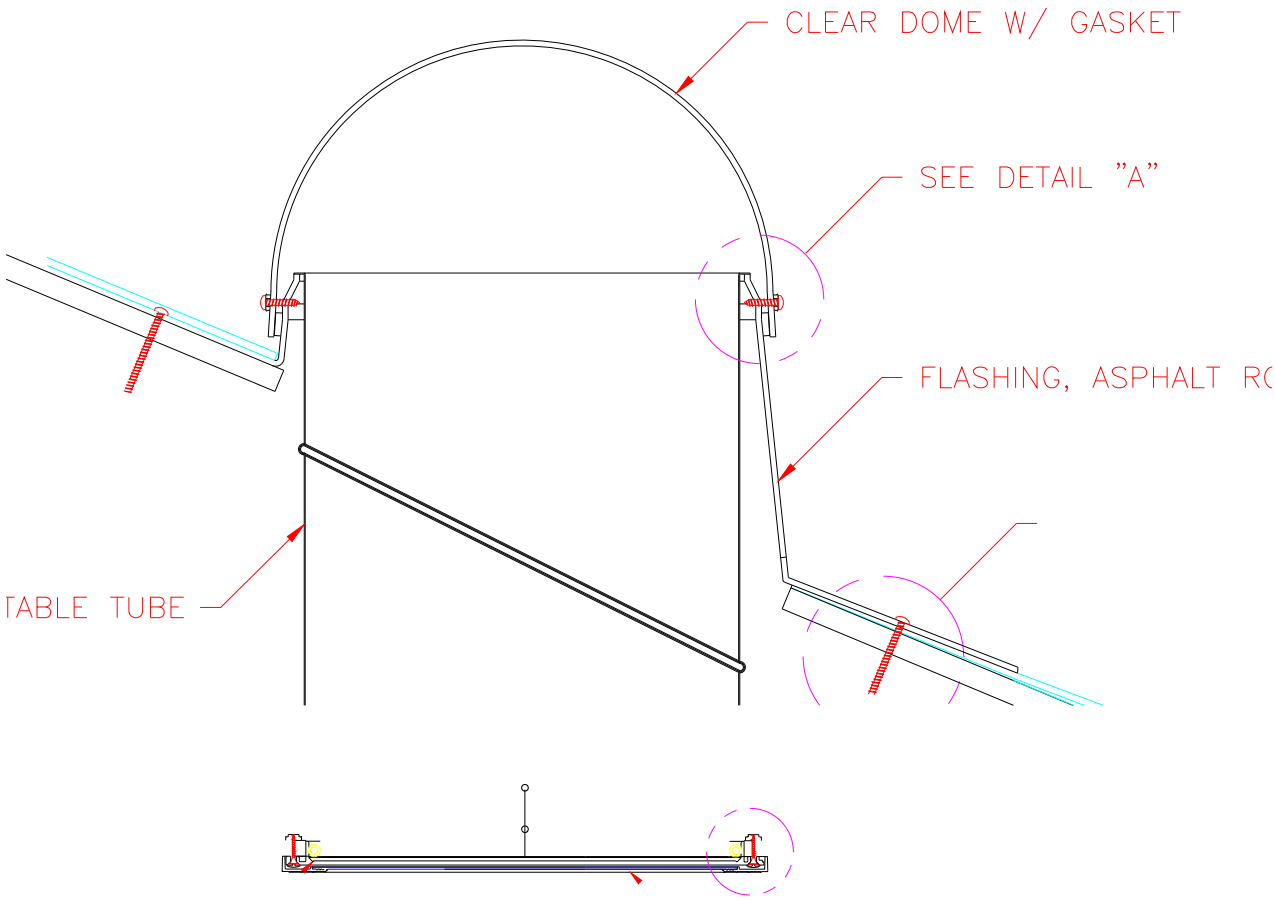


Figure 8-75 DXF File for Use as an Underlay in THERM.

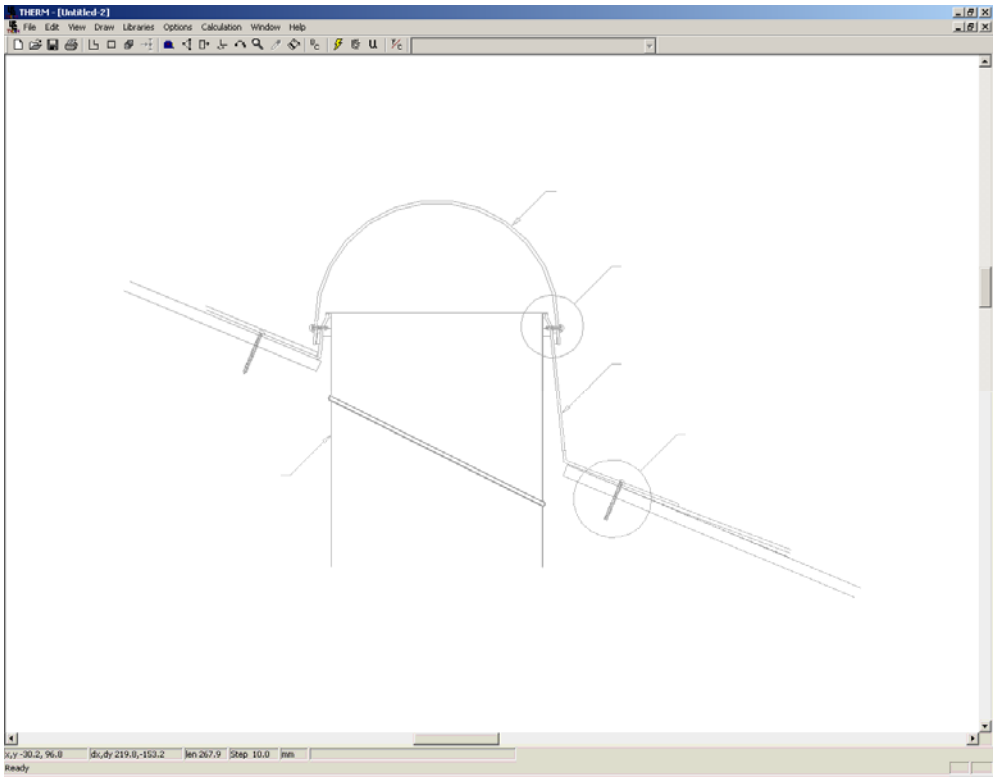


Figure 8-76 Underlay of the Top Part of the Tubular Daylighting Device.

Draw the geometry of all solid pieces of the tubular skylight, making sure that the shaft is 350 mm (14 in.) wide. The width of the dome should be adjusted to fit over such a shaft but thickness of the dome material shall not be changed. Include all of the details of sealing as per the manufacturers' drawings and specifications. The figure below shows the completed dome, collar, and one side of the shaft wall, along with gaskets.

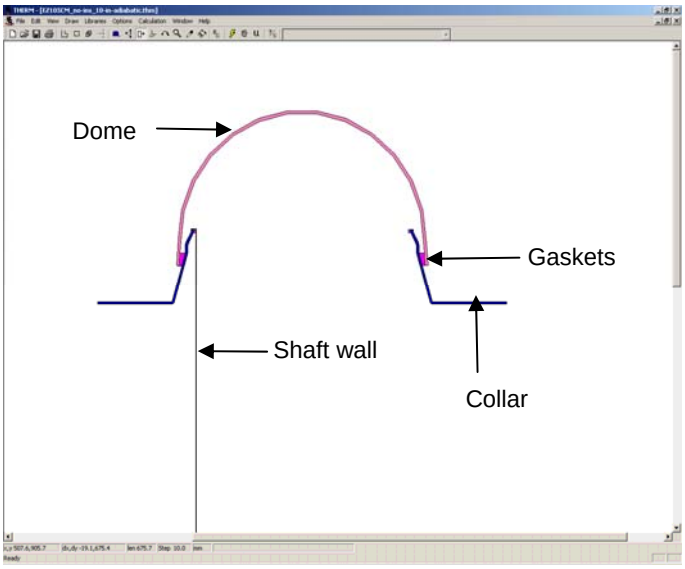


Figure 8-77 THERM drawing of the dome, collar, gaskets and one section of the shaft wall.

The figure below shows the completed solid sections without any frame cavity polygons defined.

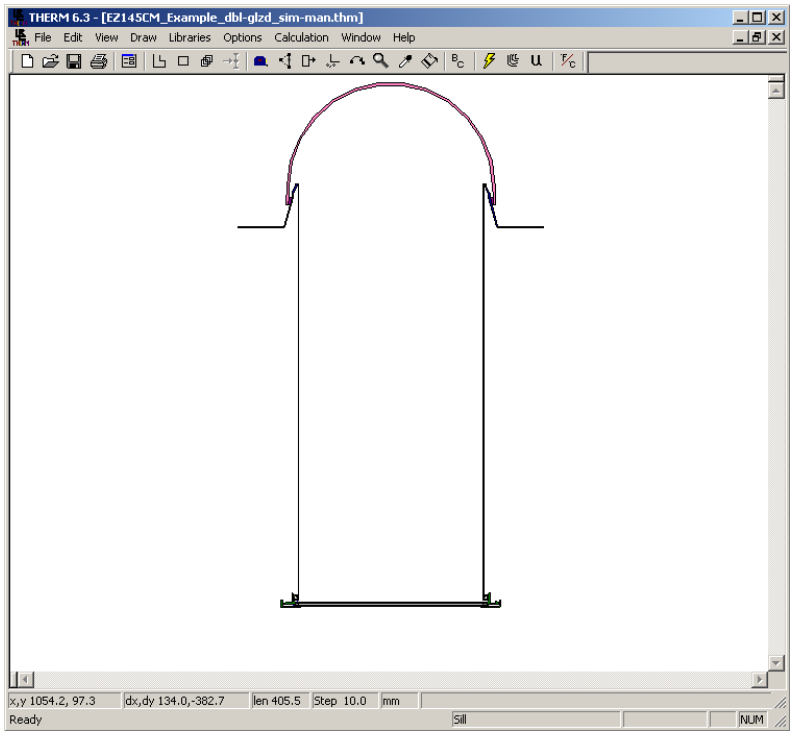


Figure 8-78 THERM drawing of all of solid sections.

Create polygons (using the **Fill** tool where possible) and assign the "Frame Cavity **NFRC 100**" material for all the frame cavities except the large central shaft/dome cavity, as shown in the figure below.

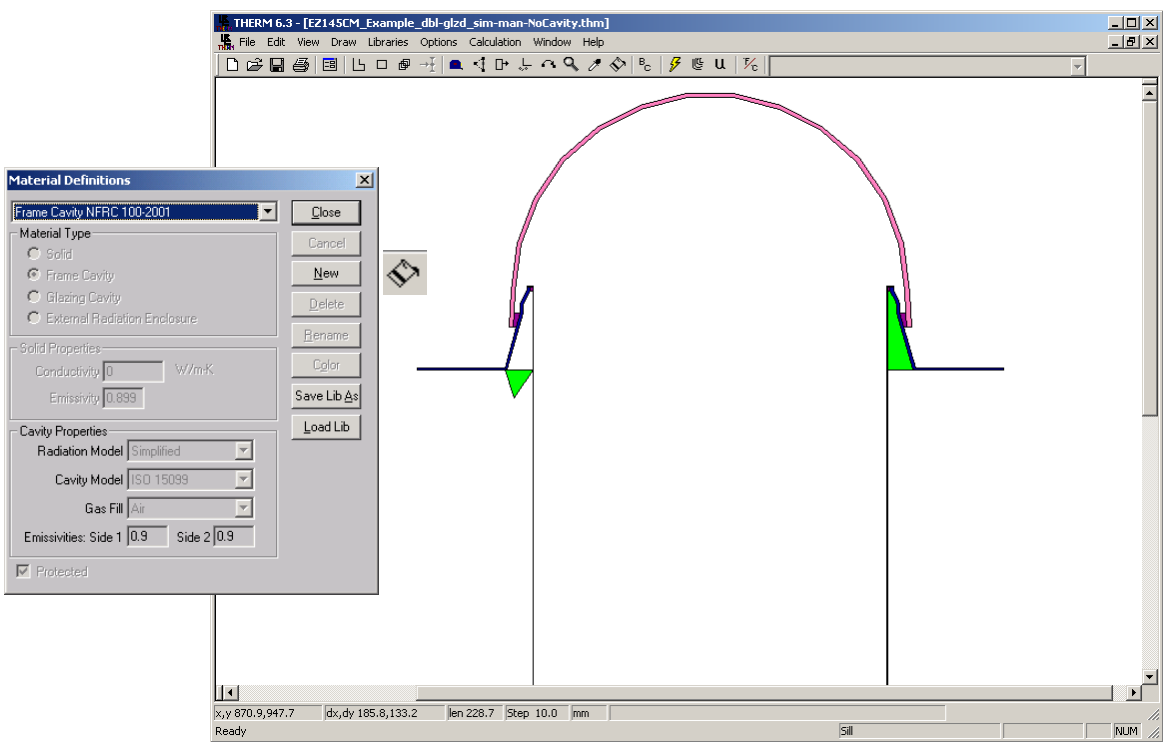


*Figure 8-79 Fill all cavities, except for shaft/dome, with the "Frame Cavity **NFRC 100**" material.*

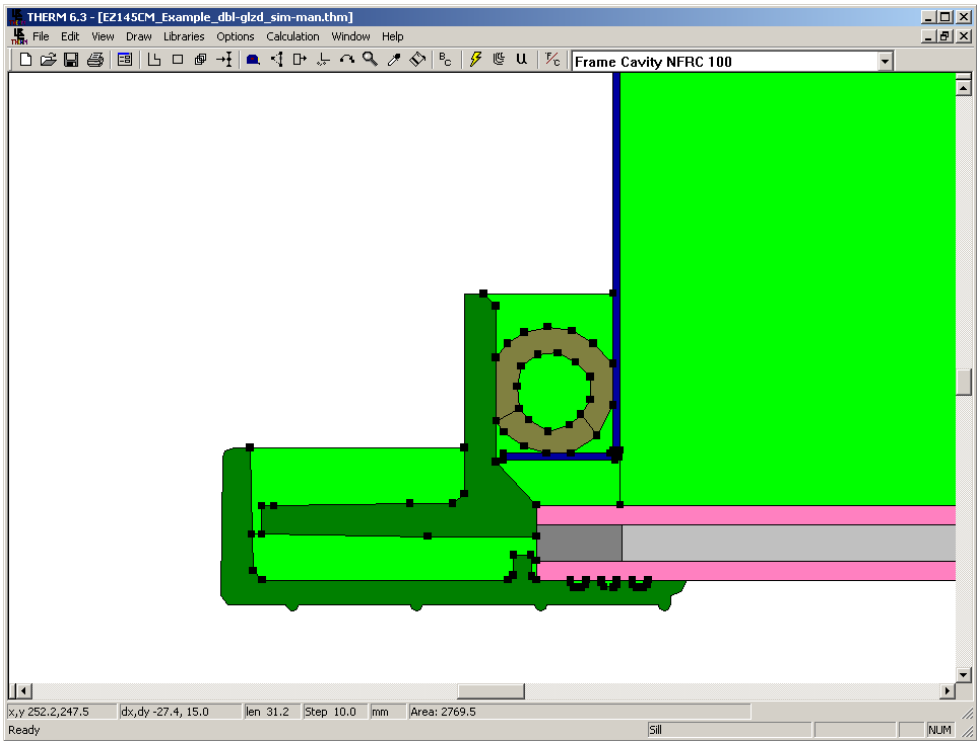


*Figure 8-80 Small Frame Cavities Around the Edges of the Diffuser set to "Frame Cavity **NFRC 100**" material.*

Before the large shaft/dome cavity can be filled, it is first necessary to calculate k_{eff} for this cavity. Open spreadsheet Tubes_keff.xls and input the four yellow highlighted fields that are available for inputting data as shown in the figure below:

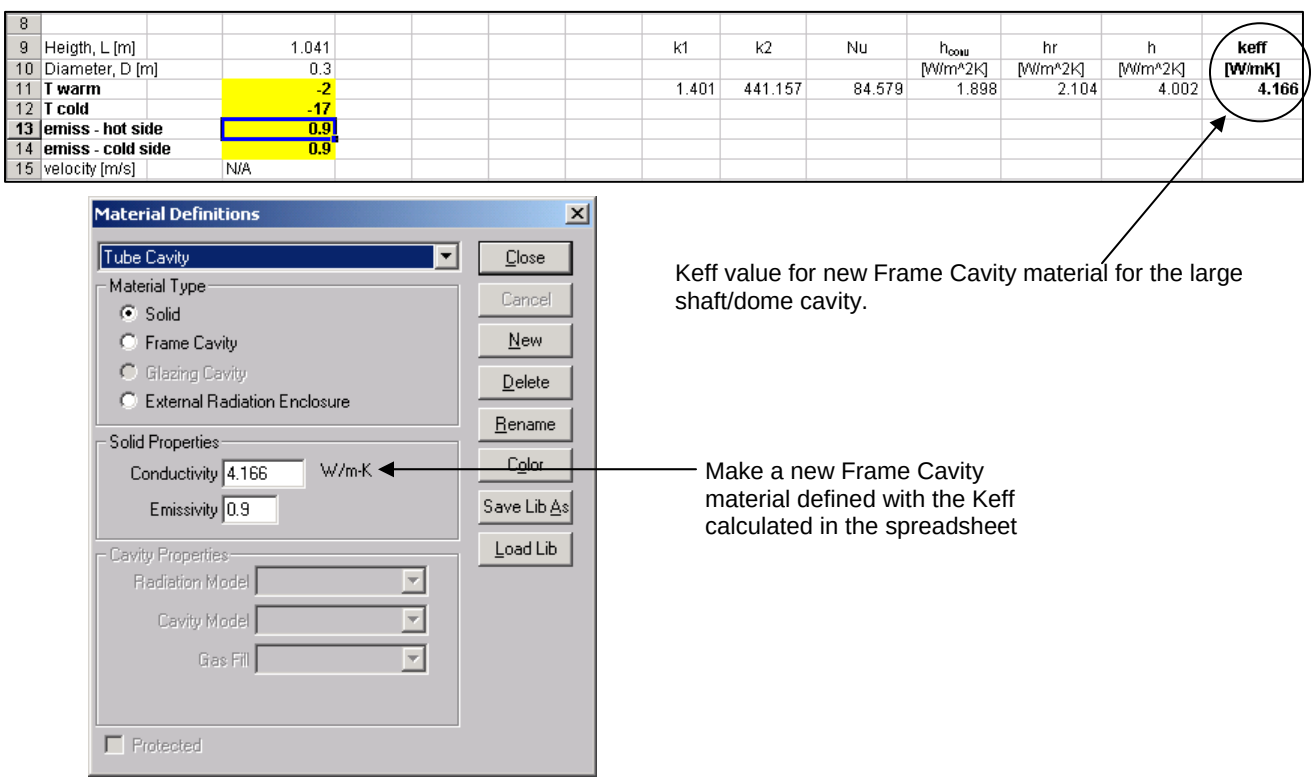


Figure 8-81 Tubes_keff.xls spreadsheet with input data highlighted in yellow

Temperatures of the inside surface of a bottom diffuser plate (T_{warm}) and top dome (T_{cold}) shall be estimated by finding respective average temperatures.

For the bottom diffuser plate, the average temperature can be estimated simply by stretching tape measure across the inside surface of the bottom diffuser plate from the left side of the shaft/dome cavity to the right side, as shown in the figure below.

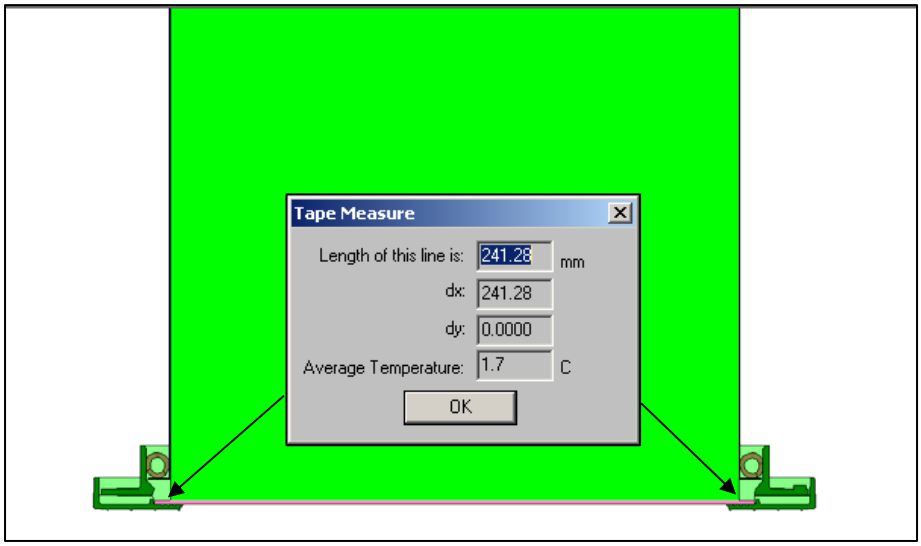


Figure 8-82. Estimate of the average temperature of the inside surface of a bottom diffuser plate

For the dome, the average temperature should be calculated in increments, because the surface consists of several straight line increments. Because the lines are of approximately the same length, the average can be estimated by summing the temperatures for all the segments and dividing by the number of segments, as shown in the figure below. As discussed at the beginning of this section, this is an iterative process, and once the model has been simulated, find the average temperatures for the diffuser plate and dome surfaces using the tape measuring tool, and if the resulting average temperatures differ by more than 1° C (2 °F) from the estimated values, the new Keff shall be calculated and the simulation repeated until the criterion of 1° C (2 °F) is met. Emissivities are input from the surface emissivities of the inside surface of the bottom diffuser plate (emiss – hot) and inside surface of the top dome (emiss – cold). The resulting k_{eff} value is calculated using the spreadsheet, and a new material shall be made with that conductivity and assigned to the shaft/dome cavity.

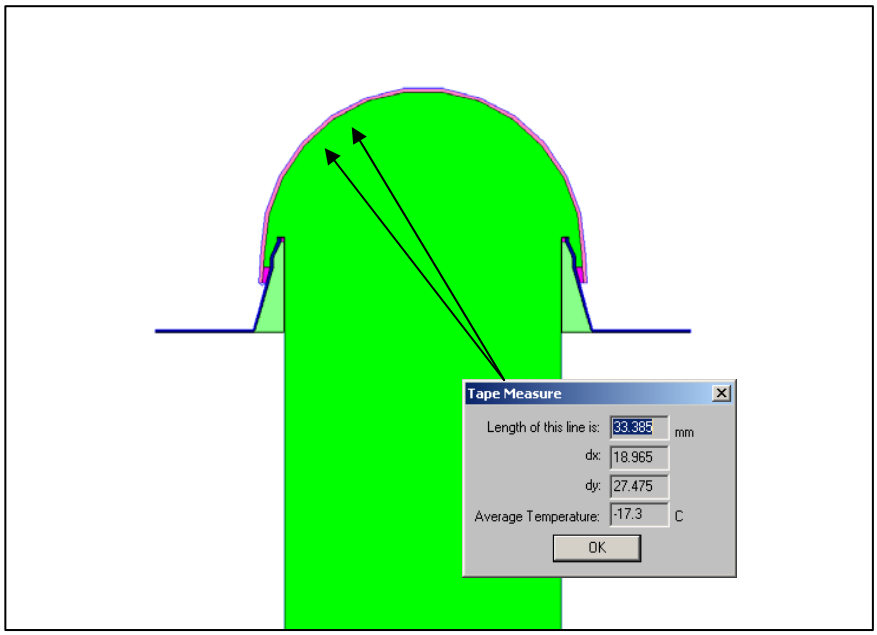


Figure 8-83. Estimate of the average temperature of the inside surface of a bottom diffuser plate temperatures of segments (usually at 15° increments)

The next step is to define the boundary conditions. The outside surface of the dome and collar should be assigned the standard "**NFRC 100-2010** Exterior" boundary condition. The bottom of the collar shall have standard "Adiabatic" boundary condition, as shown in the figure below.

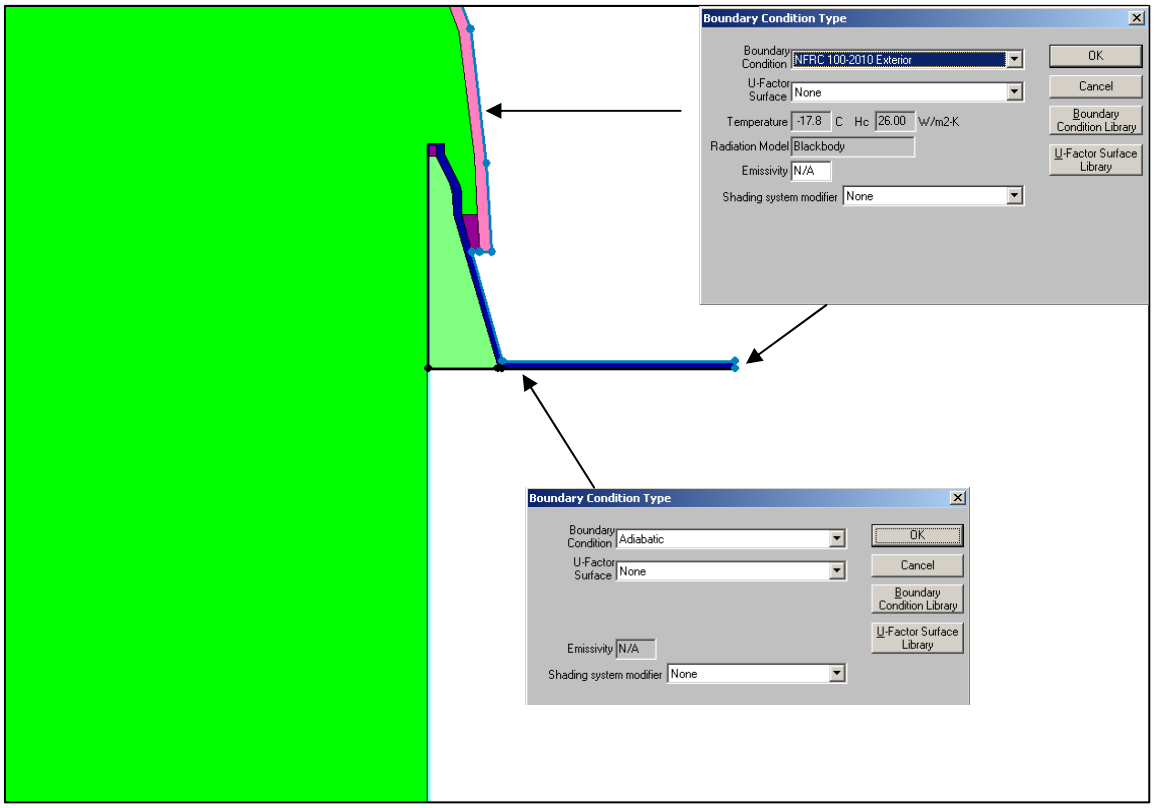


Figure 8-84. Exterior and adiabatic boundary conditions near the top dome

The outside surfaces of the shaft walls, except for the bottom 250 mm (10 inches) should be assigned a user defined "Attic boundary condition" (see description of all boundary conditions at the beginning of this section). The bottom 250 mm (10 in.) of the shaft walls and portion of the diffuser plate edge assembly shall have an "Adiabatic" boundary condition as shown in the figure below.

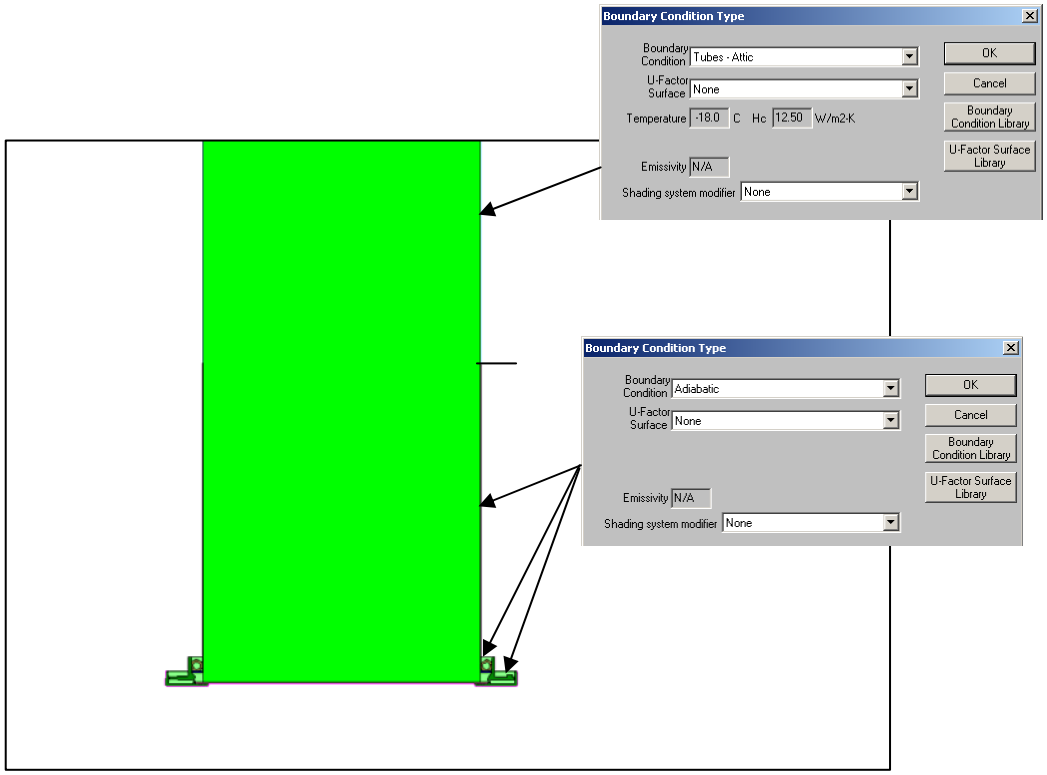


Figure 8-85. Attic and adiabatic boundary conditions on the shaft wall and near the bottom diffuser

The remaining boundary condition, "Indoor Side of Diffuser Plate" shall be applied to the exposed surfaces of the bottom diffuser plate and edge assemblies up to the point where adiabatic boundary condition ends, as shown in the figure below.

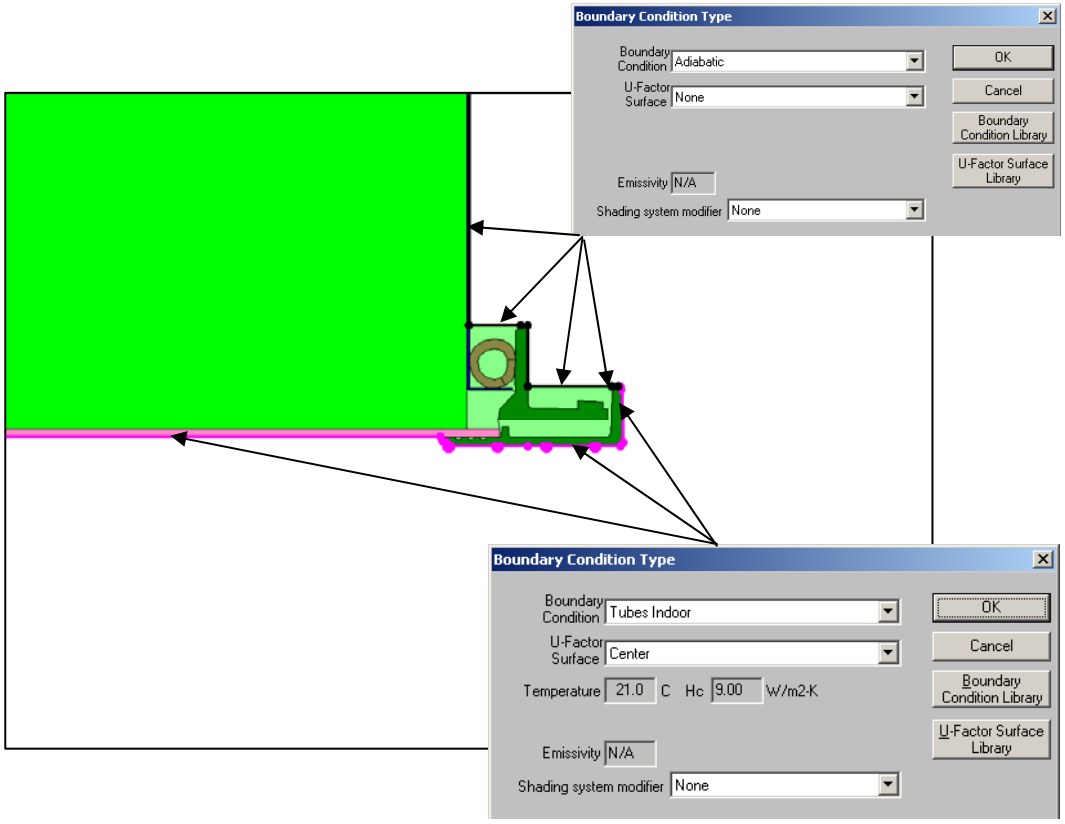


Figure 8-86. Indoor boundary condition on the exposed surfaces of the diffuser plate

After all boundary conditions are defined, the remaining task left is to define the U-factor tag. The U-factor shall be calculated for the area corresponding to the rough opening in the ceiling, which is defined on Figure 8-50. Select bottom diffuser plate and insert points on both sides of the model and define U-factor tag "Center" (or some other name if desired) for the surface between those two points.

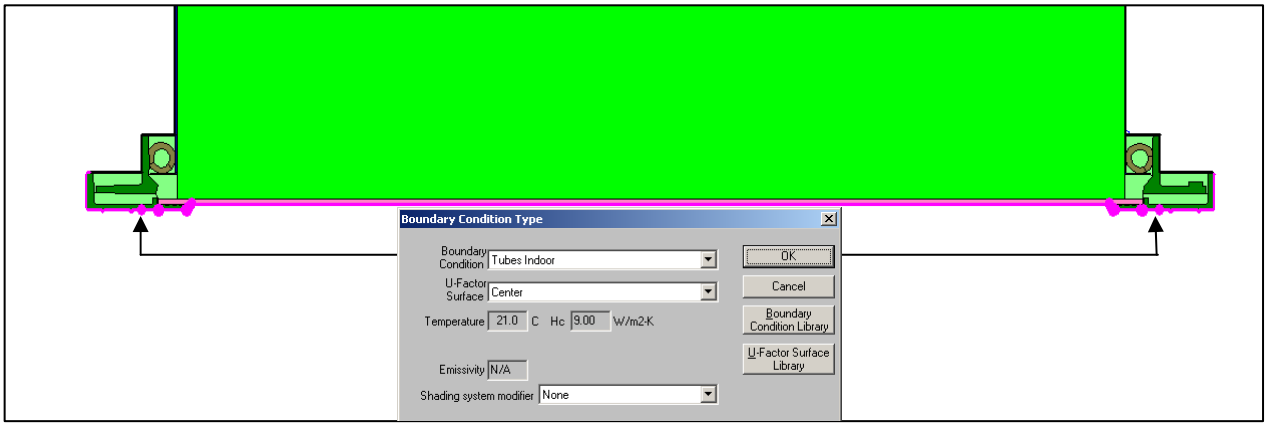


Figure 8-87. Definition of U-factor tag

This completes the definition of the model. The final step is to simulate the problem. As discussed at the beginning of this section, it is an iterative process to obtain the Keff value for the material defined for the

shaft/dome cavity. Once the model has been simulated, find the average temperatures for the diffuser plate and dome surfaces using the tape measuring tool, and if the resulting average temperatures differ by more than 1° C from the estimated values, the new Keff shall be calculated and the simulation repeated until the criterion of 1° C is met. The resulting U-factor is the overall product U-factor.

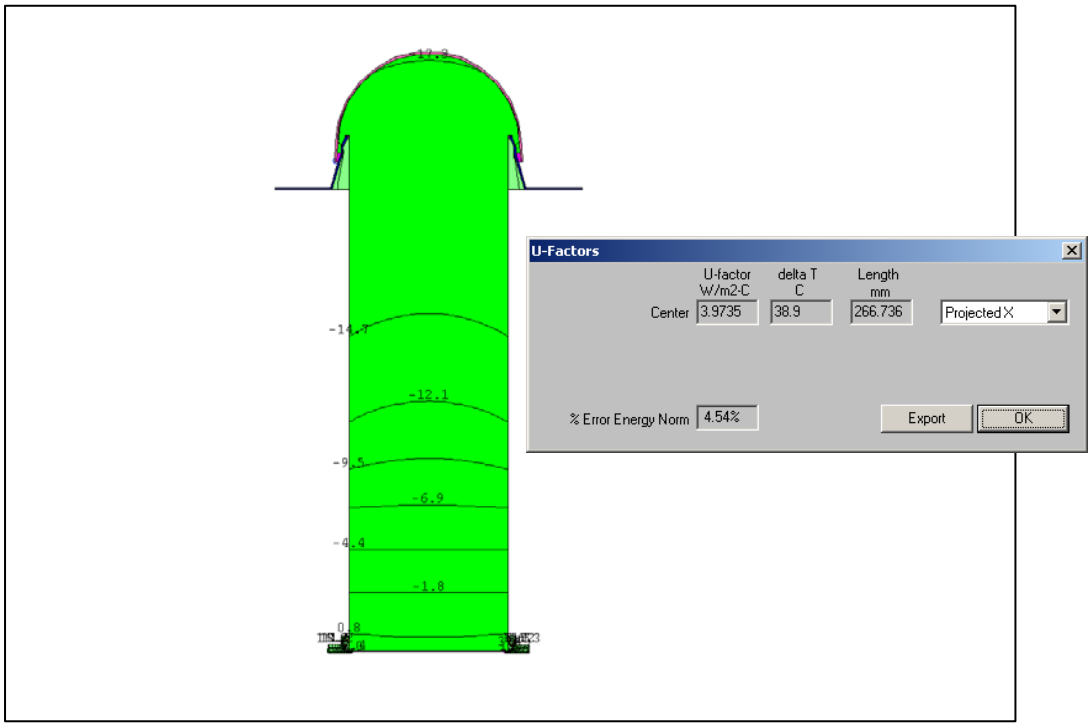


Figure 8-88. Temperature Contour plot and U-factor results

8.6.7. Example: Tubular Device Problem With the Double-Glazed Diffuser Plate

Using a double glazed diffuser plate is a variation to the design presented in the first example. This case can be modeled by first using WINDOW to calculate the effective conductivity of the gap space in a diffuser and then specifying this conductivity in the THERM model.

In WINDOW create a special boundary conditions for this case (i.e., tubes diffuser) by copying the **NFRC 100-2010** record in the Environmental Conditions Library to a new record, and set outdoor wind speed to 0 (this is the closest approximation to convection and radiation heat transfer inside shaft/dome cavity that borders cold side of this double layer diffuser). Name the new environmental condition something that makes it clear how it is to be used, such as "NFRC Tubular Skylight", as shown in the figure below.

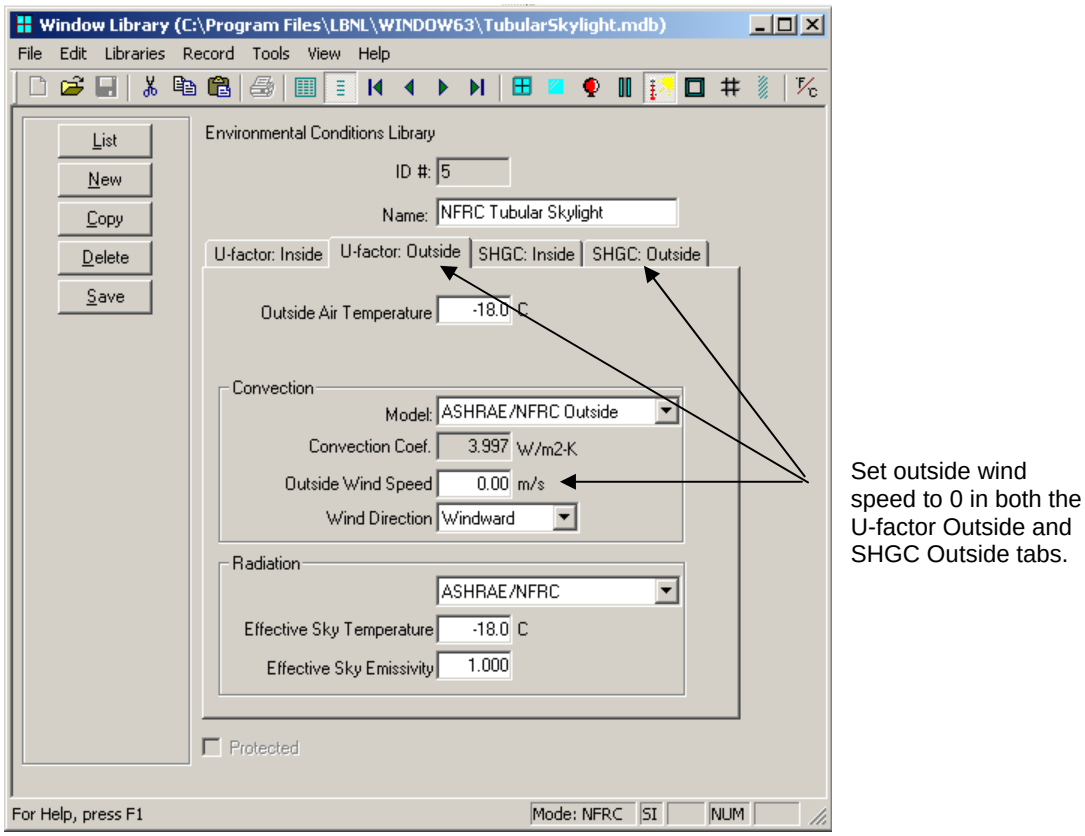


Figure 8-89. New environmental conditions for calculating center of glass performance of the diffuser plate.

In the glass library, create the new glazing layer, naming it appropriately to the material used (called Lexan in this example) and specify the thickness per the manufacturer drawings. Set the conductivity and emissivity by copying the values from the library of material thermo-physical properties or value derived from NFRC 101.

In the Glazing System Library, create a new double glazed system using the newly defined entries in the Glass Library, and reference the new environmental condition, "NFRC Tubular Skylight". Set the tilt to **0** degrees, and set the gap thickness and gap gas according to the manufacturer's specifications. After the calculation is done, make note of the effective conductivity (**Keff** value under the **Center of Glass Results** tab) for later use in THERM.

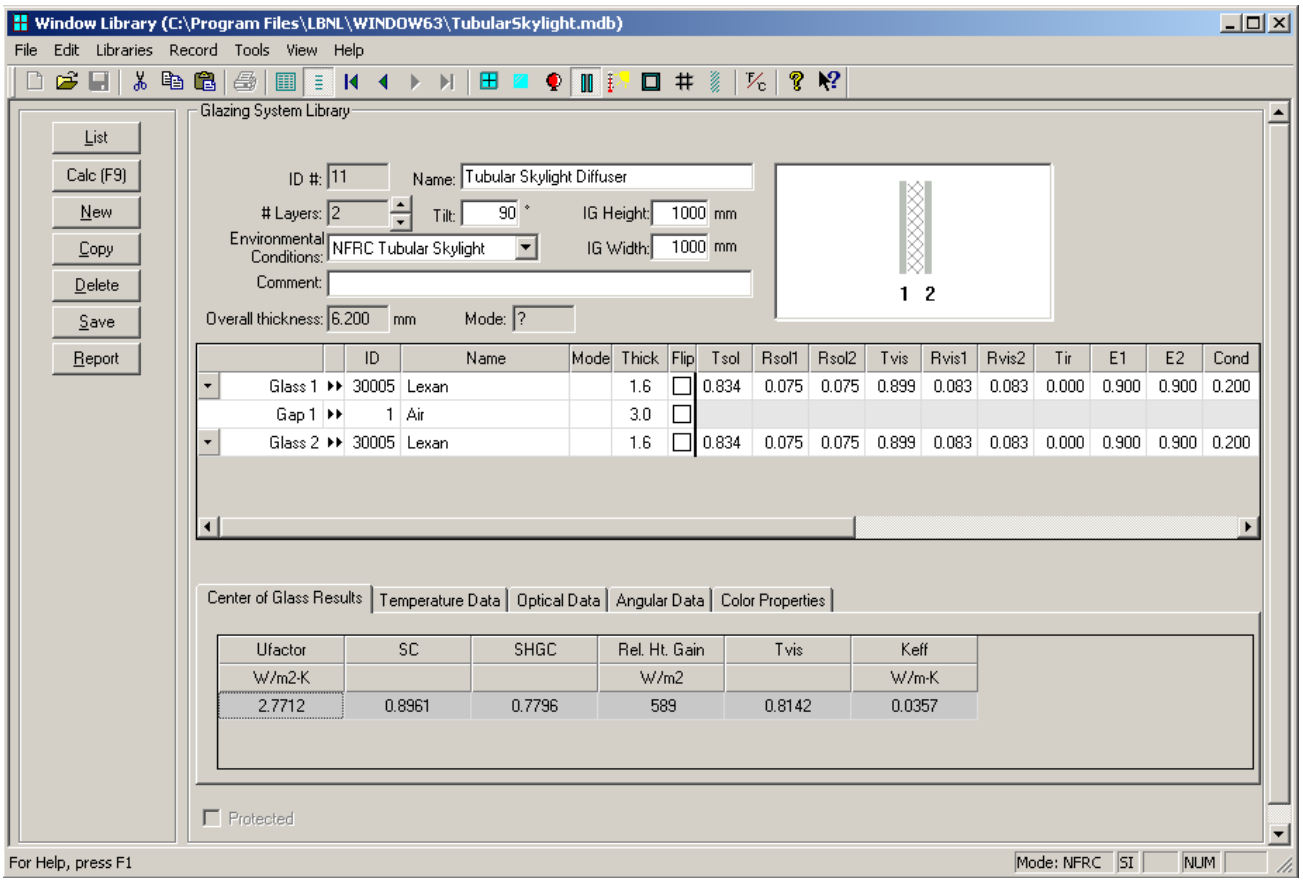


Figure 8-90. Glazing system for the double-layer diffuser plate

These calculations are only for U-factor; the SHGC results will not be valid because the layers were created without spectral data. When performing a calculation on this glazing system, the following message will appear, indicating that there is not spectral data associated with the glazing layers.

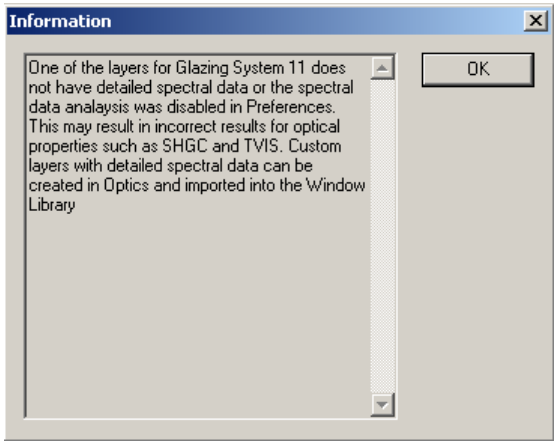


Figure 8-91. Message at calculation time, indicating that there is not spectral data for the glazing layers. Therefore, the SHGC value will not be accurate.

In THERM draw the geometry of the double-layer diffuser plate, including the detail of spacer and draw the rest of the geometry as per original example.

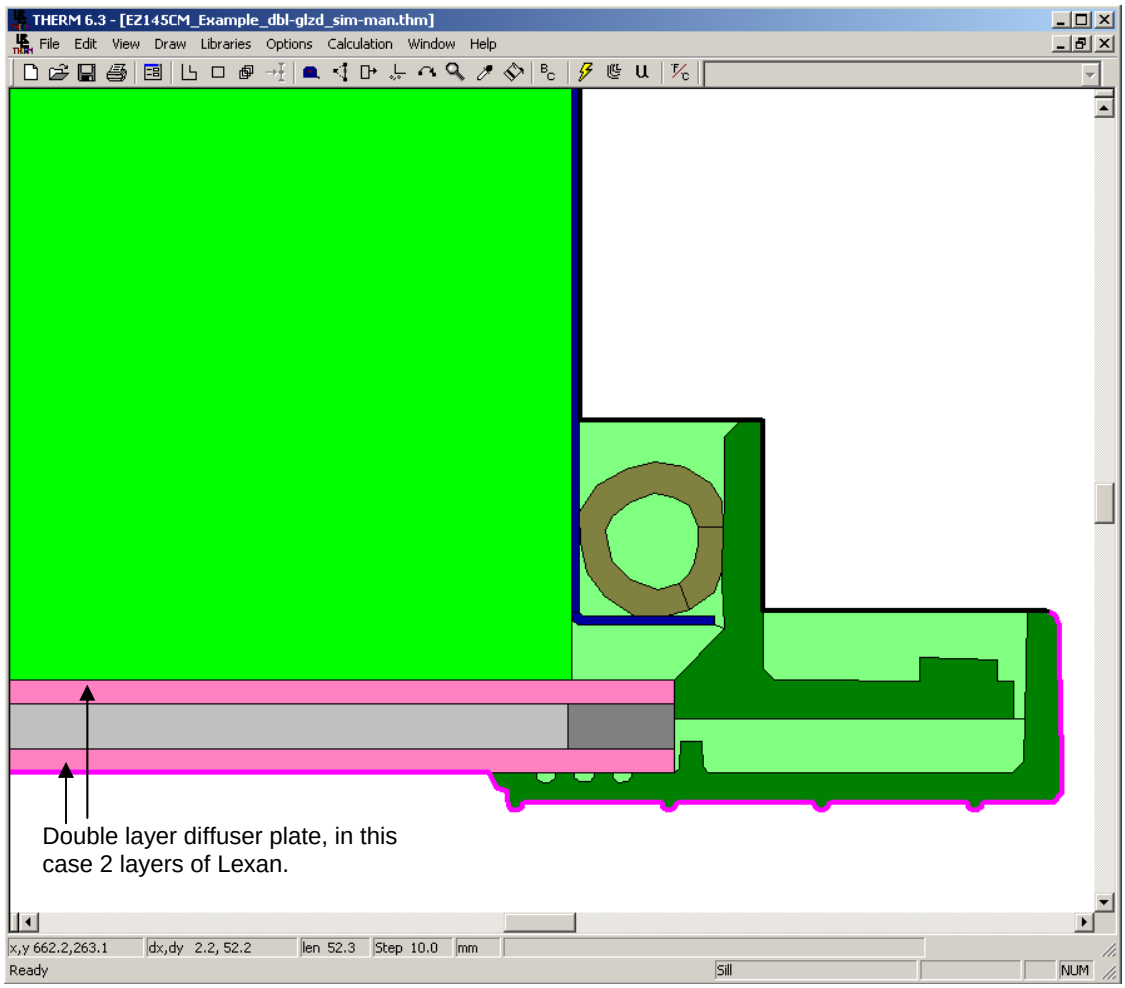


Figure 8-92. THERM model of double-layer diffuser plate

Define a new material with the conductivity equal to the effective conductivity (Keff) calculated in WINDOW and fill the cavity with that material. As discussed at the beginning of this section, it is an iterative process to obtain the Keff value for the material defined for the shaft/dome cavity. Once the model has been simulated, find the average temperatures for the diffuser plate and dome surfaces using the tape measuring tool, and if the resulting average temperatures differ by more than 1° C (2 °F) from the estimated values, the new Keff shall be calculated and the simulation repeated until the criterion of 1° C (2 °F) difference is met.

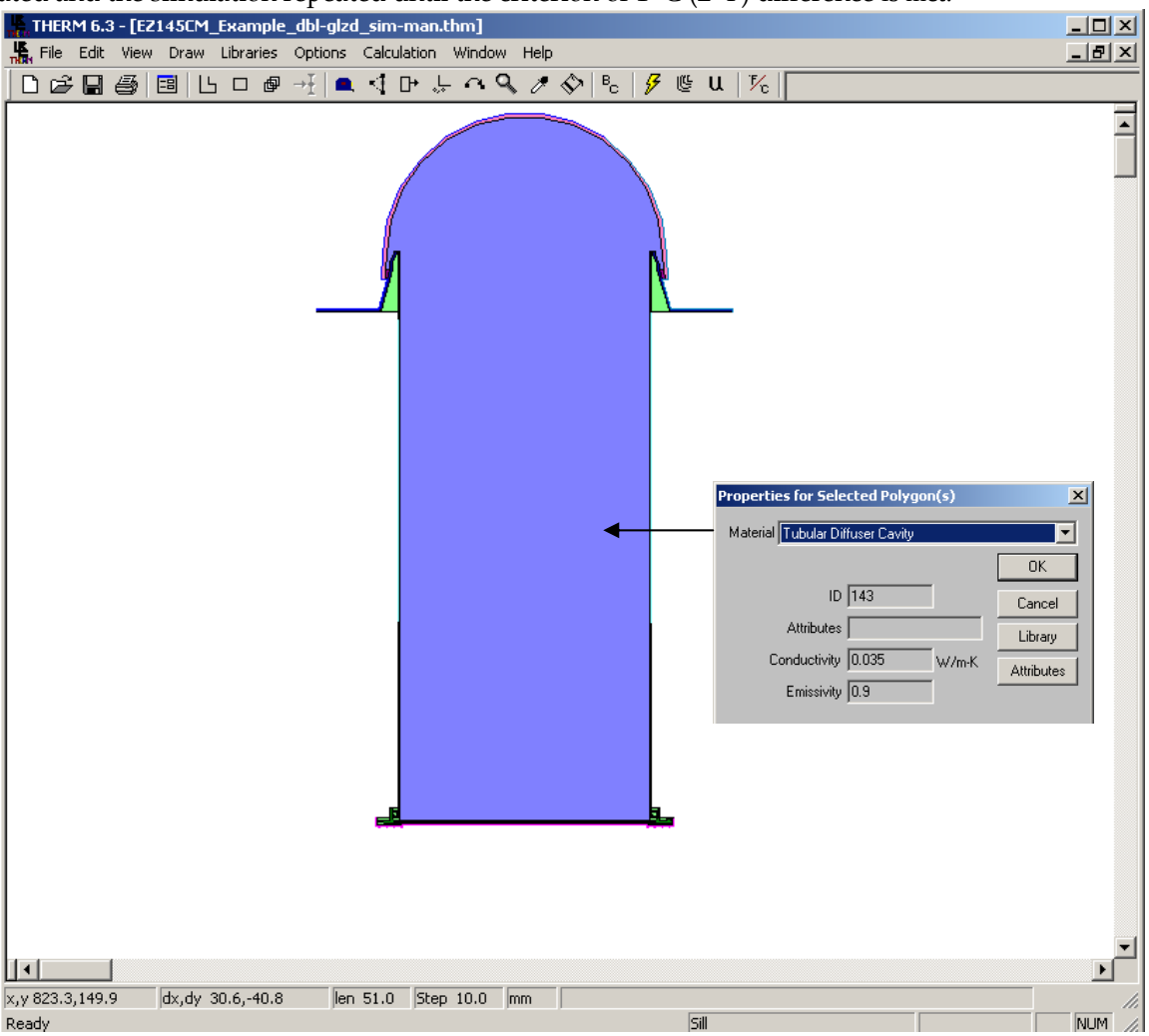


Figure 8-93. THERM model of double-layer diffuser plate

Define the same set of boundary conditions as in previous example and perform calculation. The following are results for an example where the two layers of Polycarbonate diffuser plates, separated by 3 mm (0.1181 inches) of air space and butyl spacer, are used.

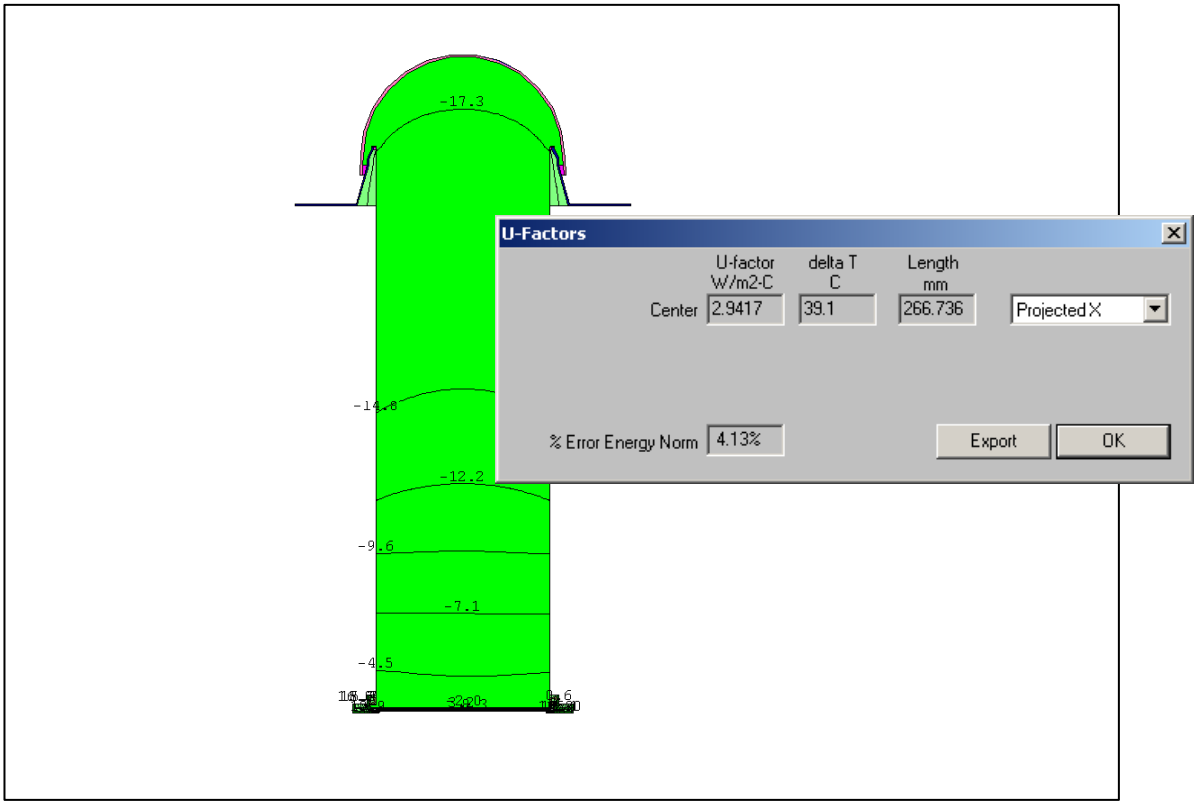


Figure 8-94. Heat Transfer Results for the Tubular Daylighting Device, Incorporating Double-Layer Diffuser Plate

Note that the overall U-factor has been reduced from 3.97 W/m²-°C (0.699 Btu/h-ft²-°F) to 2.94 W/m²-°C (0.518 Btu/h-ft²-°F), by using double-layer configuration for the diffuser plate instead of the original single layer. This analysis does not include solar optical properties or Solar Heat Gain Coefficient calculation, which will also be affected by the introduction of double-glazed diffuser plate. It is likely that the daylighting performance would be negatively affected due to the presence of an additional diffuser plate, which will reduce overall visible transmittance (VT).

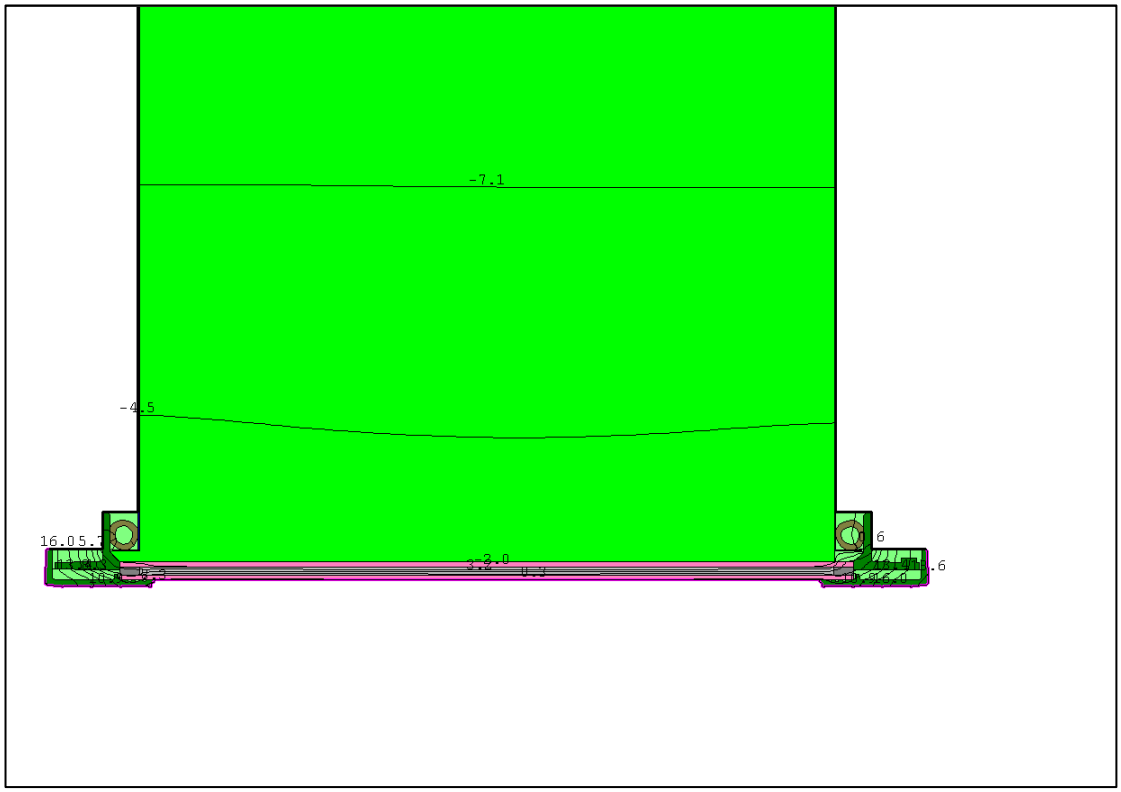


Figure 8-95. Zoomed-in Region Near the Diffuser Plate

References:

Curcija, D.C. 2001. "Proposed Methodology for Modeling Tubular Skylights For NFRC Rating Purposes." CEERE Technical Report. June, 2001.

8.7 Doors

Swinging entry doors are modeled differently than window products because there are more opaque sections to be modeled in THERM. The procedures for modeling doors are included in *NFRC 100* and that document should be reviewed in detail before modeling any entry door systems.

NFRC has defined nine regions within a door that need to be modeled. These regions include:

- Frame Area
- Lite Frame Area
- Divider area
- Edge-of-divider area
- Edge-of-Lite Area
- Center-of-lite area
- Door Core Area
- Panel Area
- Edge-of-Panel Area

NFRC 100 contains several figures which illustrate the location of the door sections to be modeled in THERM.

When modeling glazing options with caming, the NFRC default caming can be used. See the section on Dividers in this chapter for information about modeling caming inside an IG.

A spreadsheet must be used to do the door area-weighting from the THERM files, because the current version of WINDOW does not area-weight doors. In THERM, the U-factor Surface Tags can have any name and as many U-factor Surface Tags can be defined as are needed to accurately describe the model. (See Section 6.2.4, "Define U-factor Surface Tags in the *THERM User's Manual*), so define as many U-factor Surface Tags as needed and name them descriptively.

SHGC CalculationWhen calculating the SHGC for the opaque components of a door, using the ISO 15099 equation for frames (see formula for $SHGC_f$ below), using an h_{out} value of 30 W/m^2-^{o}C.

$$SHGC_f = \alpha_f \cdot \frac{U_f}{\frac{A_{surf}}{A_f} h_{out}}$$

Boundary Conditions for Steel Skin Doors

The following boundary conditions (BC) shall be applied when modeling doors containing a steel skin with either a non-metal or wood edge or steel edge. The appropriate BC shall be applied to applicable individual sections.

Door section material	Boundary Condition
Non-metal / wood edge	Wood / Vinyl
Steel edge	Thermally-Improved

Chapter 9 contains a door example, which describes in detail the THERM modeling steps.

8.8 Spacers

8.8.1. Overview

THERM has the capability to model spacers in great detail, so that modeling of spacer effective conductivity is no longer needed. Spacer models can be easily reshaped in THERM, and the program's cut and paste feature allows spacers to be copied into each cross section as needed. A library of spacer models can be produced for each spacer type. See the *THERM User's Manual*, Section 3.5, "Adding a Custom Spacer". A sample spacer, spacer.thm, is included on the THERM installation CD.

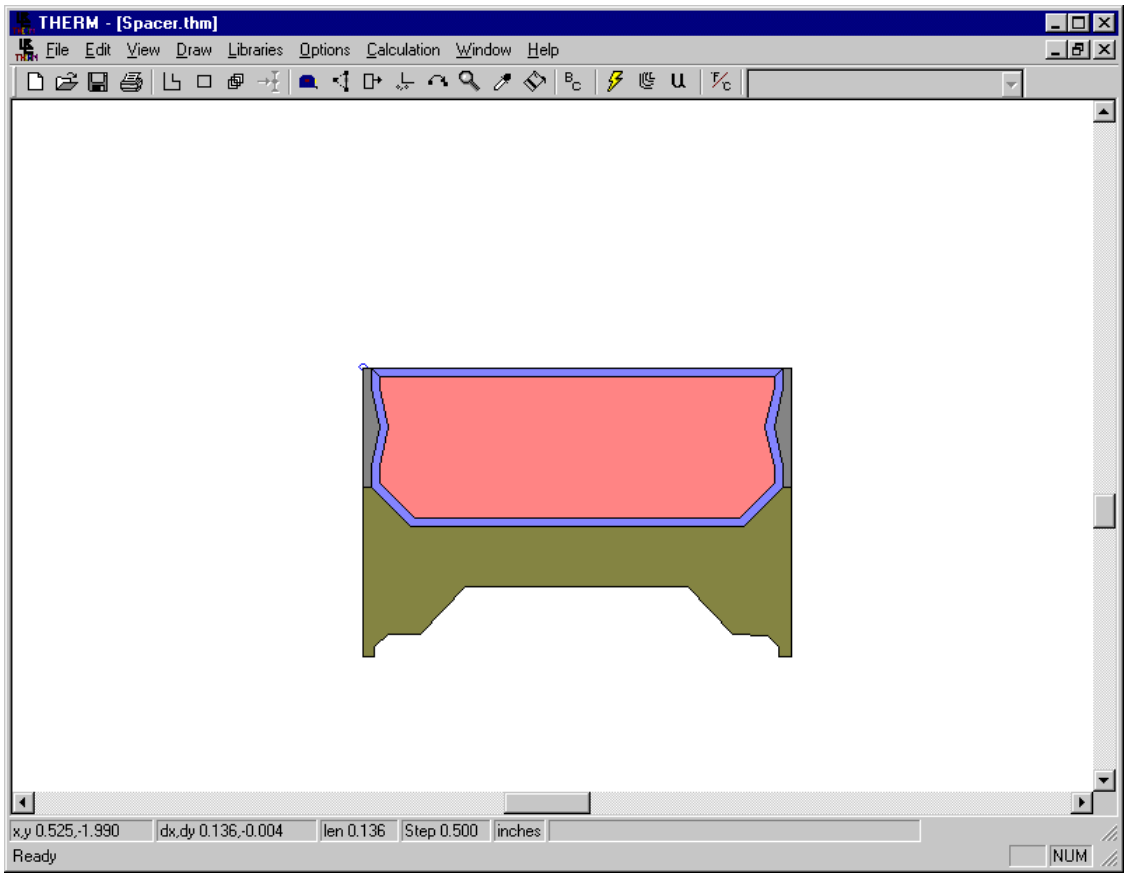


Figure 8-96. spacer.thm sample file.

8.8.2. Linking Glazing Cavity properties (imported from WINDOW) for Open Spacers

The properties of a glazing cavity can be linked to another polygon in order to properly model spacers that are open to the glazing system cavity. Section 5.11.5, "Linking Materials Properties of Polygons" in the *THERM User Manual* explains this methodology in detail.

To Link the properties of two materials, follow these steps:

- Select the polygon that is to linked to another polygon
- Select the Libraries/Create Link menu choice.
- The cursor will become an Eye Dropper. Click the Eye Dropper cursor in the polygon to be linked to. The material properties of the first polygon are not linked to the material properties of the second polygon.

When using the multiple glazing calculation option, THERM will automatically use the glazing system cavity properties for each glazing option for the linked polygon.

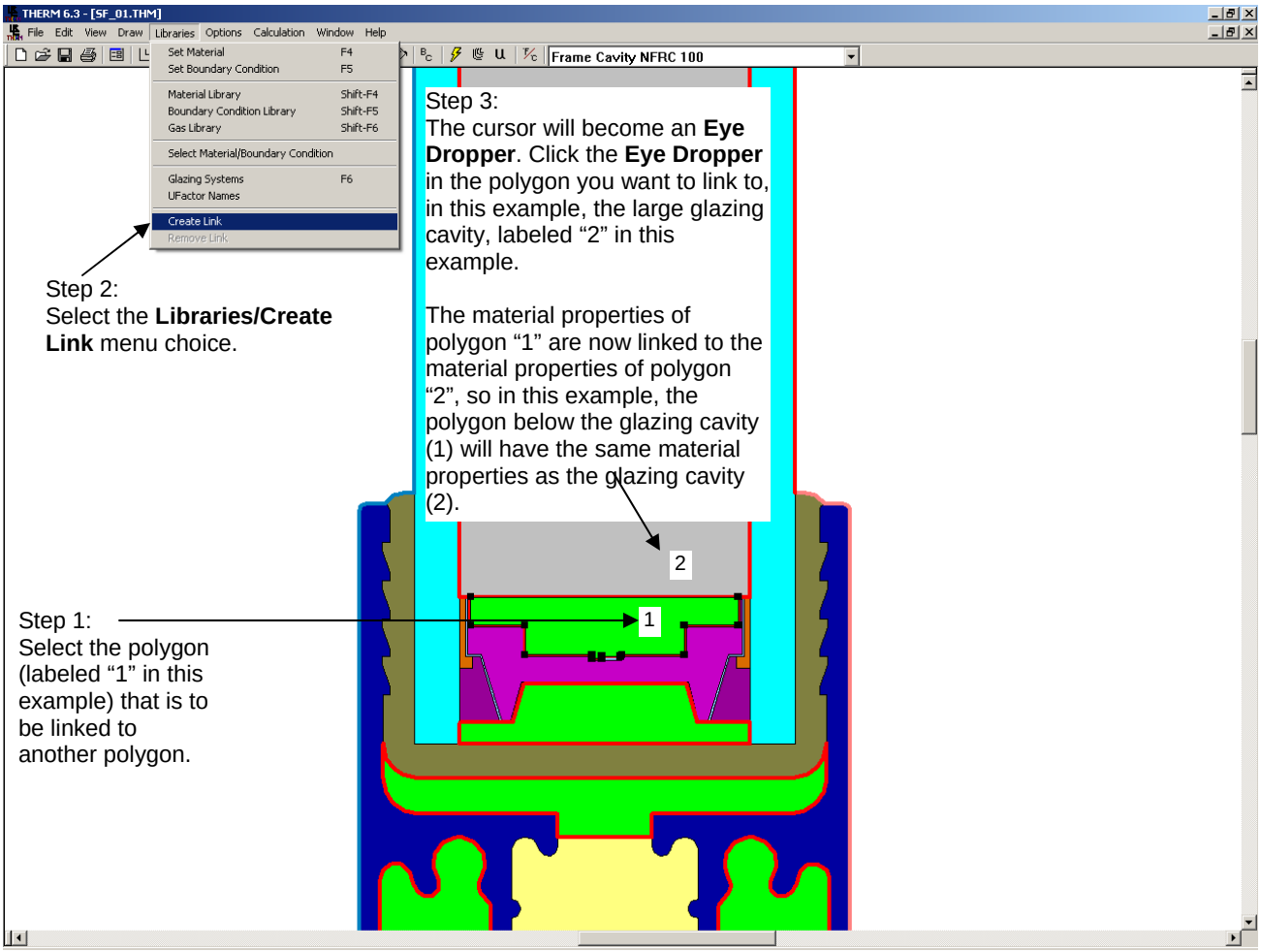


Figure 8-97. Link the open spacer cavity to the glazing system cavity using the Library/Create Link feature .

8.9 Non Continuous Thermal Bridge Elements

Bolts skip and debridge thermal break, including partially de-bridged thermal break material, and thermally slotted cross section shall be included in the model using the concept of *isothermal planes*. The isothermal planes methodology calculates an effective conductivity of the bridging material based on area weighting the sections of the product with and without thermal bridging material based on the bridging material spacing dimensions. This method is also valid for other regularly spaced thermal bridges such as skip-and-debridged systems.

The effect on the performance of a curtain wall system due to bolts is explained in detail in an ASHRAE paper published in 1998 entitled *"The Significance of Bolts in the Thermal Performance of Curtain-Wall Frames for Glazed Facades", by Brent Griffith, Elizabeth Finlayson, Mehrangiz Yazdanian and Dariush Arasteh.*

The THERM model to be simulated for the final result is one in which the actual materials of the thermal bridging elements are replaced with a user-defined material having an effective conductivity which represents the area-weighted value that combines the bridging and non-bridging elements.

Figure 8-98 below illustrates an example of a curtain wall system which would require that the thermal bridging elements, in this case the bolts, be modeled using the isothermal planes method.

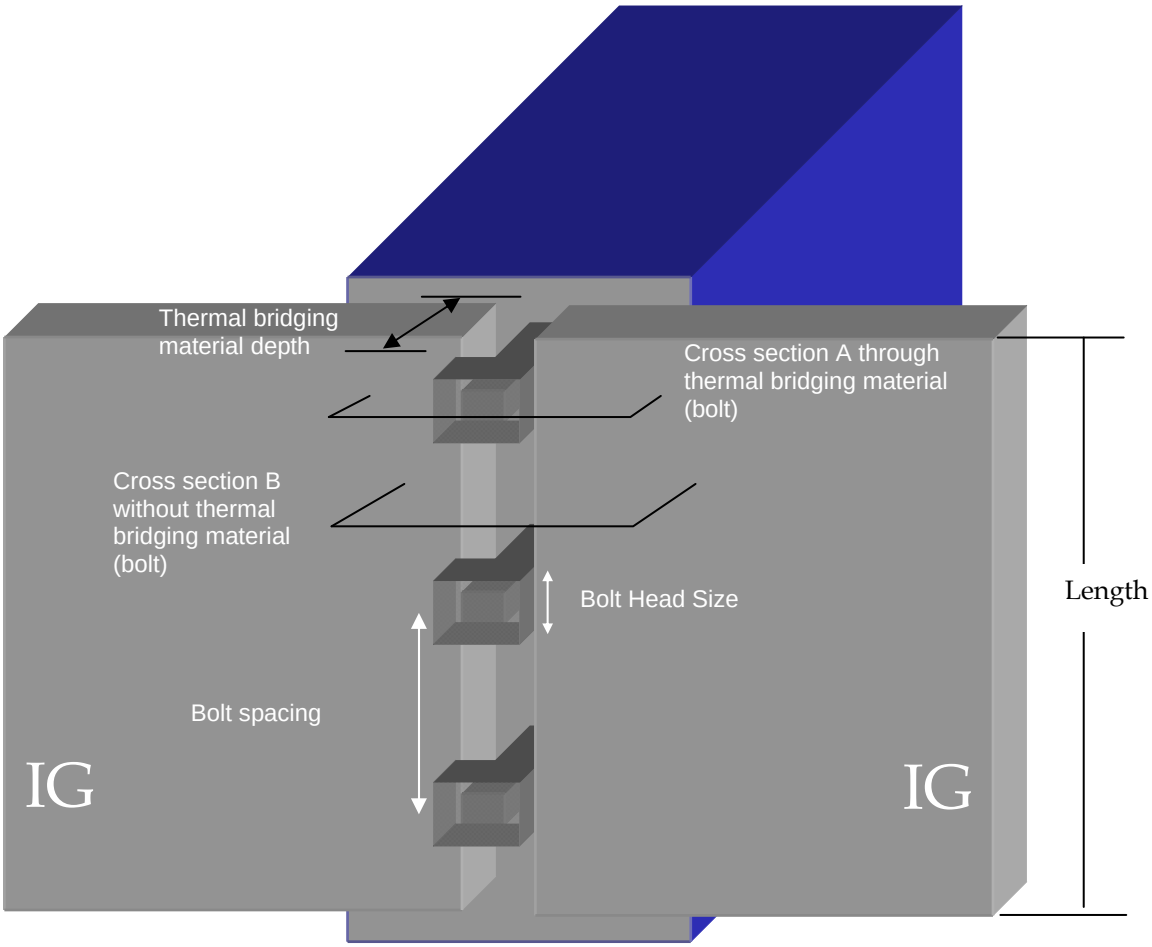


Figure 8-98. Example of a curtain wall system with regularly spaced bolts which act as thermal bridges.

8.9.3. Modeling Steps

The steps for constructing the final THERM model to be simulated are the following:

1. Draw the THERM model without the thermal bridging material.
2. Determine the conductivities of the materials that the thermal bridging material replaces.
   - Conductivities of *materials* can be obtained from the THERM Material Library
   - Conductivities of *air-filled* cavities (such as frame cavities) are assumed to be 0.024 W/m-K (or 0.014 Btu/hr-ft-^{o}F).
3. Using a cross-section that contains the non-thermal bridging material, measure the depths of each element of the non-thermal bridging material that will have a different thermal conductivity in the non-bridging cross section.
4. Use the conductivities of the non-thermal bridging materials and depths of the non-thermal bridging materials in Equation 2 below to determine the Resistance (R) for each non-thermal bridging element.
5. Sum the resistances (Rt) and divide by the total depth of the non-thermal bridging elements to obtain Kn, as shown in Equation 3, to calculate the conductivity of the non-thermal bridging elements
6. Calculate the fraction of thermal and non-thermal bridging material along the length of the façade using Equations 4 and 5.
7. Calculate the final effective conductivity value for the thermal bridging elements using Equation 1.
8. In THERM, define a new material with the Keff value derived in Step 7, and assign it to the cross section polygons that represent the thermal bridging elements.
9. Simulate the model.

8.9.4. Equations

Calculate the effective conductivity of thermal bridging elements (e.g., bolts, screws, etc.)

Keff= Fb*Kb + Fn*Kn *Equation 1*

where

Fb = Fraction of the Length which contains the thermal bridging elements (see equation 4 below)

Fn = the fraction of the Length which contains non-thermal bridging elements(see equation 5 below)

Kb = conductivity of the thermal bridging elements

Kn = conductivity of the non-thermal-bridging elements
(from the sum of the resistances, Rt, of individual elements from Equation 2 below)
Assume a default value of 0.024 W/m-K for air cavities.

This methodology should be applied with the following caveats:

- If less than 1% (to obtain percentage, multiply fraction by a 100) of the Length is made of thermal bridging elements (such as stainless steel), i.e., Fb < 0.01, do not model the thermal bridging elements.
- If between 1% and 5% of the Length is made of thermal bridging elements (0.01 <= Fb <= 0.05) and if the conductivity of the thermal bridging elements is more than 10 times the conductivity of the thermal break, model the thermal bridging elements using the keff calculated in Equation 1.
- If more than 5% of the length is made of thermal bridging elements (Fb > 0.05), model the thermal bridging elements using the keff calculated in Equation 1.

Calculate the total resistance of the non-thermal bridging elements, Rt, by summing individual resistances (non-thermal bridging element conductivity) for each non-thermal bridging element using the formula:

$Rt = \Sigma(D / k)$ *Equation 2*

Where:

Rt = Sum of the thermal resistances of the individual non-thermal bridging material. Units: $m^2 \cdot K/W$ (SI), or $hr \cdot ft^2 \cdot °F/Btu$ (IP)

D = Depth of the individual non-thermal bridging elements that will be substituted by the calculated effective conductivity. Units: m (SI), or ft (IP), or (in) (alternate IP)k = conductivity of the individual non-thermal bridging elements that will be substituted. Units: $W/m \cdot K$ (SI), or $Btu/hr \cdot in \cdot °F$ (IP), or $Btu \cdot in/hr \cdot ft^2 \cdot °F$ (alternate IP)

Therefore:

Kn=Dt/Rt *Equation 3*

Where:

Dt = Total depth, which is the sum of the depths of the individual non-thermal bridging elements

Calculate the fraction of thermal bridging material to non thermal bridging material as follows:

Fb=Wb / Sb (%Fb=Fb·100) *Equation 4*

Fn=1-Fb *Equation 5*

Where:

Wb = Bridging material width

Sb = Bridging material spacing

8.9.5. Example 1: Bolts in Curtain Wall

Note: This example is only presented in SI units and is not translated into IP units.

The following figures show two cross sections of the curtain wall in Figure 8-96. Figure 8-97 represents the cross section of the curtain wall where the bolt occurs (screw threads should be averaged and not drawn explicitly), and Figure 8-98 represents the cross section of the curtain wall where the bolt does not occur. The geometry of the cross-section in Figure 8-97 would be used for the final THERM run, and the conductivity of the materials used to define the bolt would be changed to the value derived from the methodology explained in this section. The geometry in Figure 8-98 is drawn only to obtain the conductivity values for calculating the conductivity of this "averaged" material.

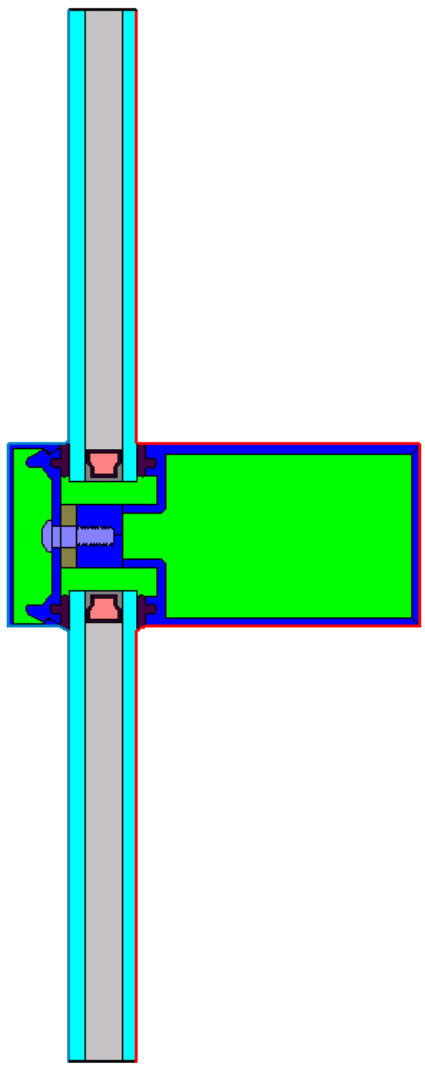


Figure 8-99. THERM cross section where the bolt occurs (curtain wall bolt.thm).

Figure 8-98 shows the conductivity values for the four materials that must be obtained for the calculation. Material 1 and 4 are air cavities, and the conductivity is assumed to be 0.024 W/m-K.

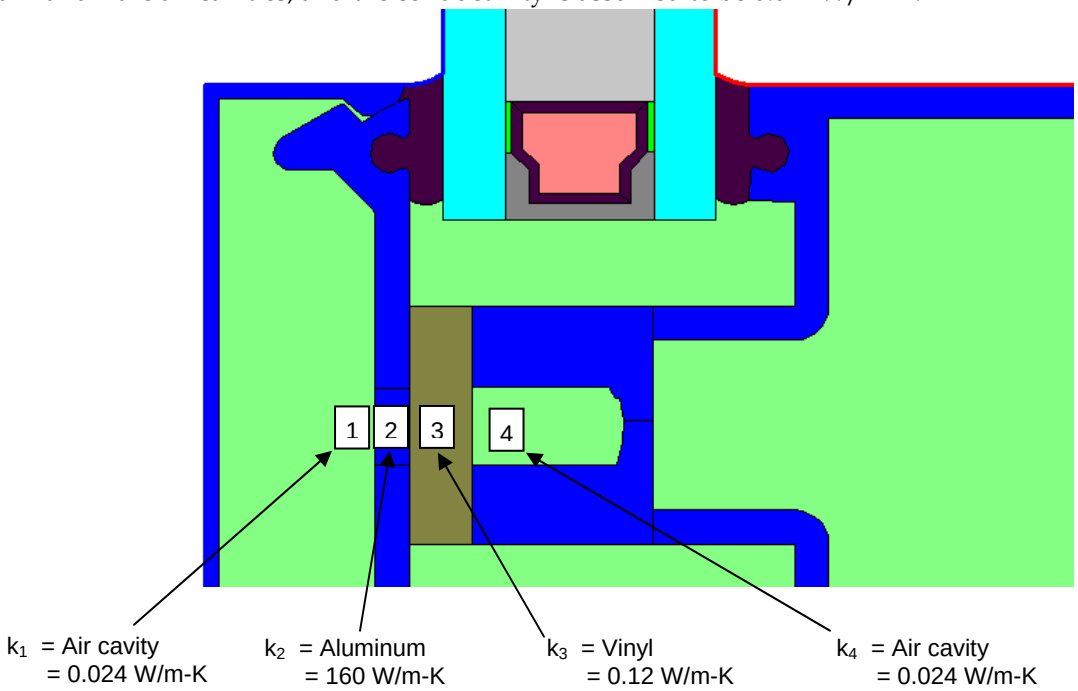


Figure 8-100. Materials in the non-bridging material cross section for which conductivities must be obtained.

Figure 8-99 shows the depths of each of the thermal bridging elements that are used in the Keff calculation.

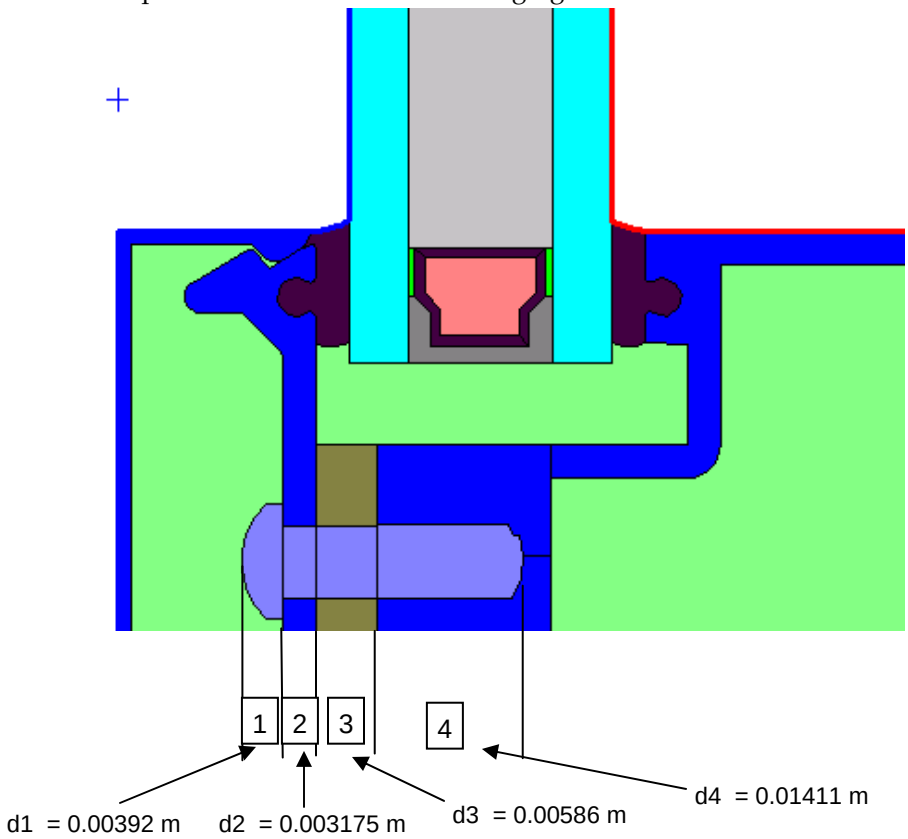


Figure 8-101. Material depths for the thermal bridging materials.

Table 8-1 shows the conductivity and depth values used to calculate the R for each non-thermal bridging element using Equation 2.

Table 8-1

Cross Section Element	Material	**Conductivity [W/mK]**	**Depth (m)**	**R [m2K/W]**
1	Air cavity (default value)	0.024	0.00392	0.16333
2	Aluminum (conductivity from THERM Material Library)	160	0.003175	0.0000198
3	Vinyl (conductivity from THERM Material Library)	0.12	0.00586	0.049
4	Air cavity (default value)	0.024	0.01411	0.587917
	Total		**0.02706**	**0.800103**

Calculate Rt as follows:

$R_t = \Sigma(d/k)$

$= (d_1/k_1) + (d_2/k_2) + (d_3/k_3) + (d_4/k_4)$

$= (0.00392 / 0.024) + (0.003175 / 160) + (0.00586 / 0.12) + (0.01411 / 0.024)$

$= 0.800103\ m^2K/W$

$D_t = 0.00392\ m + 0.003175\ m + 0.00586\ m + 0.01411\ m$

$= 0.02706\ m$

Calculate the conductivities as follows:

$Kn = D_t/R_t$

$= 0.02706 / 0.800103$

$= 0.033821\ W/m \cdot K$

Kb = 14.3 W/m·K (stainless steel)

Calculate the fraction of bolt to no bolt as follows:

Wb = Bolt head width

= 11.1 mm

Sb = Bolt spacing 12′′

= 304.8 mm

Fb = Wb / Sb

= 11.1 mm / 304.8 mm

= 0.036 (%Fb=0.036·100 = 3.6%)

Fn = 1-Fb

= 1- 0.036

= 0.964

Calculate the new Keff, which will be used in THERM as follows:

Keff = Fb*Kb + Fn*Kn

Keff = (0.036 * 14.3)+(0.964 * 0.033827)

= 0.55 W/m·K

In THERM, create a new material in the Material Library with this Keff. In the THERM cross section, the bolt material should be changed from Stainless Steel to this new material. The resulting cross section is a 2-D thermal equivalent of the cross section with and without the thermal bridging material.

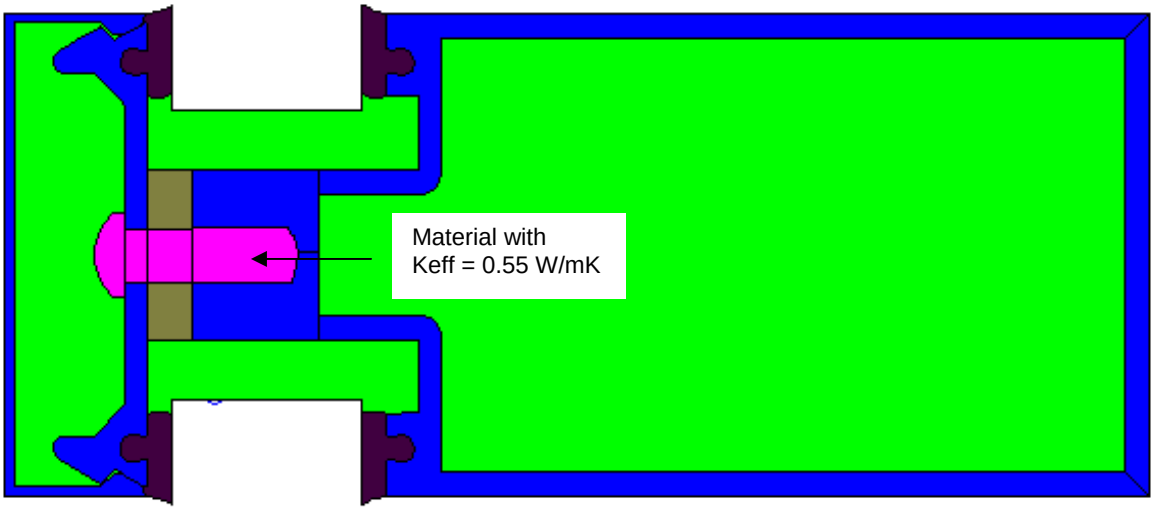


Figure 8-102. Final THERM model with boundary conditions defined.

8.9.6. Example 2: Thermally slotted cross-section

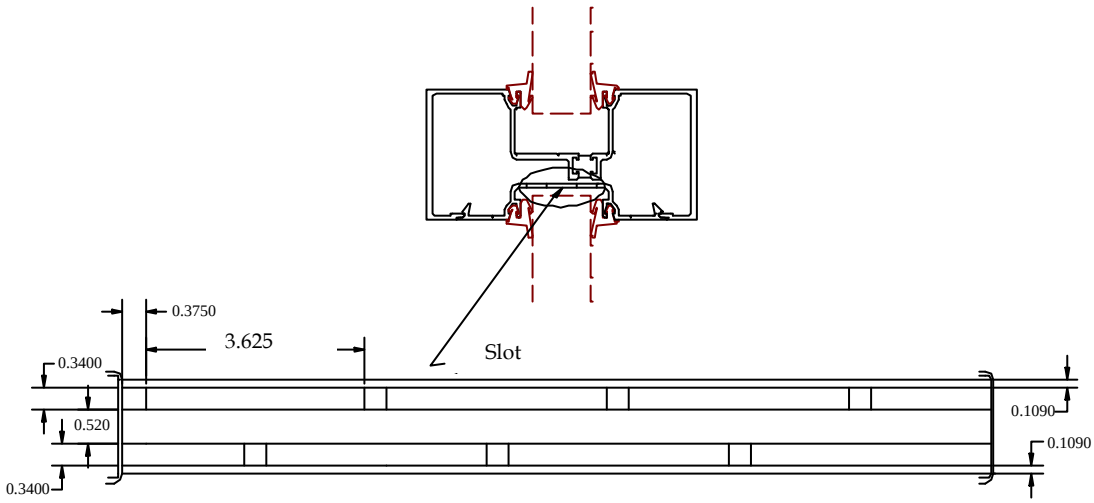


Figure 8-103. DXF for thermally slotted cross section.

Step I

Skip = 0.009525 m (0.375 in)

Slot (Air) = 0.092075 m (3.625 in)

Interval = 0.092075 m (3.625 in) + 0.009525 m (0.375 in)

= 0.1016 m (4 in)

=)

Fb = 0.009525 m/ 0.1016 m

= 0.094 m (3.7 in)

Fn = 1-Fb

= 1- 0.094 m

= 0.906 m (35.67 in)

Percent of thermal bridge = (Fb)*100

= (0.094 m) * 100

= 9.4%

Because the thermal bridge is 9.4% of the length of the façade, the skip-and-debridge needs to be calculated using the isothermal plane procedure. Note: The rest of the example will be in SI units only, with no IP unit translation

Kb = 160 W/m-K (conductivity of skipped debridge, in this case Aluminum)

Rt = ∑ (Depth/ conductivity)

= D_d/k_d

= (0.0086 m/0.024W/m-K)

= 0.35833 m^2-K/W

where Depth is length of thermal bridge in a direction of heat flow, and the air is assumed to have the conductivity of 0.024 W/m-K

Kn = total depth/Rt

= 0.0086m/ 0.35833 W/m-K

= 0.024W/m-K

Keff = Fb*Kb +Fn*Kn

= 0.094*160 W/m-K + 0.906* 0.024W/m-K

= 15.062 W/m-K

To convert to IP:

Keff = 15.062 W/m-K * 0.57782

= 8.703 Btu/hr-ft-^{o}F

or in alternative IP units,

Keff = 15.062* 0.57782 * 12 in/ft

= 104.436 Btu-in/hr-ft^2-^{o}F

Step-2

Replace the strip of air-aluminum-air with new keff material of 15.078 W/m-K

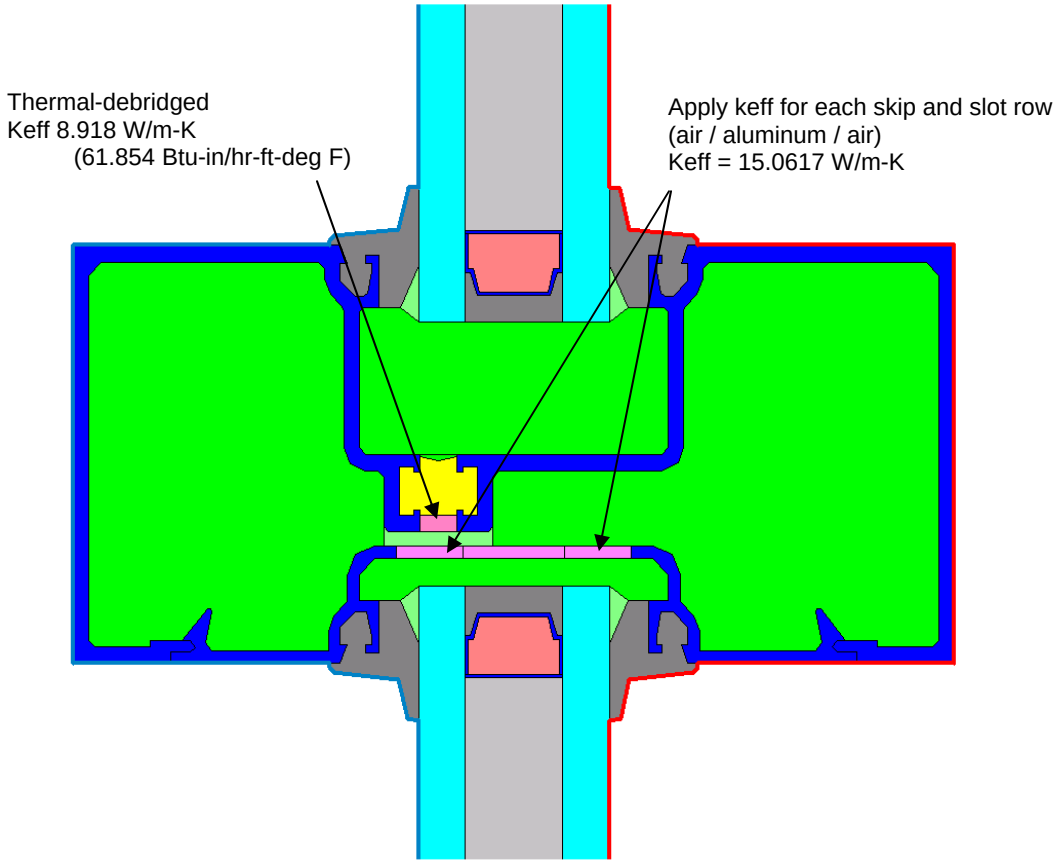
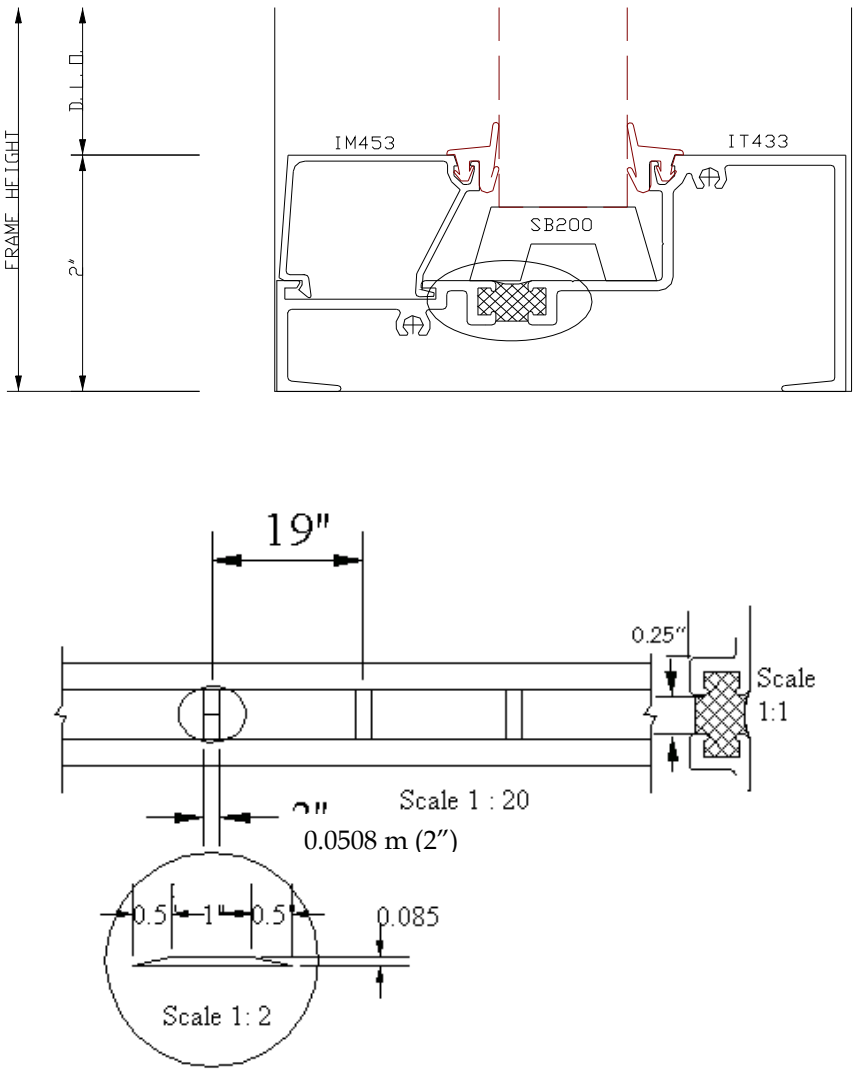


Figure 8-104. New Keff assigned to each skip and debridged row.

Step 3

Define the Boundary condition and run the model to calculate the U-factor for frame and edge-of-glass.

8.9.7. Example 3: Skip-and-debridge:



Note: the skip trapezoid shall be treated as a rectangle equal to the total length of the base of the trapezoid.

Figure 8-105. Drawings for Example 3 Skip and Debridge.

STEP 1

Skip = 0.0508 m (2 in)

Debridge (Air) = 0.4318 m (17 in)

Interval = 0.508 m (2 in) + 0.4318m (17 in) = 0.4826 m (19 in)

Note: The rest of the example will be in SI units only, with no IP unit translation

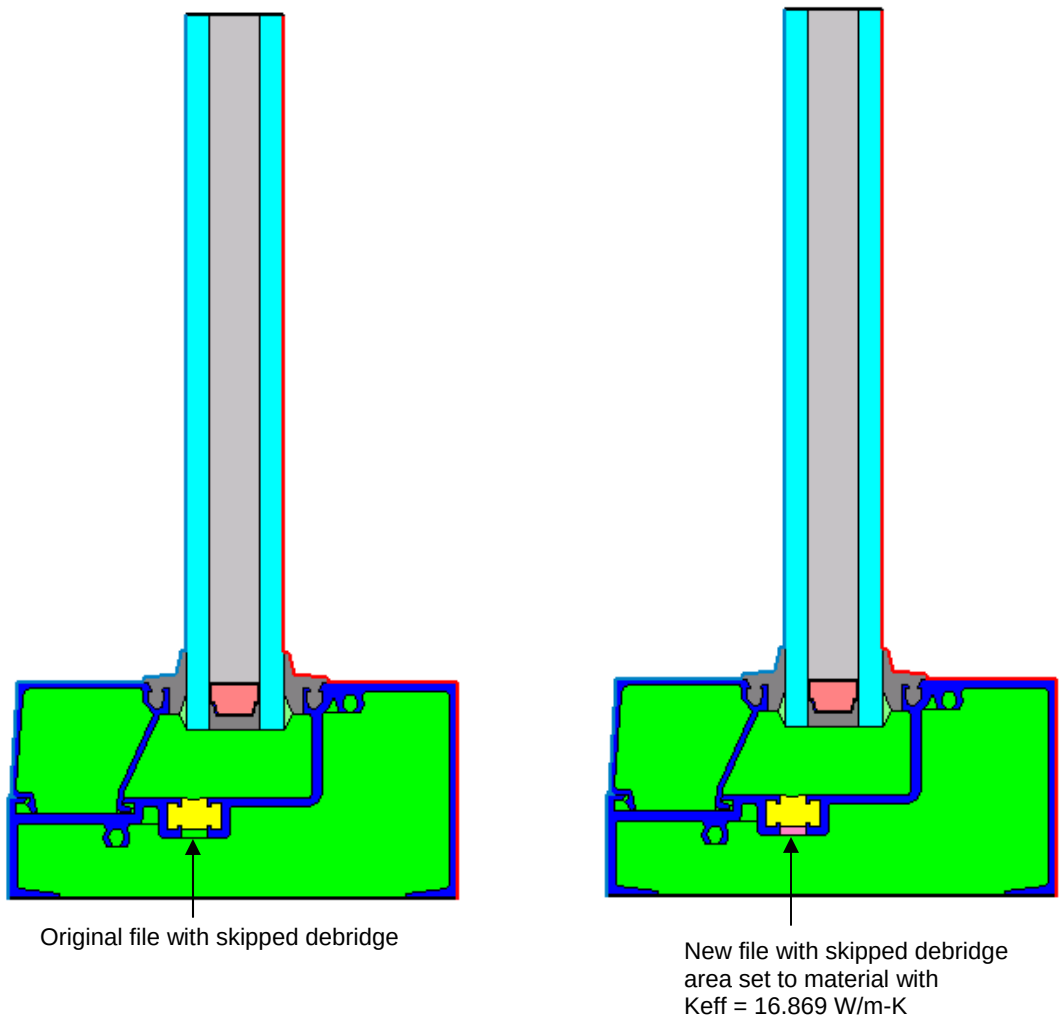


Figure 8-106. Original THERM model and new model with new Keff for skipped debridge area.

Fb = 0.0508 m/ 0.4826 m = 0.1053

Fn = 1-Fb
= 1- 0.1053 = 0.4947

%Fb = (Fb) ·100
= (0.1053) · 100
= 10.53% (Skip-and-debridge needs to be calculated using Isothermal plane procedure).

Kb = 160 W/m-K (conductivity of skipped debridge, in this case aluminum)

Rt = ∑ Length/ conductivity
= (0.00635 m/0.024 W/m-K)
= 0.2646 m^2-K/W

The length is the length of material in a direction of heat flow i.e. 0.25″ as shown in the figure. (The air effective conductivity calculated using THEM)

Kn = length/Rt
= 0.00635m/0.2646 m^2-K/W
= 0.024 W/m-K

Keff = Fb*Kb +Fn*Kn
= 0.1053*160 W/m-K + 0.8947*0.024 W/m-K
= 16.869 W/m-K

To convert to IP:

Keff = 16.869 * 0.57782 = 9.747 Btu/hr-ft-F (or in alternative IP Units: 116.97 Btu-in/hr-ft^2-F)

8.10 Site Built fenestration products (Curtain Walls, Window Walls and Sloped Glazing)

A few things to be aware of:

- Review the drawings carefully for non-continuous elements. These systems tend to have many such elements including shear blocks, installation clips and spacers at the bolts.
- Site built modeling is partially dependent on the installation of the product. Make sure that the drawings you have show the installation.
- Site built products are typically multiple lite systems where the intermediate vertical and horizontal frame members repeat in some pattern.
- Curtain Walls, per NFRC 100 Table 4-3, shall be simulated and tested with the intermediate verticals as jambs and intermediate horizontals as the head and sill members.
- Window Walls, or also known as strip windows, per NFRC 100 Table 4-3, shall be tested and simulated with intermediate verticals as jambs and standard head and sill members.
- Sloped Glazing may also be rated based on the centerline dimensions if utilized like a curtain wall or window wall, except for solariums and sunrooms. Sloped glazing of solariums and sunrooms shall be simulated and tested with standard jamb, head, and sill members.

Modeling of the representative products above used to compare to the physical validation test is as follows:

1. Simulate the full vertical intermediate member twice (for the left and right jambs):
    a. Once with the left glass replaced with wood, which is the same thickness as the IG unit
    b. Once with the right glass replaced with wood, which is the same thickness as the IG unit. The wood shall extend to the original site line.
2. Simulate the horizontal members.
    a. If this is for a curtain wall, then once with the top glass replaced with wood, which is the same thickness as the IG unit and then a second time with the bottom glass replaced with wood, which is the same thickness as the IG unit. The wood shall extend to the original site line.
    b. If this is for a window wall or sloped glazing, then the standard sill and head members are modeled.
3. A physical thermal testing laboratory shall test a sample with the same cross sections as simulated in the steps listed above per NFRC 102.
4. Validation is checked by comparing the values obtained by simulating the product using steps 1 and 2 above, and the physical test results.

8.10.1. Curtain Walls, Window Walls, and Sloped Glazing

NFRC defines a curtain wall and window wall as any building wall carrying no super imposed vertical load. A *curtain/window wall system* will typically be exterior to the building framework and will typically bypass the building floors.

NFRC 100 Table 4.3 states that curtain walls, window walls, and sloped glazed wall systemsare simulated as two lites with one vertical mullion. See the introduction to this section for the specific members of curtain walls, window walls, and sloped glazed wall systems that are to be modeled. If the intermediate vertical and horizontal members were simulated full width or height for the jambs, head and sill, then the total area of the frame as simulated would be significantly larger than actual frames, so for rating purposes, some members (depending on

whether it is a curtain wall, window wall or sloped glazing) are simulated as ½ the full height (for head and sill) or width (for jambs). The vertical mullion is always simulated full width.

Modeling Procedures:

- **Curtain Walls:** See the modeling steps in the following section.

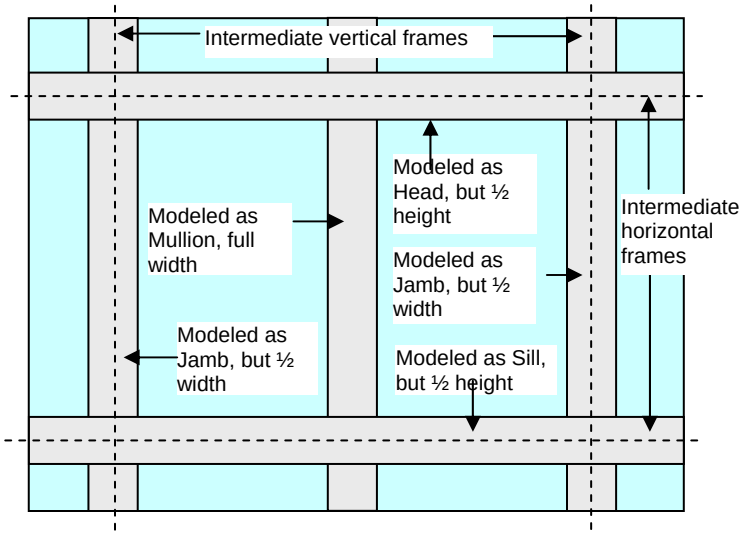


Figure 8-107. Curtain Wall Modeling Method

- **Window Walls:** For window walls, the standard head and sill members are modeled, and therefore the steps for simulation are identical to that of a normal window cross-section.

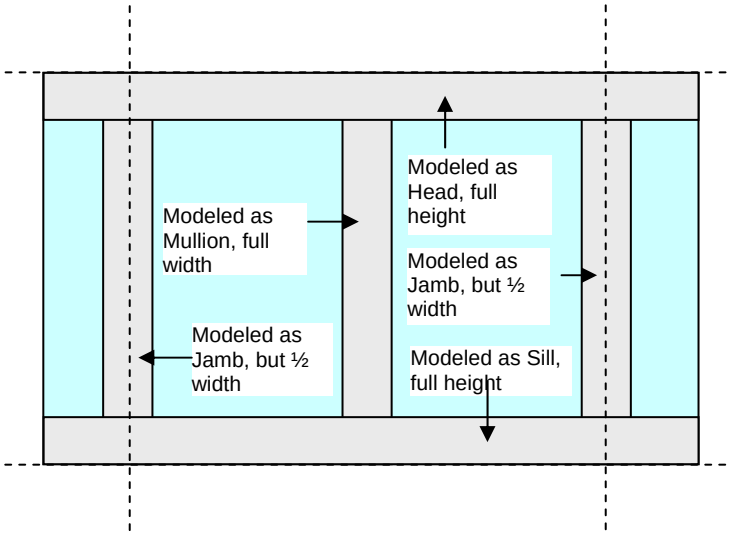


Figure 8-108. Window Wall Modeling Method

- **Sloped Glazed Wall System:** If the product to be simulated is a sloped glazed wall system, then the modeling steps are identical to a curtain wall or window wall, except that the cross-section is to be sloped 20 degrees (see skylight section for instruction on sloping products).

8.10.2. Curtain Wall Modeling Procedure

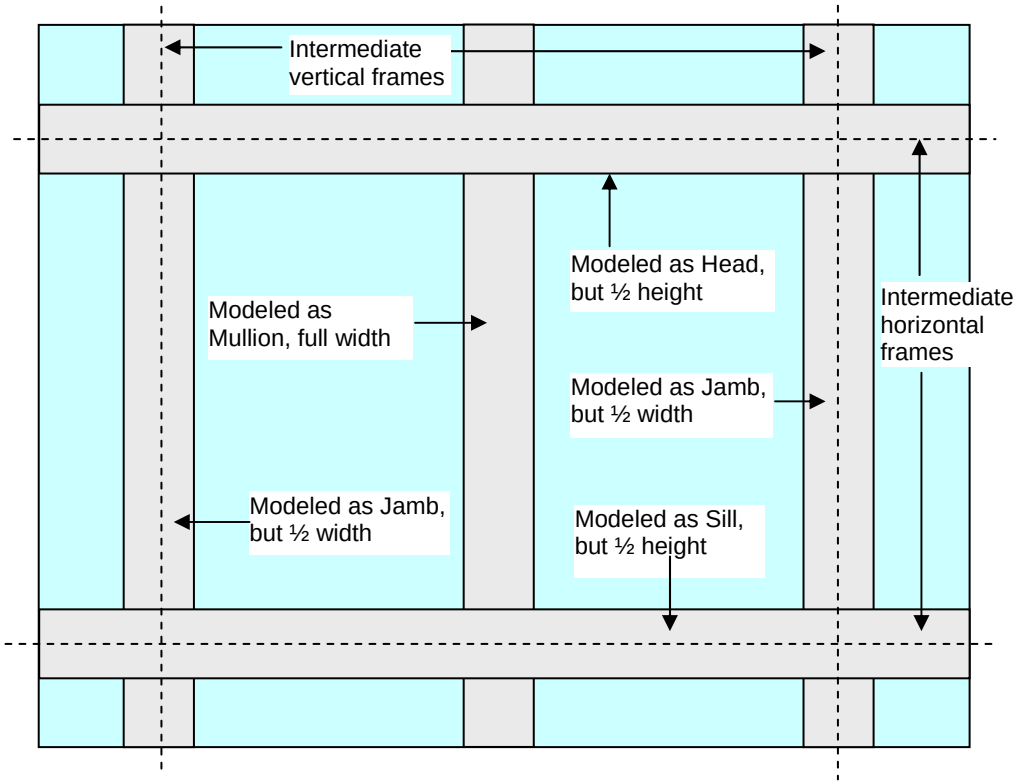


Figure 8-109. Curtain wall simulation model (represented by dotted lines) for rating, where the framing members are modeled at half their width.

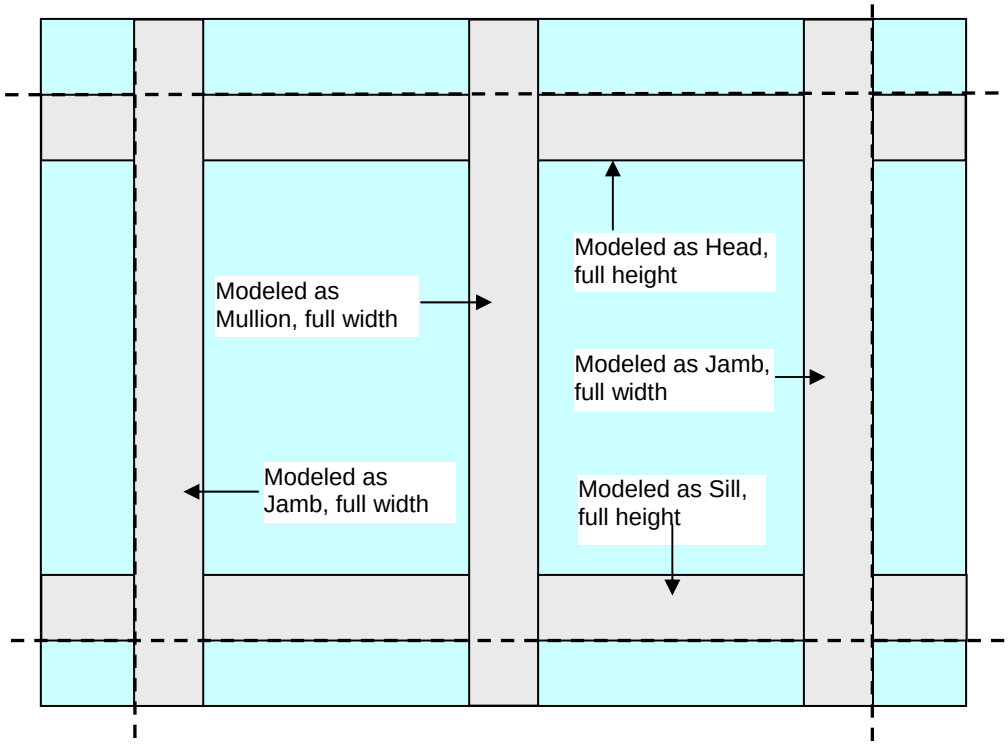


*Figure 8-110. Curtain wall simulation model (represented by dotted lines) to match **testing**.*

Steps in Modeling Curtain Walls for Rating Simulation

In WINDOW:

- Create glazing systems in WINDOW as usual, with Tilt set to “90".

In THERM:

- Draw the cross sections for curtain walls in the same manner as any other model in THERM – it will be a model similar to a meeting rail.

The following discussion lists the steps for making cross sections for intermediate horizontal and vertical frames. In the example, the horizontal frame and vertical frame are the same so only one drawing will be needed.

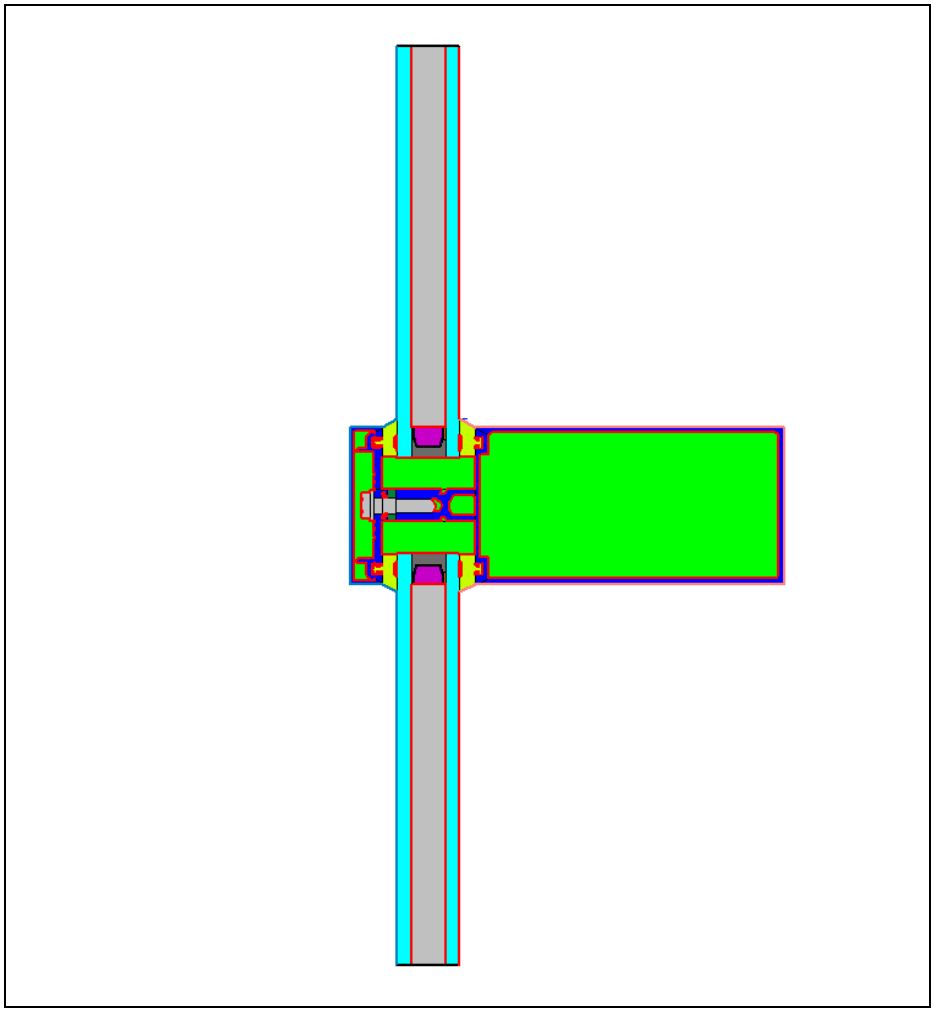


Figure 8-111. Curtain Wall Mullion Cross Section (mull.thm)

Modeling the Intermediate Vertical Mullion:

Using the dimensioned drawings or a DXF file, create the cross section for the frame portion of the vertical mullion. The figure below shows a THERM cross section of the frame portion of the vertical mullion.

Make sure that the section is oriented correctly with the glazing oriented up and down.

- If bolts are present make sure to model them as non-continuous thermal bridging elements if needed. (see Section 8.9).
- Pay particular attention to the aluminum finish in order to assign the correct materials to the drawing. (In the figure below, where the arrows point to Aluminum)

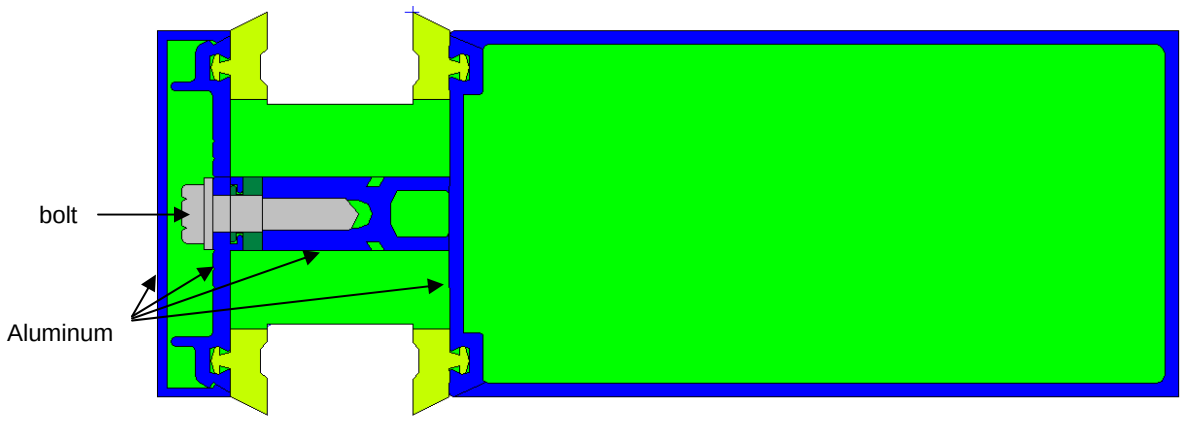


Figure 8-112. Mullion frame cross section without glass (Mull_noglass.thm)

This vertical cross section will be used for the vertical intermediate (mullion) and for the jambs. The jamb model it is necessary to determine and mark the ½ width point between the sight lines. The easiest way to do this is to make temporary reference rectangles as follows:

Determine Frame Midpoints

In order to model the "half-width" frame dimensions for the rating simulation, it is necessary to determine the mid-point of the frame, which is most easily done before the glazing systems are inserted.

- Draw a rectangle from the sight line (highest interior point) for both glazing systems, going horizontally in both directions, so that each rectangle is larger than the horizontal dimension of the frame.
- On both the right and left side of the frame draw a rectangle between the other two reference rectangles and make sure it contacts the frame.
- Measure the exterior rectangle just created in the vertical dimension. The midpoint of the frame is half of this dimension.
- For both the right and left sides of the frame cross section, select the vertical frame component and insert a point on the frame at the midpoint dimension.

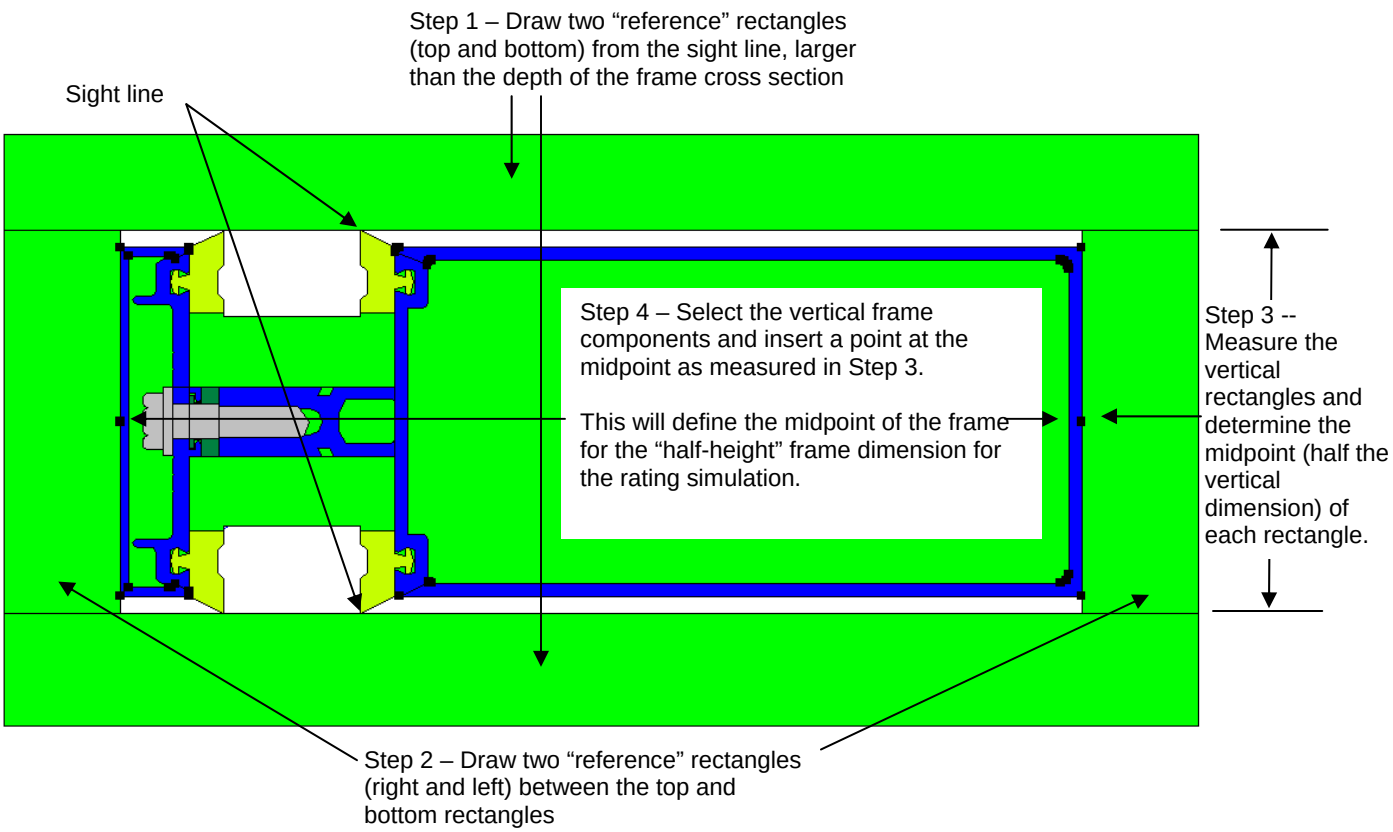


Figure 8-113. Determine the frame mid-points (mull_midpoint.thm)

Finish the cross section

- Delete the four "reference" rectangles.
- Insert the glazing and spacers as usual.
- In **Therm File Properties** (File/Properties), set the **Cross Section Type** to "Vertical Meeting Rail".
- Assign the **Boundary Conditions** as follows:
  - **Interior Frame:** For the mullion cross section, the entire frame width (not just half) is modeled, so all the interior frame boundary condition elements are assigned a **Boundary Condition** of "<frame type> Interior (Convection Only), and a **U-factor Surface** tag of "Frame".

- **Interior Glazing:** Set the **Boundary Conditions** for each glazing system to "<glazing system> U-factor Inside Film" and the **U-factor Surface** tag to "Edge" for the first 63.5 mm (2.5 inches) from the sight line, and "None" for the remainder of the glazing system.
- **Exterior Frame:** Set the **BoundaryCondition** to "NFRC 100-2010 Exterior" and the **U-factor Surface** tag to "SHGC Exterior" for the exterior frame
- **Exterior Glazing:** Set the **BoundaryCondition** to "NFRC 100-2010 Exterior" and the **U-factor Surface** tag to "None" for both exterior glazing systems.

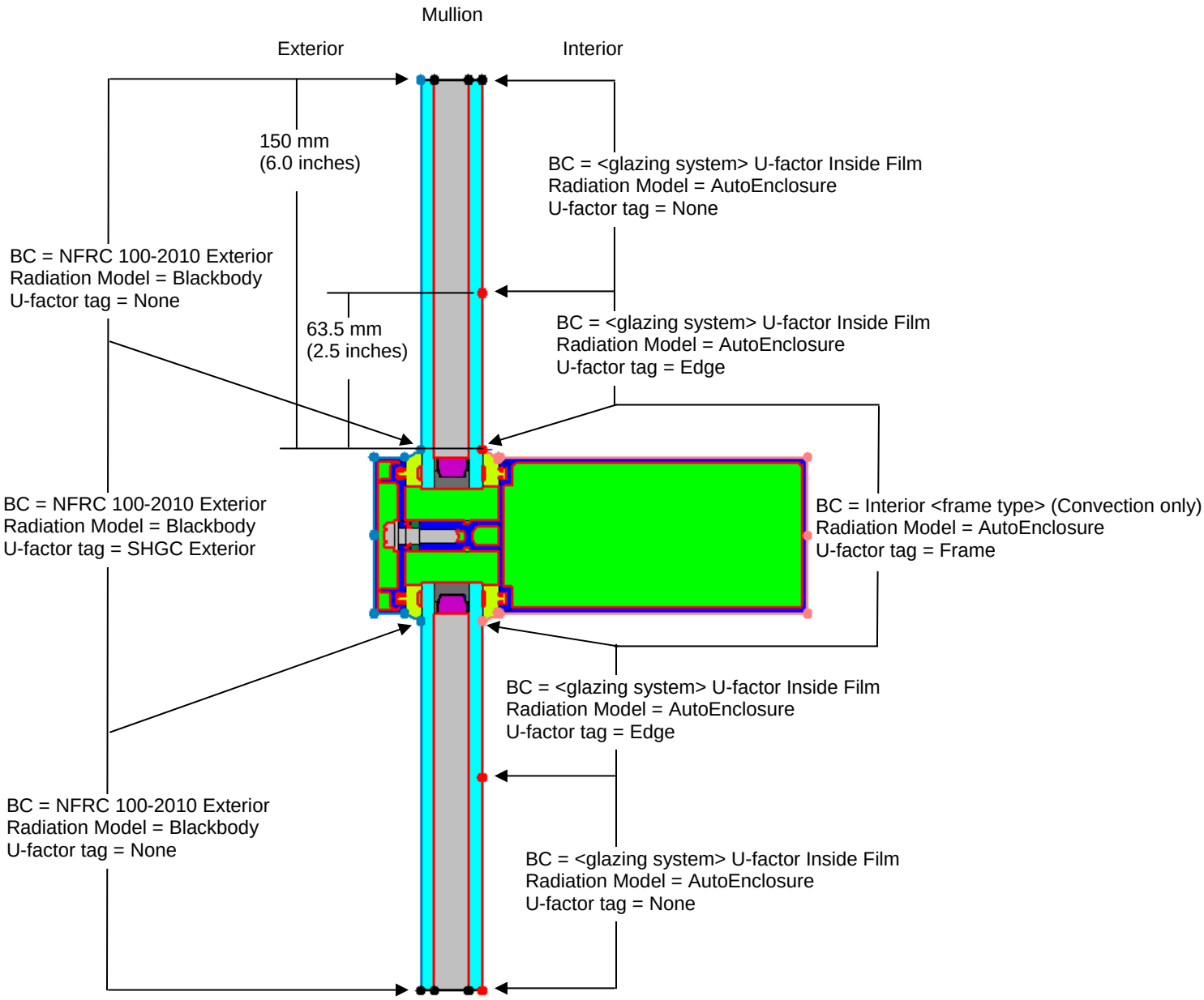


Figure 8-114. Curtain Wall Mullion Boundary Conditions (mull_boundary.thm)

Modeling Curtain Wall Jambs:

In this example, the curtain wall jambs are modeled using the same drawing as the mullion. The boundary conditions are adjusted to capture the heat flow of only half the width. Since the sections may be asymmetrical, both the left and right portions of the mullion are required to be simulated as left and right jambs.

For the Right Jamb:

- Copy the vertical mullion drawing with boundary conditions assigned .
- In **Therm File Properties** (File/Properties), set the **Cross Section Type** to "Vertical Meeting Rail".
- Do not change the **Boundary Conditions** but assign new **U-factor Surface** tags as follows:
  - **Interior Frame:**
    - from the midpoint to the top sight line set the **U-factor Surface** tag to "Frame"
    - from midpoint to the bottom sight line and the entire bottom glass assign the **U-factor Surface** tag to "None".
    - **Interior Glazing System:** for the first 63.5 mm of the top glazing system set the **U-factor Surface** tag to "Edge", and the remainder of the glazing system to "None". For the entire bottom glass assign the **U-factor Surface** tag to "None".
  - **Exterior Frame:**
    - from the midpoint to the top sight line assign the **U-factor Surface** tag to "SHGC Exterior"
    - from midpoint to the bottom sight line assign the **U-factor Surface** tag to "None".
  - **Exterior Glazing System:** set the **U-factor Surface** to "None".

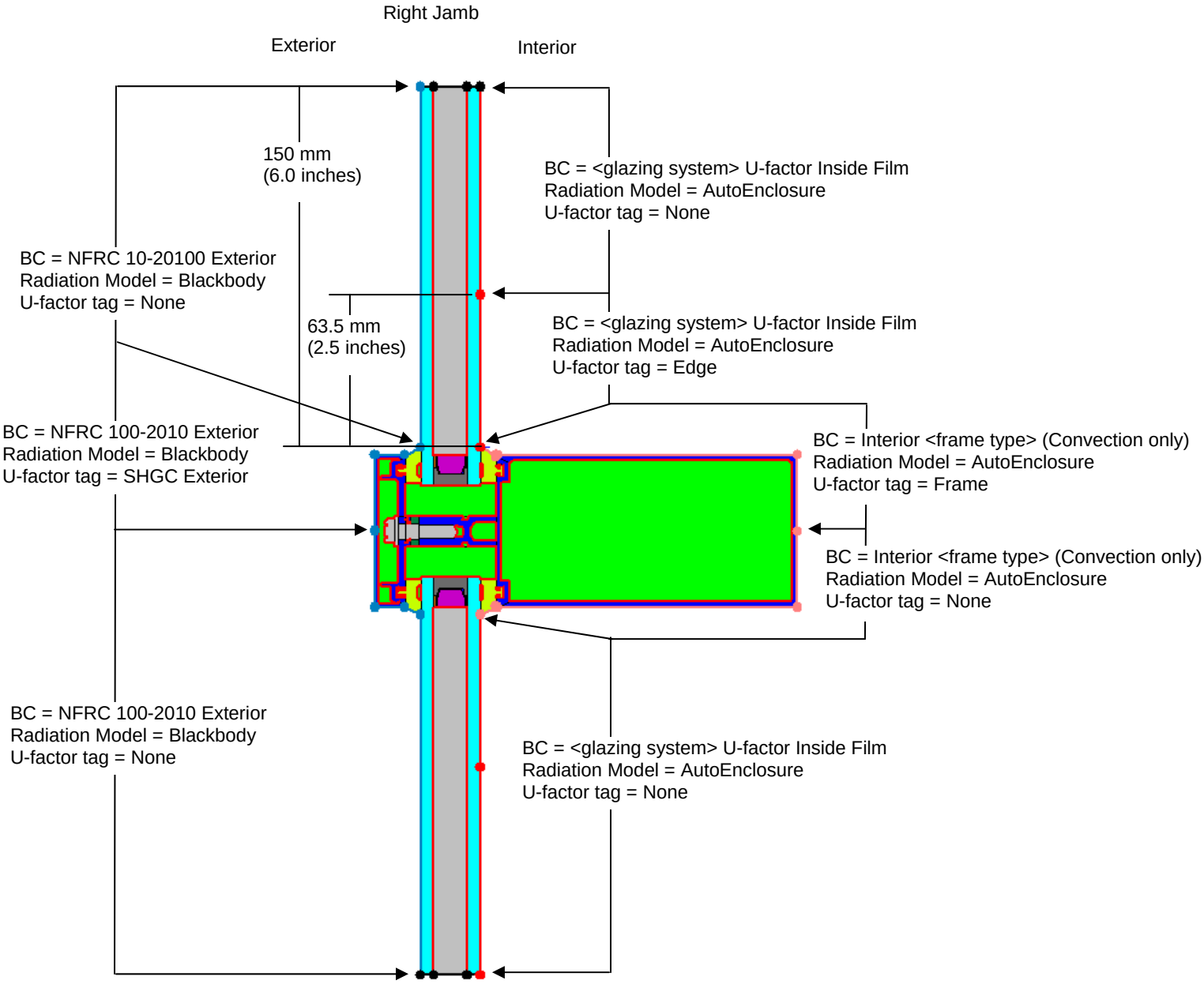


Figure 8-115. Right Jamb Boundary conditions (rightjamb_boundary.thm).

For the Left Jamb:

- The process is the same as the right jamb except that the Frame, edge and SHGC Exterior tags are assigned to the bottom half of the drawing and the top half is assigned the tag of "none"

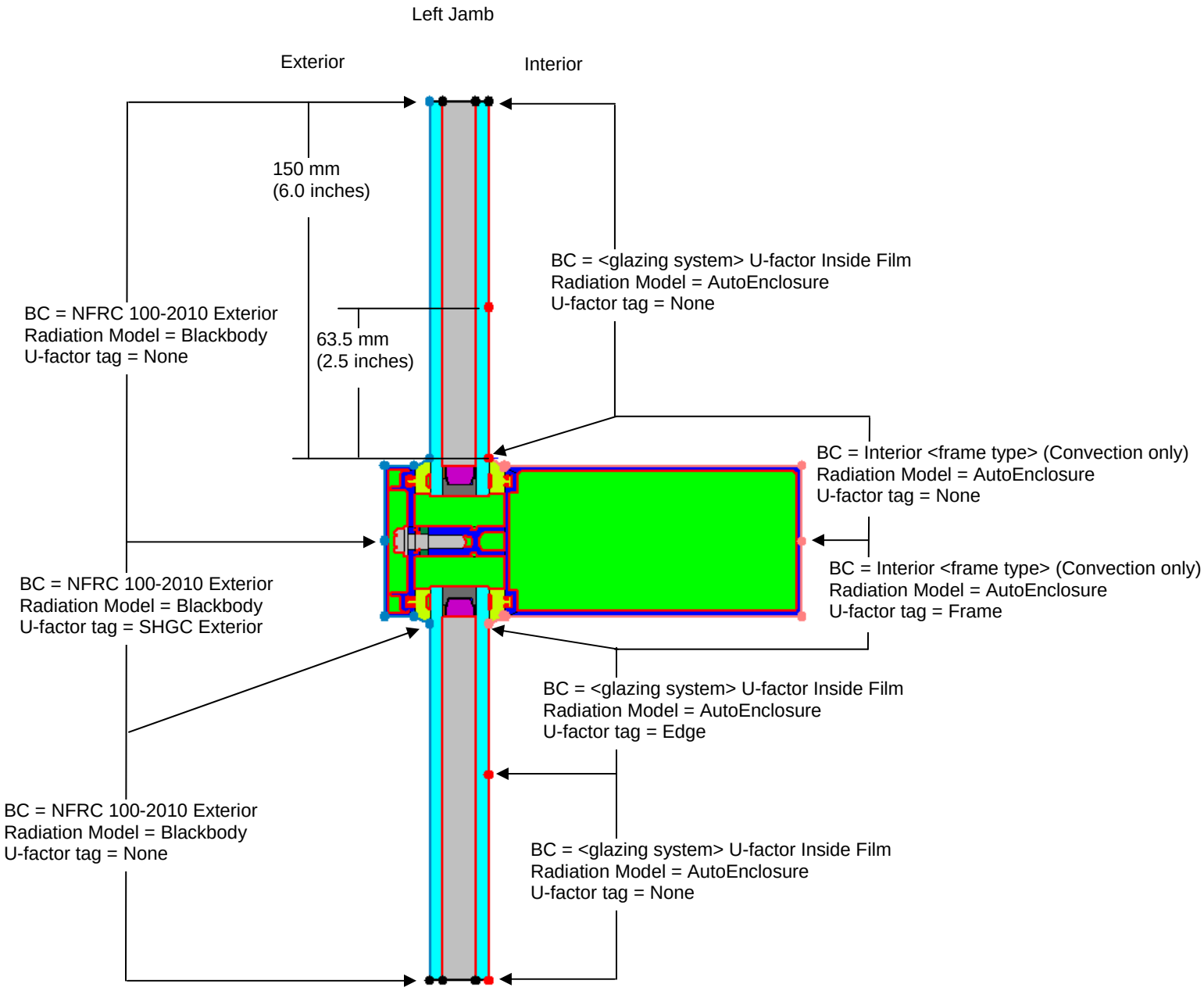


Figure 8-116. Left Jamb Boundary Conditions (leftjamb_boundary.thm)

NOTE: the Therm File option " Use CR Model for Window Glazing System" may be left checked since Therm will not calculate Condensation resistance for a cross section Type tagged Vertical Meeting Rail or Jamb.

Modeling the Intermediate Horizontal (as Head and Sill):

The horizontal frame cross section is drawn in exactly the same way as the intermediate vertical frame cross section, including inserting the midpoint. For this example the horizontal and vertical frames are identical so the same drawing is used. Assign boundary conditions in the usual way and then assign new boundary condition U-Factor Surface tags as follows for the head and sill.

For the Head:

- Use the drawing for the intermediate horizontal.
- In **Therm File Properties** (File/Properties), set the **Cross Section Type** to "Head".
- Assign the Boundary Conditions as follows:
  - **Interior Frame:**
    - For the interior frame from the midpoint to the *bottom* sight line, set the **Boundary Condition** to "<frame type> Interior (Convection Only), and the **U-factor Surface** tag to "Frame".
    - For the interior frame from midpoint to the *top* sight line, set the **Boundary Condition** to "<frame type> Interior (Convection Only), and the **U-factor Surface** tag to "None".
  - **Interior Glazing:** Set the **Boundary Conditions** for each glazing system of the bottom of the glass to "<glazing system> U-factor Inside Film" and the **U-factor Surface** tag to "Edge" for the first 63.5 mm (2.5 inches) from the sight line, and "None" for the remainder of the glazing system.
  - **Exterior Frame:**
    - For the exterior frame from the midpoint to the *bottom* sight line, set the **BoundaryCondition** to "NFRC 100-2010 Exterior" and the **U-factor Surface** tag to "SHGC Exterior".
    - For the exterior frame from the midpoint to the *top* sight line, set the **BoundaryCondition** to "NFRC 100-2010 Exterior" and the **U-factor Surface** tag to "None".
  - **Exterior Glazing:** Set the **BoundaryCondition** to "NFRC 100-2010 Exterior" and the **U-factor Surface** tag to "None" for both exterior glazing systems.

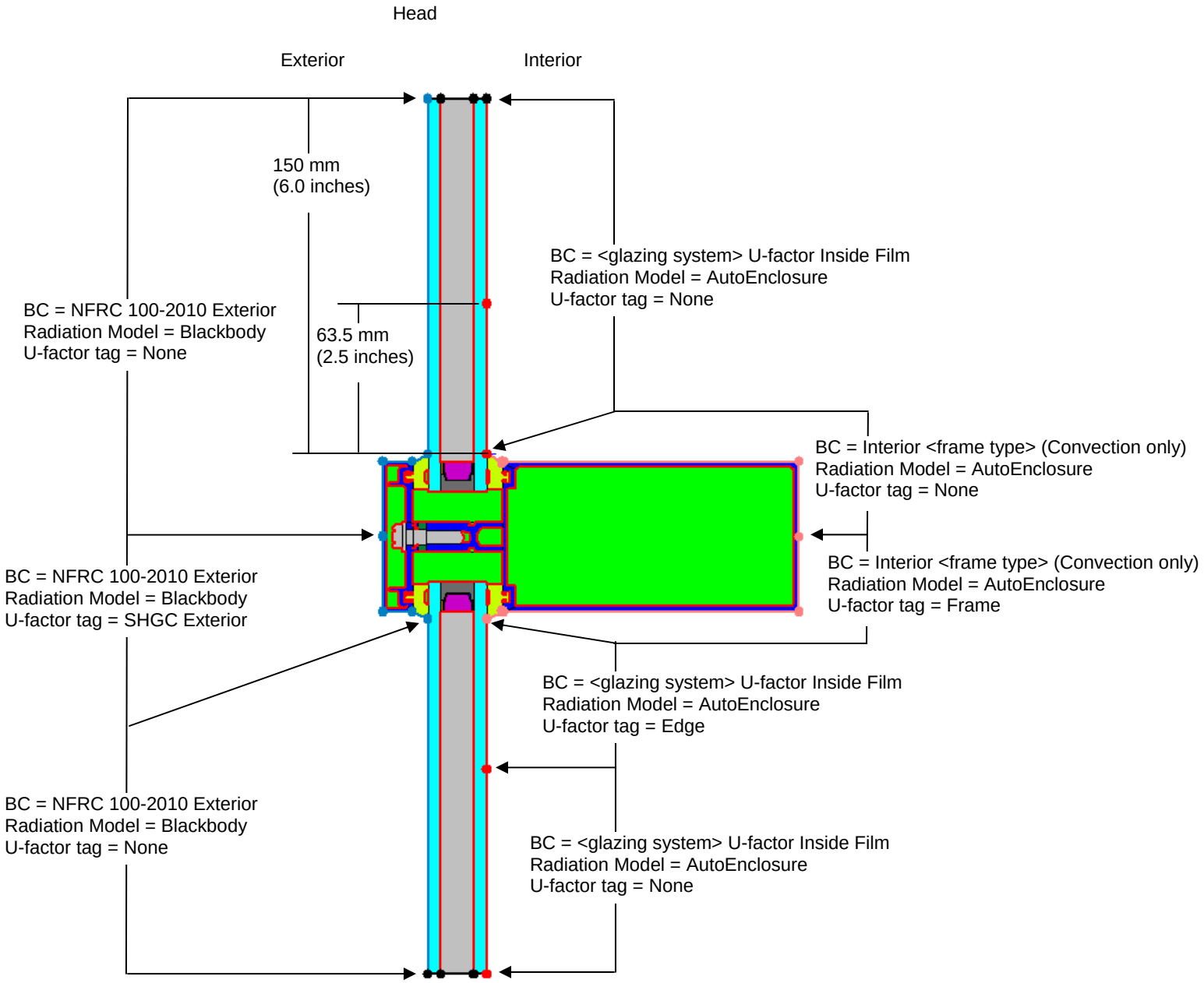


Figure 8-117. Head Boundary Conditions (head_boundary.thm)

For the Sill:

- Use the drawing for the intermediate horizontal.
- In **Therm File Properties** (File/Properties), set the **Cross Section Type** to "Sill".
- Assign the Boundary Conditions as follows:
  - **Interior Frame:**
    - For the interior frame from the midpoint to the *top* sight line, set the **Boundary Condition** to "<frame type> Interior (Convection Only), and the **U-factor Surface** tag to "Frame".
    - For the interior frame from midpoint to the *bottom* sight line, set the **Boundary Condition** to "<frame type> Interior (Convection Only), and the **U-factor Surface** tag to "None".
  - **Interior Glazing:** Set the **Boundary Conditions** for each glazing system of the *top* of the glass to "<glazing system> U-factor Inside Film" and the **U-factor Surface** tag to "Edge" for the first 63.5 mm (2.5 inches) from the sight line, and "None" for the remainder of the glazing system.
  - **Exterior Frame:**
    - For the exterior frame from the midpoint to the *top* sight line, set the **BoundaryCondition** to "NFRC 100-2010 Exterior" and the **U-factor Surface** tag to "SHGC Exterior".
    - For the exterior frame from the midpoint to the *bottom* sight line, set the **BoundaryCondition** to "NFRC 100-2010 Exterior" and the **U-factor Surface** tag to "None".
  - **Exterior Glazing:** Set the **BoundaryCondition** to "NFRC 100-2010 Exterior" and the **U-factor Surface** tag to "None" for both exterior glazing systems.

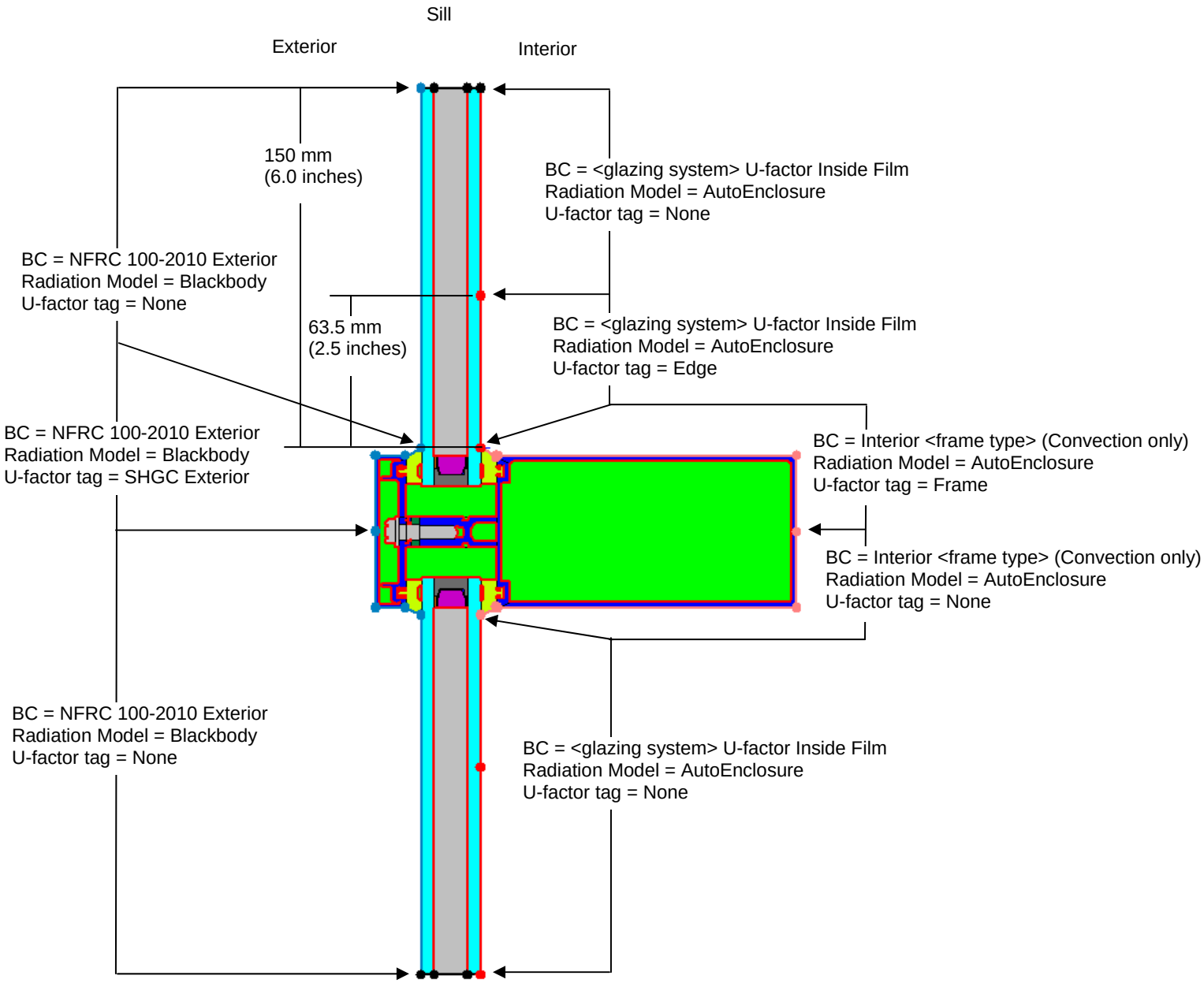


Figure 8-118. Sill Boundary conditions (sill_boundary.thm)

It is a good idea at this point to verify the orientation and the direction of the gravity arrows of these sections.

In WINDOW:

Calculate these files and import into WINDOW. Use the files to create the whole product in the Window Library as applicable.

8.11. Retractable Venetian Blinds in Fully Open Position

Integral venetian blinds (venetian blinds between two glazing layers in a glazing system) fall into the category of a dynamic glazing product. The rules for rating dynamic glazing products, according to NFRC 100 and 200, state that they must be rated in both their fully open and fully closed positions. In the case of modeling retractable integral venetian blinds as part of a dynamic glazing product, the fully open position is when the venetian blind is completely retracted. However, even when completely retracted, the stacked venetian blind slats become a "block" of material that must be modeled.

The following illustrates how to model a fully retracted venetian blind that has a stack of blind slats at the top of the glazing system.

In this discussion, only the Head section will be discussed. For Vertical Sliding windows where the lower sash contains an integral venetian blind, the lower sash portion of the Meeting Rail section will be modeled with the same venetian blind considerations as the Head section. The other cross sections (Jambs, Sills and Meeting Stiles) are modeled normally, without any venetian blind considerations. Two examples will be illustrated:

- The venetian blind fully retracted inside a double glazed system.
- The venetian blind fully retracted between a double glazed system and a third glazing layer (such as, but not limited to, an add-on panel).

8.11.3. Venetian Blind Fully Retracted Inside a Double-Glazed System

The following figure shows the Head cross section for a venetian blind in the fully-retracted position inside a double-glazed system.

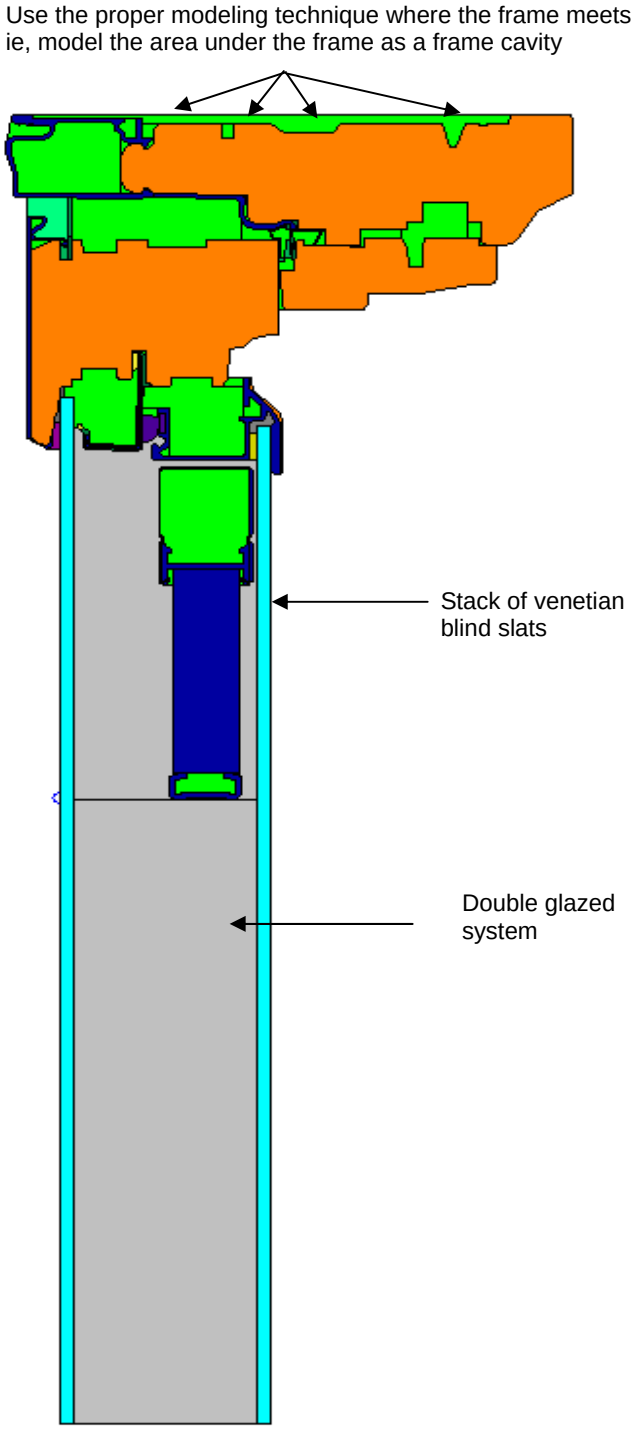


Figure 8-107. Head cross section with fully retracted venetian blind inside a double-glazed system.

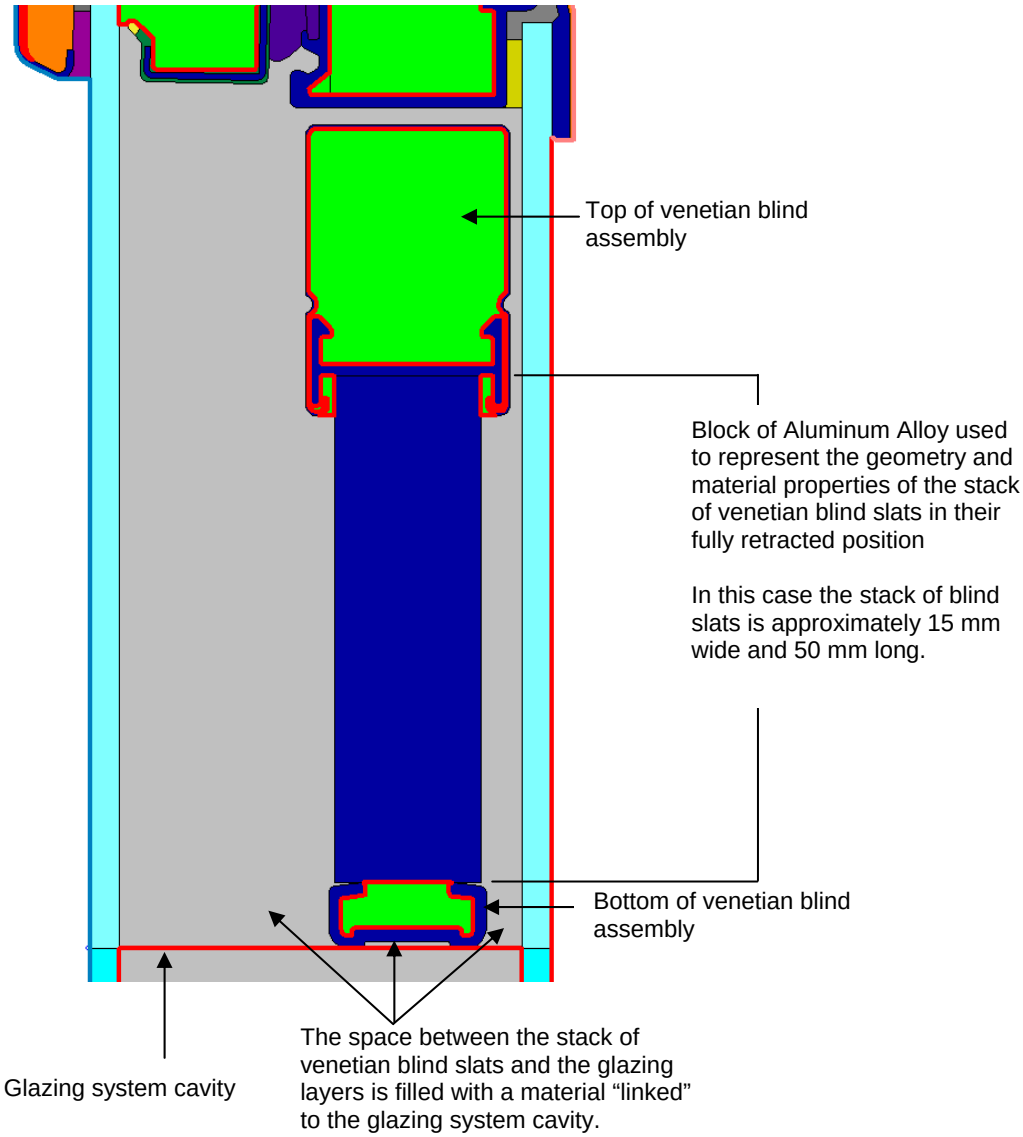


Figure 8-108. The Head cross section with the retracted venetian blind, including the stacked slats, and the top and bottom assemblies for the blind that are continuous across the section.

Follow these steps to model a fully retracted venetian blind:
(Note: This example was done for Aluminum slat blinds. If the material of the blinds is not Aluminum, use the appropriate material properties from NFRC 101 "Procedure for Determining Thermo-Physical Properties of Materials for Use in NFRC-Approved Software Programs" for the stack of retracted venetian blind slats.)

1. Draw the Head cross section of the product frame.
2. Draw the geometry of the retracted venetian blind, including the length and width of the stacked venetian blind slats and any continuous hardware that holds the blind in place (top and bottom). (*Note: In this case, the system seems to be "floating" because non-continuous hardware is used to attach the blind to the fenestration system.*)

3. Insert the glazing system.
   The example shown below has glazing layers that intersect the frame at two different heights. There are numerous methods for modeling this. The method shown is to "stretch" the glazing layers to meet the frame at the appropriate place, and this method also necessitates inserting points on the glazing system for the correct boundary conditions segments. Another method would be to insert "float glass" polygons for the glazing layer extensions – this method eliminates the need to insert the points in the glazing system for the boundary condition segments.

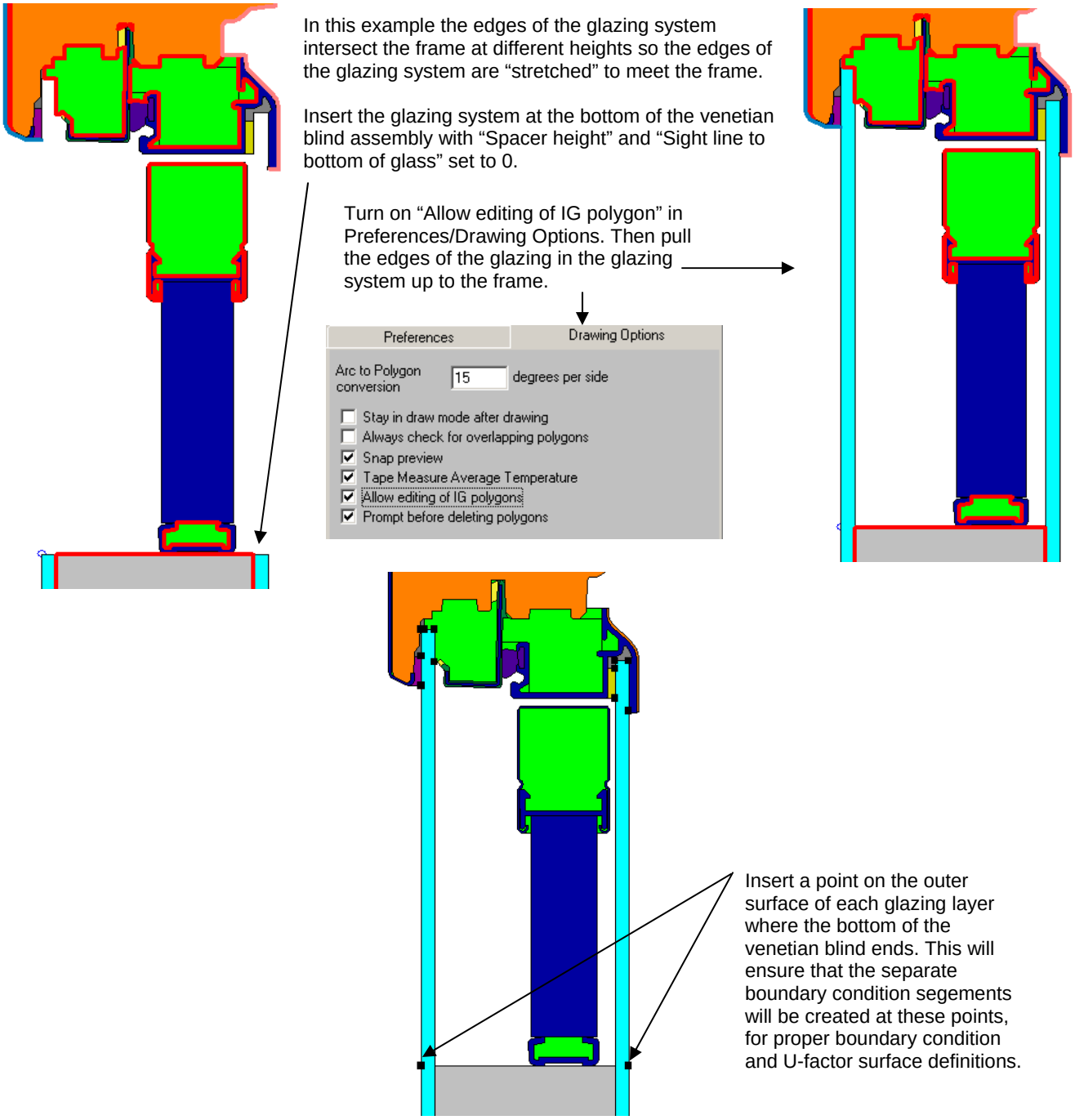


Figure 8-109. Insert the glazing system.

4. Fill the cavities around the venetian blind with a material, and then link that material to the cavity of the main glazing system. There may be several cavities to be linked, as shown in the figure below.

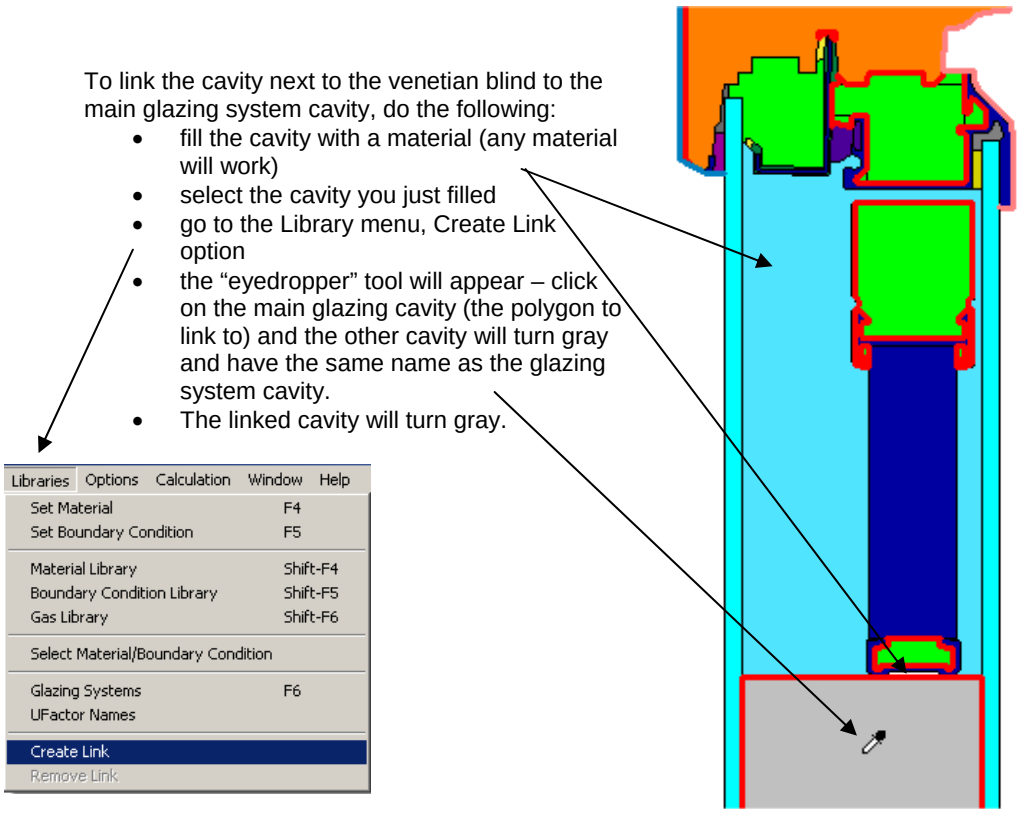


Figure 8-110. Fill the cavity next to the venetian blind by linking it to the main glazing cavity.

5. Generate the Boundary Conditions. The section of the warm side of the glazing system adjacent to the retracted venetian blind should be defined with a U-factor Surface tag of "Frame".

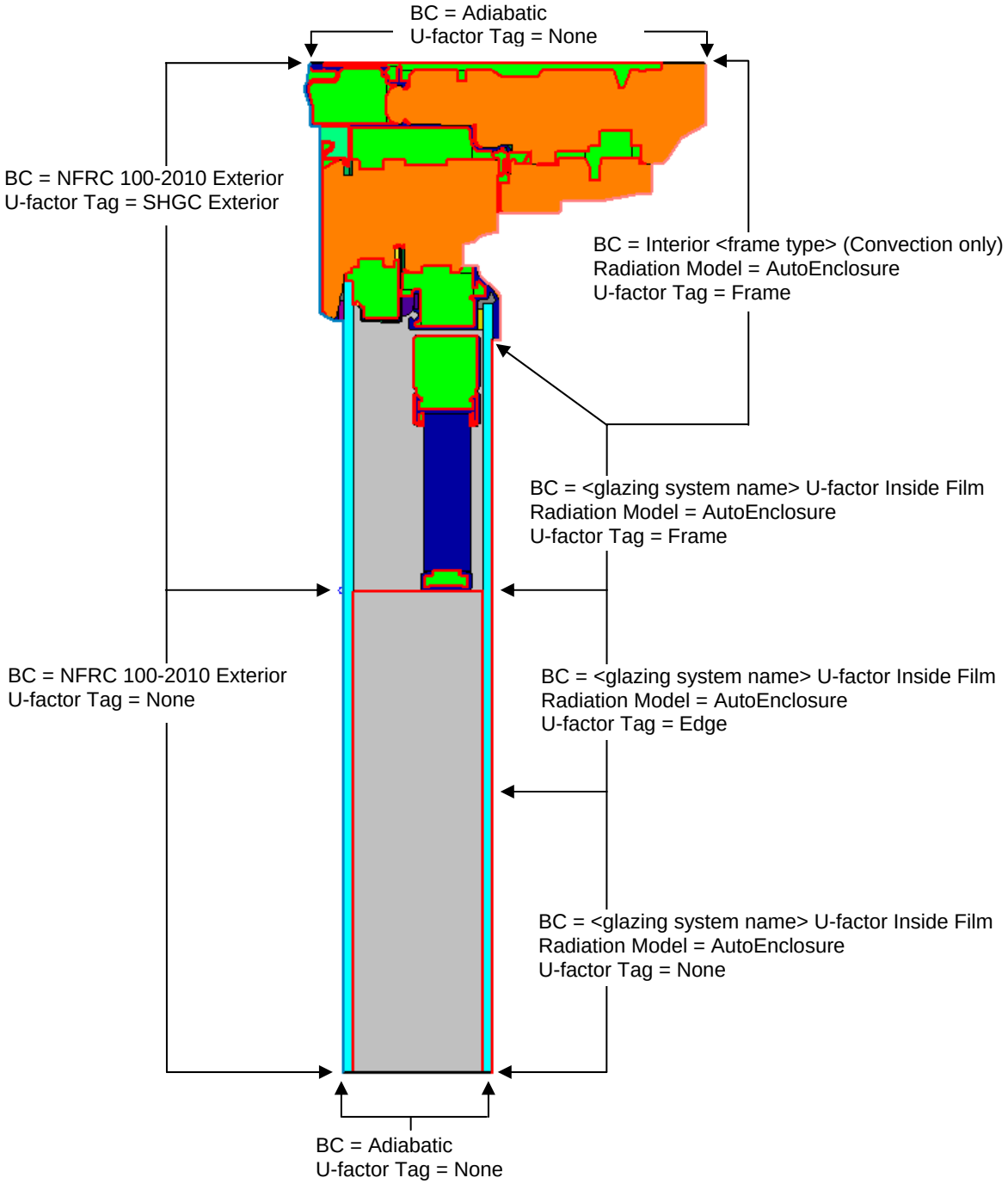


Figure 8-111 Define the boundary conditions for the cross section

6. Calculate the results for this cross section.
7. Complete the calculations for the other product cross sections (Sill, Jambs and Meeting Rails / Stiles as appropriate).
8. Import all the cross sections into the WINDOW Frame Library and calculate the total product U-value, SHGC and VT.

8.11.4. Venetian Blind Fully Retracted Between a Double-Glazed System and a Third Glazing Layer

The following figure shows the Head cross section for a venetian blind in the fully-retracted position between a double-glazed system with a third glazing layer, such as, but not limited to, an add-on panel.

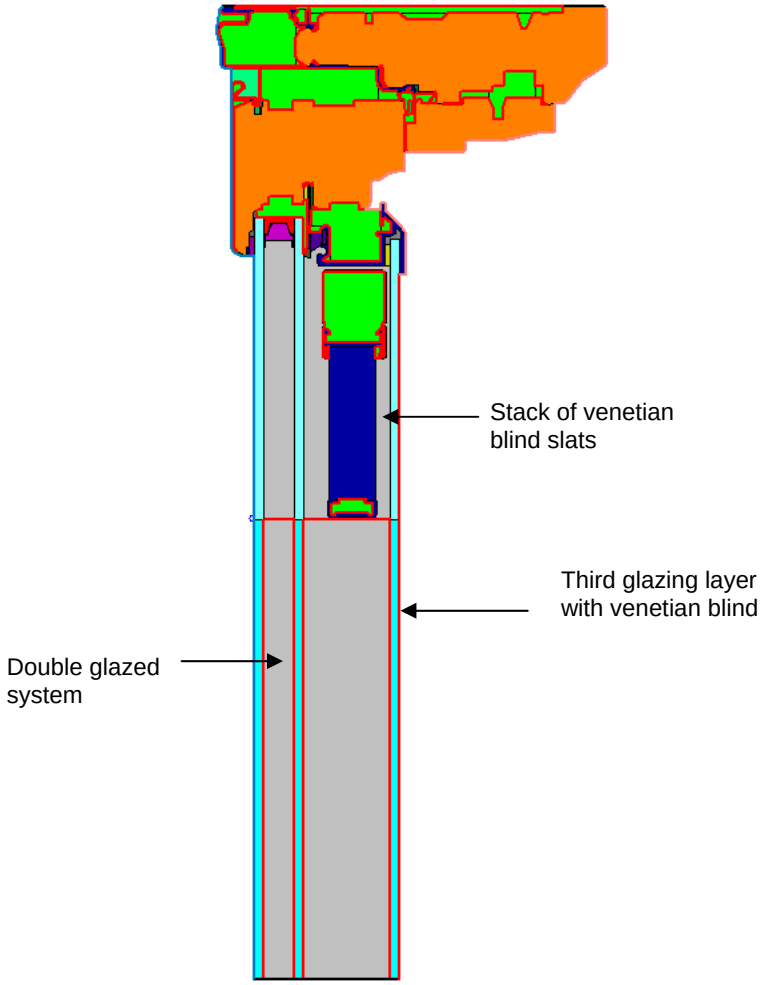


Figure 8-112. Head cross section with fully retracted venetian blind between a double-glazed system and a third glazing layer.

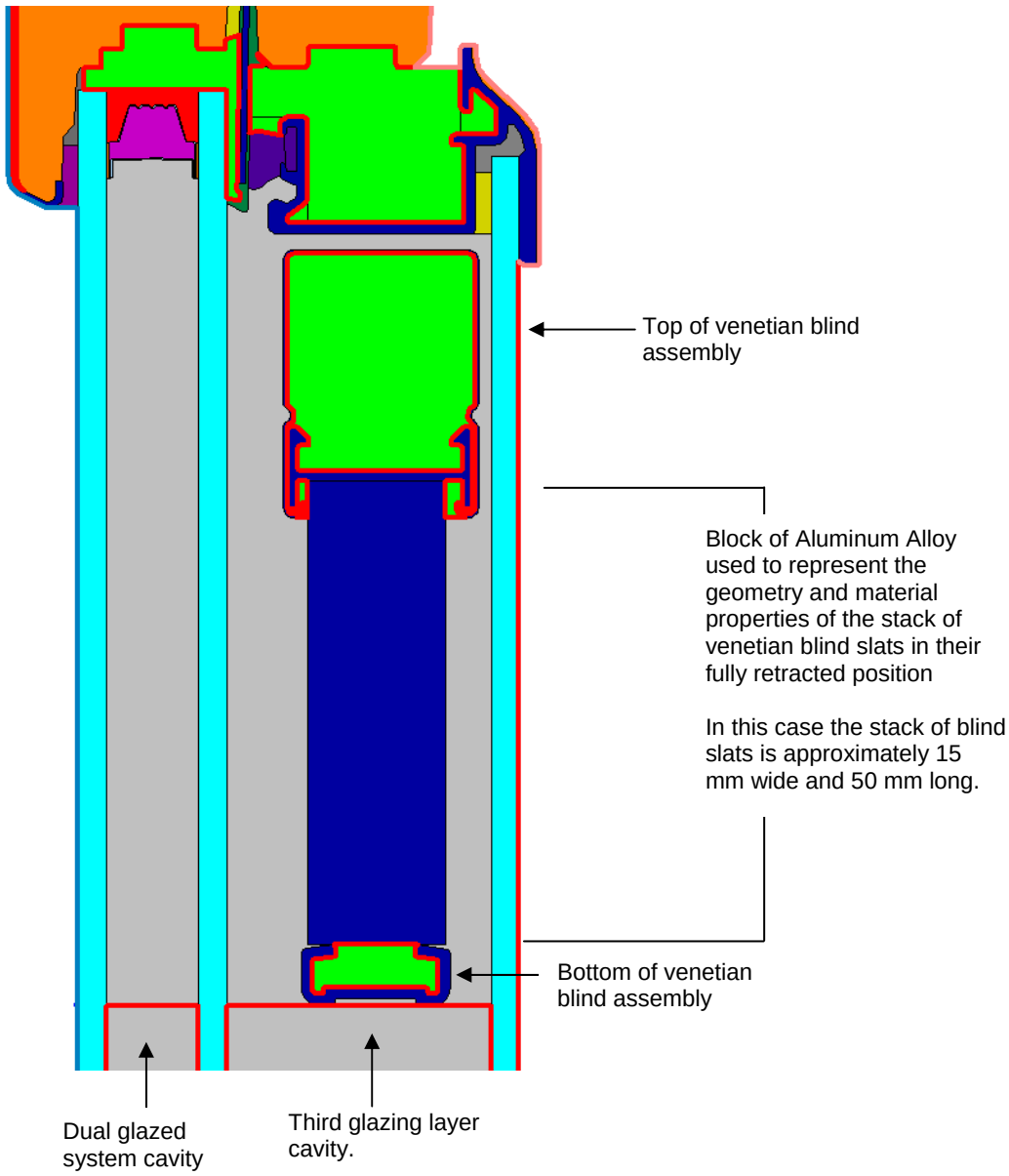


Figure 8-113. The Head cross section with the retracted venetian blind, including the stacked slats, and the top and bottom assemblies for the blind that are continuous across the section.

Follow these steps to model a fully retracted venetian blind between a double glazed system and a third glazing layer:
(Note: This example was done for Aluminum slat blinds. If the material of the blinds is not Aluminum, use the appropriate material properties from NFRC 101 "Procedure for Determining Thermo-Physical Properties of Materials for Use in NFRC-Approved Software Programs" for the stack of retracted venetian blind slats.)

1. Draw the Head cross section of the product frame.
2. Draw the geometry of the retracted venetian blind, including the length and width of the stacked venetian blind slats and any continuous hardware that holds the blind in place (top and bottom).
3. In WINDOW, make the appropriate glazing system (in this case a triple glazed system that represents the double glazed system and a third glazing layer (such as an add-on panel)).

4. Insert the glazing system.
   The example shown below has glazing layers that intersect the frame at two different heights. There are numerous methods for modeling this. The method shown is to "stretch" the glazing layers to meet the frame at the appropriate place, and this method also necessitates inserting points on the glazing system for the correct boundary conditions segments. Another method would be to insert "float glass" polygons for the glazing layer extensions – this method eliminates the need to insert the points in the glazing system for the boundary condition segments.

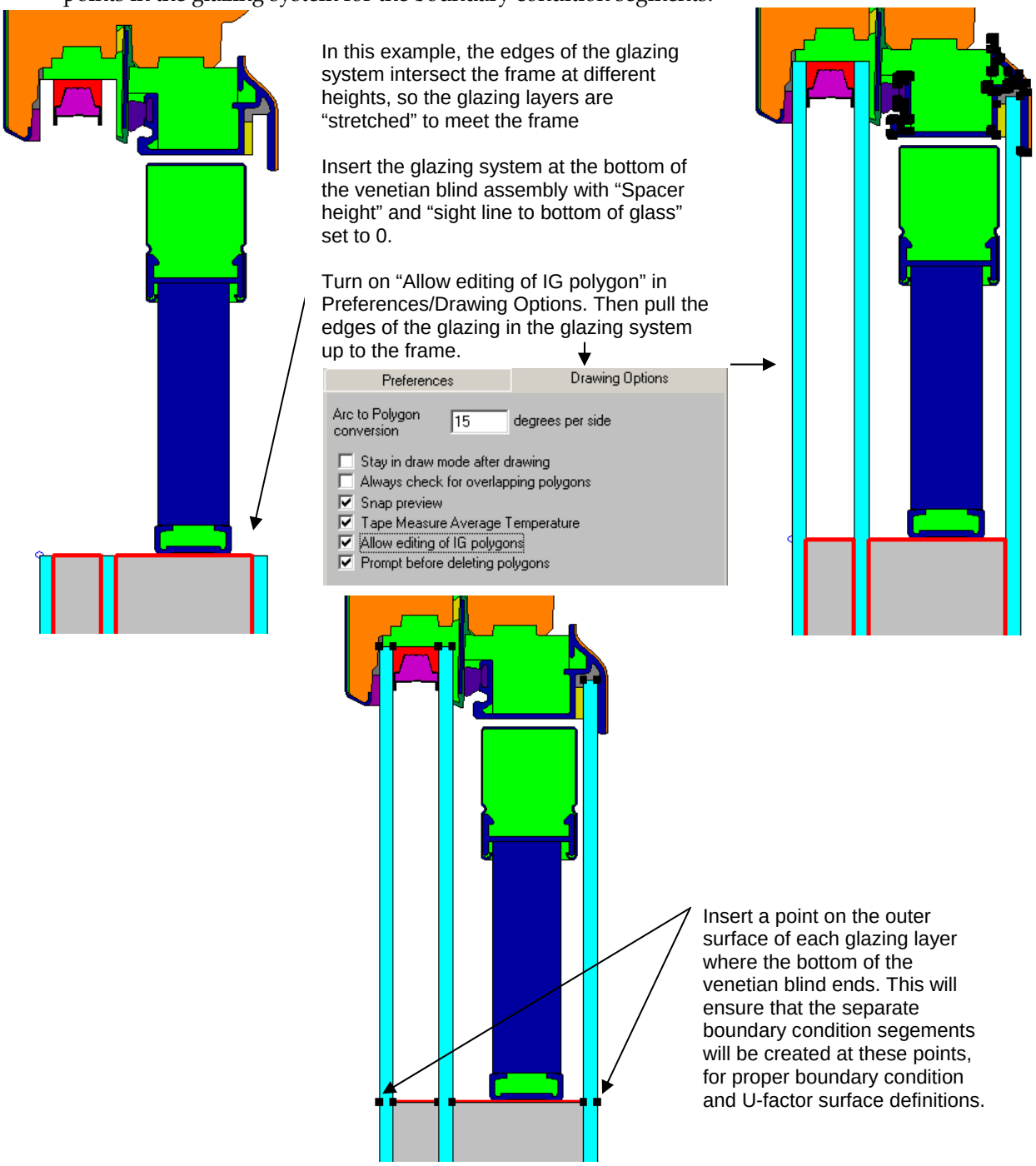


Figure 8-114. Insert the glazing system and edit it if necessary to bring the glazing layers to the frame.

5. Fill the cavities in the double glazing system and around the venetian blind in the third glazing layer with a material (any material), and then link that material to the appropriate cavity – the double glazing system cavity to the double glazing system and the third glazing layer cavity to the third glazing layer. There may be more than one area that is linked to a cavity, so make sure to link them all.

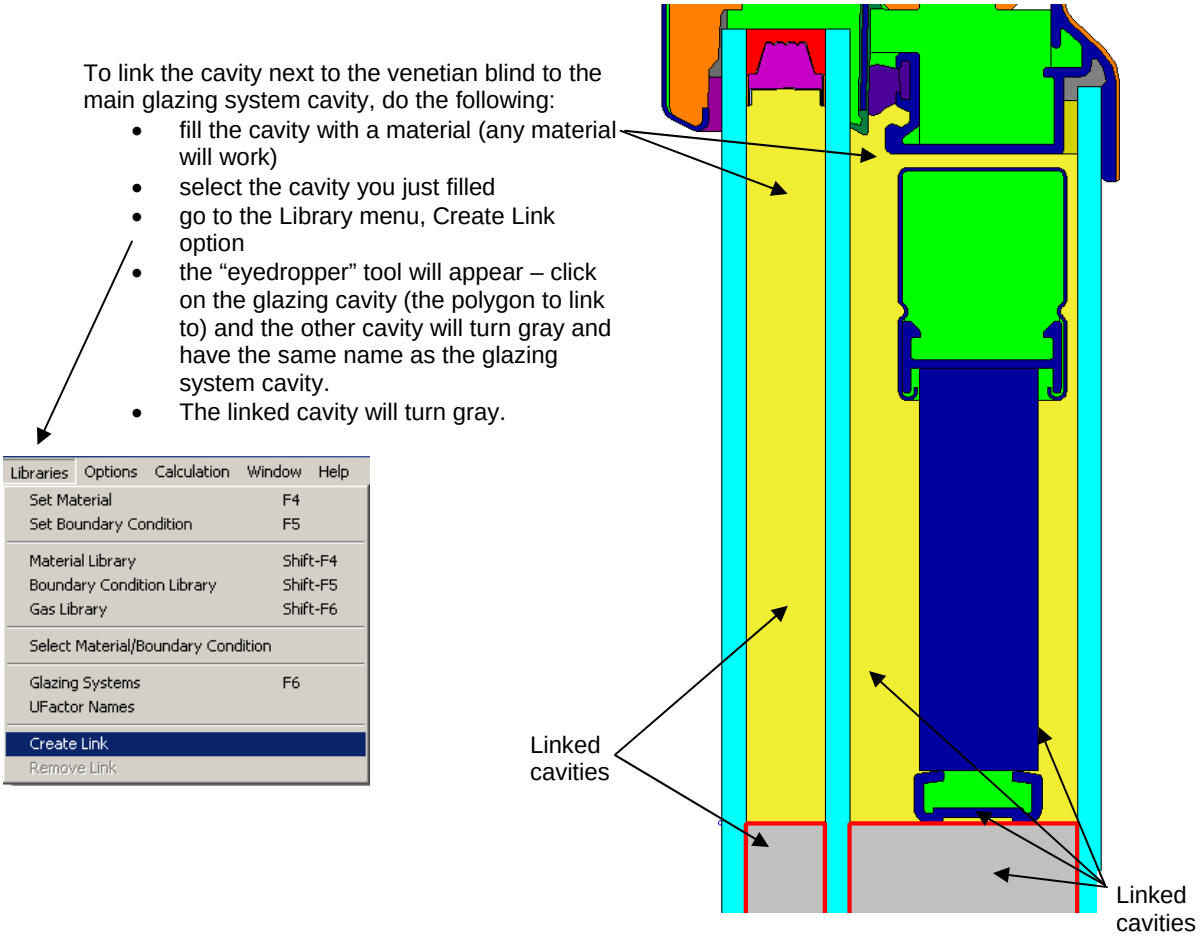


Figure 8-115. Fill the cavity next to the venetian blind by linking it to the main glazing cavity.

6. Generate the Boundary Conditions. The section of the warm side of the glazing system adjacent to the retracted venetian blind should be defined with a U-factor Surface tag of "Frame".

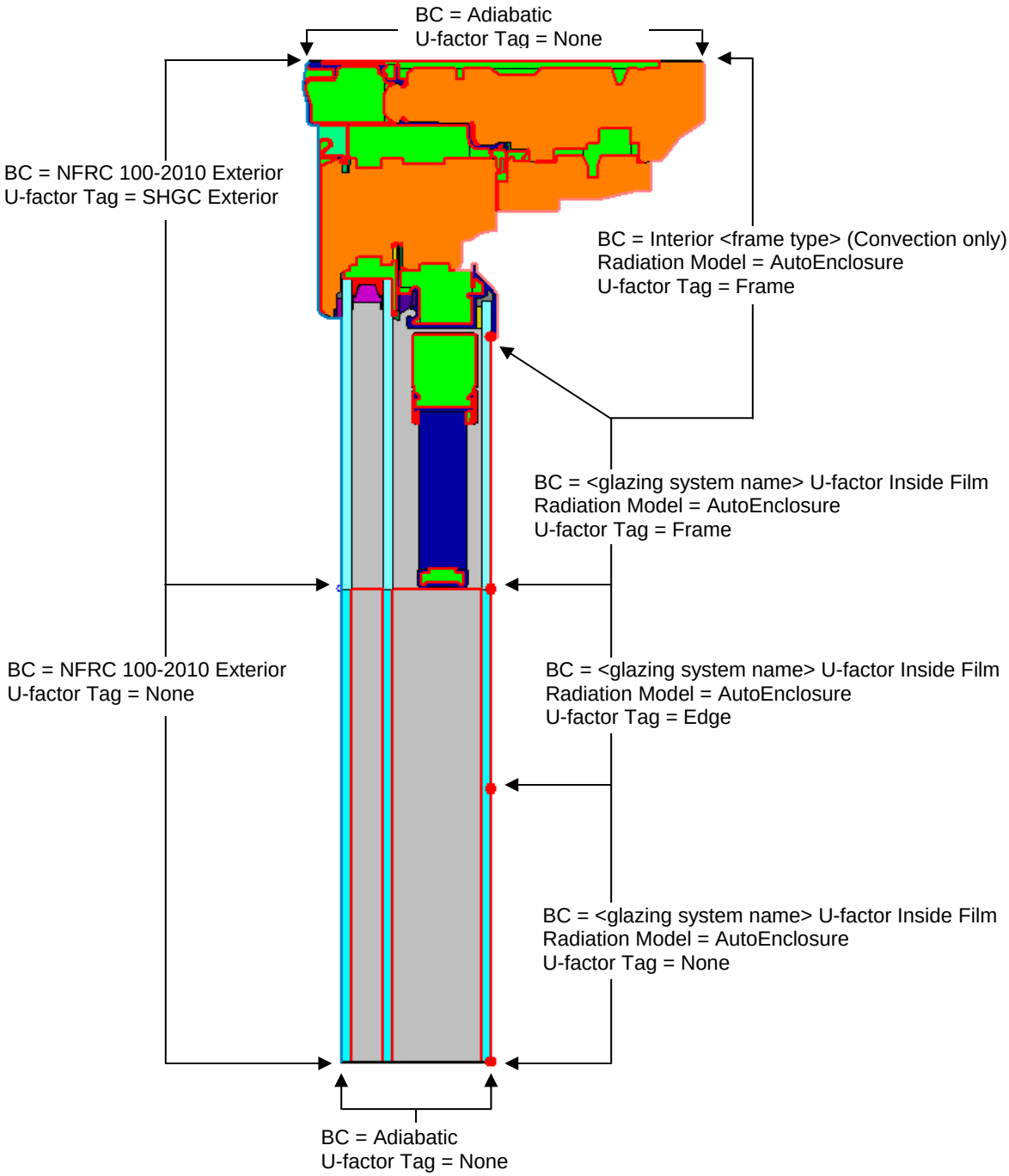


Figure 8-116 Define the boundary conditions for the cross section

7. Calculate the results for this cross section.
8. Complete the calculations for the other product cross sections (Sill, Jambs and Meeting Rails / Stiles as appropriate).
9. Import all the cross sections into the WINDOW Frame Library and calculate the total product U-value, SHGC and VT

8.12 Garage / Rolling Doors

Garage doors and rolling doors are modeled differently than window products because there are more opaque sections to be modeled in THERM. The procedures for modeling doors are included in *NFRC 100:* and that document should be reviewed in detail before modeling any entry door systems.

As with all other product modeling, all relevant cross sections must be modeled in THERM. Detailed illustrations of sections, elevations and model details, as well as the area-weighting methodology for calculating the whole product properties (based on THERM results from of each cross section) are defined in NFRC 100-2004. The information in this manual covers the specific modeling prcedures for the THERM cross-sections.

NFRC has defined nine regions within a door that need to be modeled. These regions include:

- Frame Area
- Lite Frame Area
- Divider area
- Edge-of-divider area
- Edge-of-Lite Area
- Center-of-lite area
- Door Core Area
- Panel Area
- Edge-of-Panel Area

NFRC 100 contains several figures which illustrate the location of the door sections to be modeled in THERM.

When modeling glazing options with caming, the NFRC default caming can be used.

A spreadsheet must be used to do the door area-weighting from the THERM files, because the current version of WINDOW does not area-weight doors. In THERM, the U-factor Surface Tags can have any name and as many U-factor Surface Tags can be defined as are needed to accurately describe the model. (See Section 6.2.4, "Define U-factor Surface Tags in the *THERM User's Manual*), so define as many U-factor Surface Tags as needed and name them descriptively.

8.12.1. Sectional Garage Door (Insulated and Non-Insulated)

The overall product U-factor is calculated based on the area weighted average of the U-factor of each component of the door. The components used for area weighting a sectional garage door are:

- Top Rail
- Bottom Rail
- End Stile
- Meeting Rail
- Door Panel Core
- Edge-of-Lite
- Center-of-Lite

The U-factor of each component is calculated using two dimensional heat transfer software THERM. The sectional garage doors with embossed or raised panels are not covered in this section. However, refer to the

entry door section for the principles of modeling embossed or raised panels which can then be applied to sectional doors.

The boundary condition details and other modeling assumptions used on the simulation models for door components are discussed in the following sections.

8.12.1.1. Top Rail Model

A nominal 2x4 wood block is used in the Top Rail Model as shown in the figure below. The torsion spring assembly, and any non-continuous hardware, shall not be included in this model. The boundary condition (BC) type and U-factor tags used in the model are illustrated in the figure below.

THERM File Properties:

- **Cross Section Type:** Head
- **Gravity Arrow:** Down

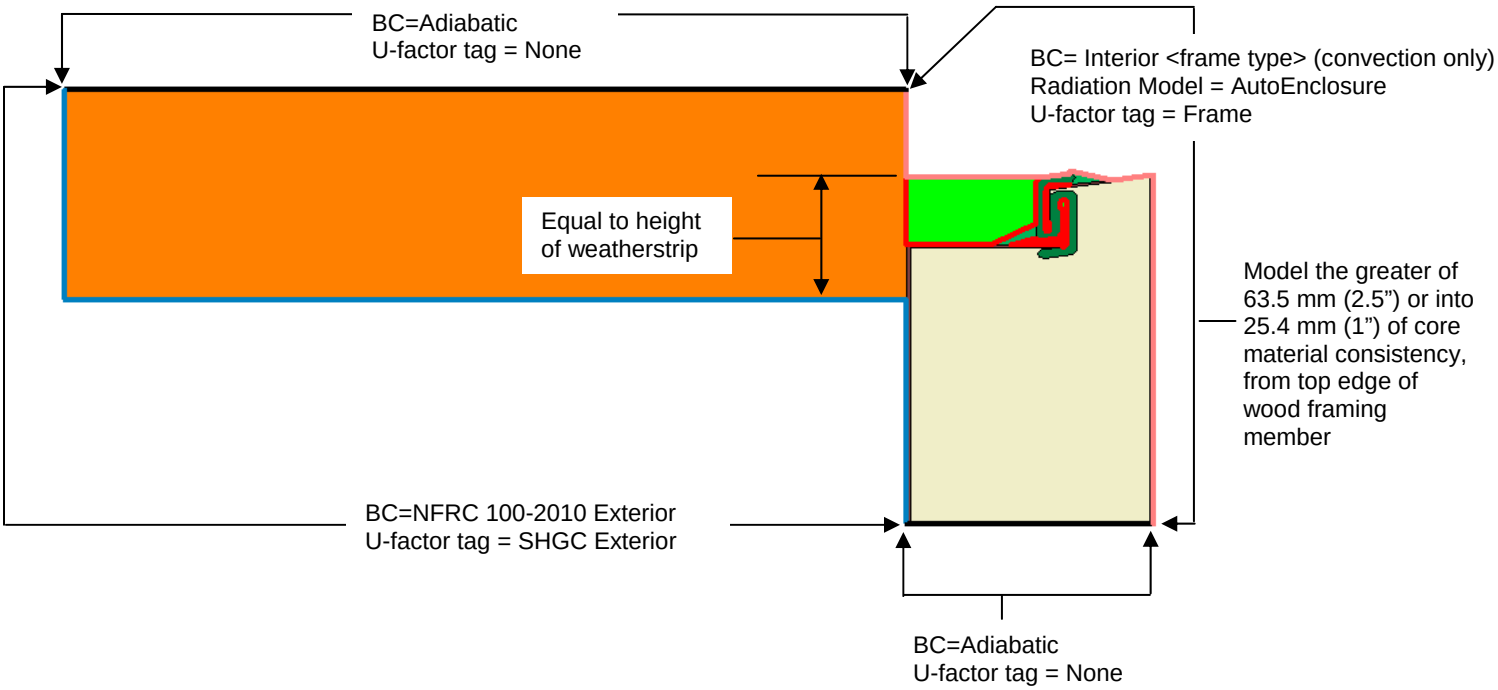


Figure 8-117 Top Rail Model.

8.12.1.2. Bottom Rail Model

A nominal 2 x 6 wood block is used in the bottom rail model of the garage door. Refer to the figure below for the boundary conditions and U-factor tag tags.

THERM File Properties:

- **Cross-section Type:** Sill
- **Gravity Arrow:** Down

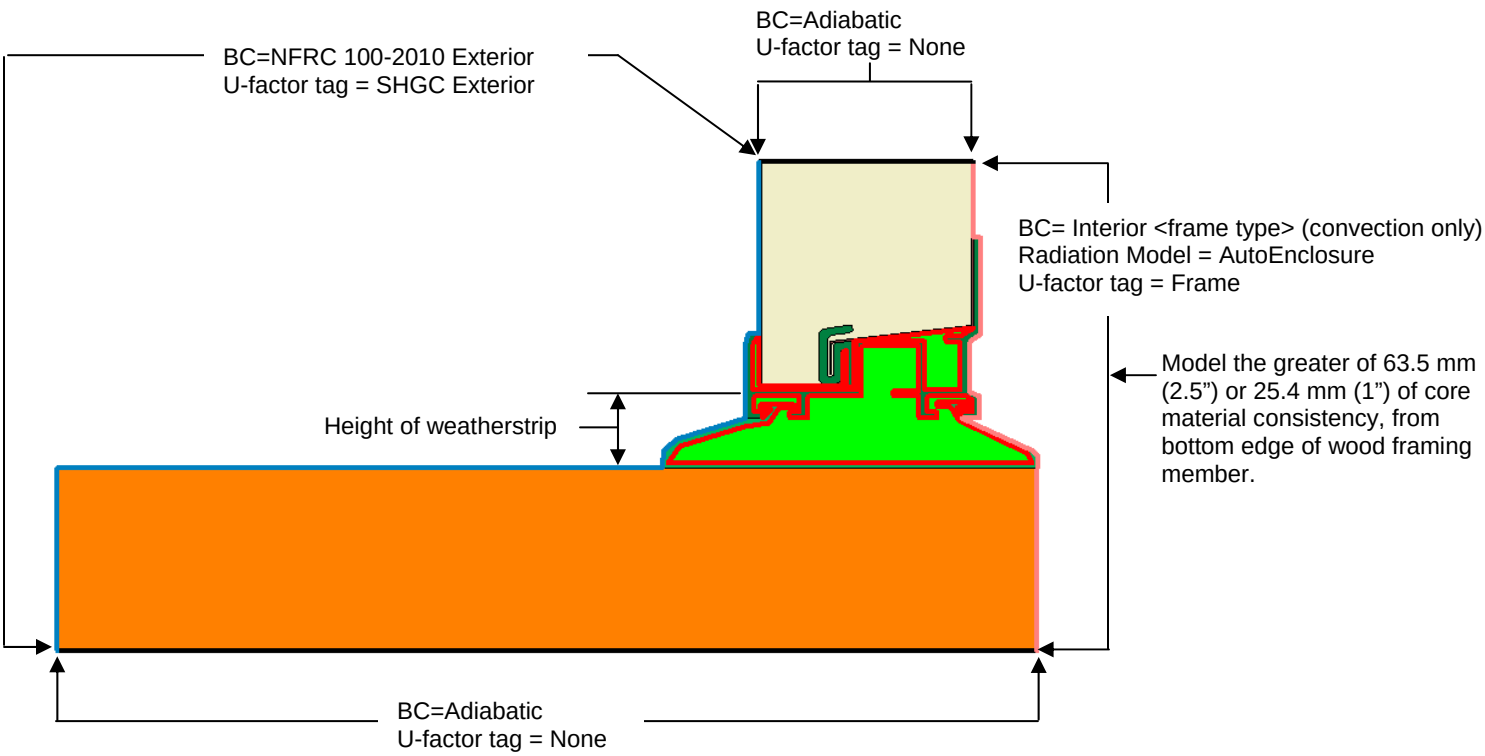


Figure 8-118 Bottom Rail Model.

8.12.1.3. End Stile Model

A nominal 2x4 wood block is used in the End Stile Model. The projected frame dimension shall incorporate a 1″ uniform section of the garage door panel. Any non-continuous hardware, such as rollers, shall not be included in the model. The boundary condition type and the U-factor tag used on the End Stile model are shown in the figure below.

THERM File Properties:

- **Cross-section Type:** Jamb
- **Gravity Arrow:** Into the Screen

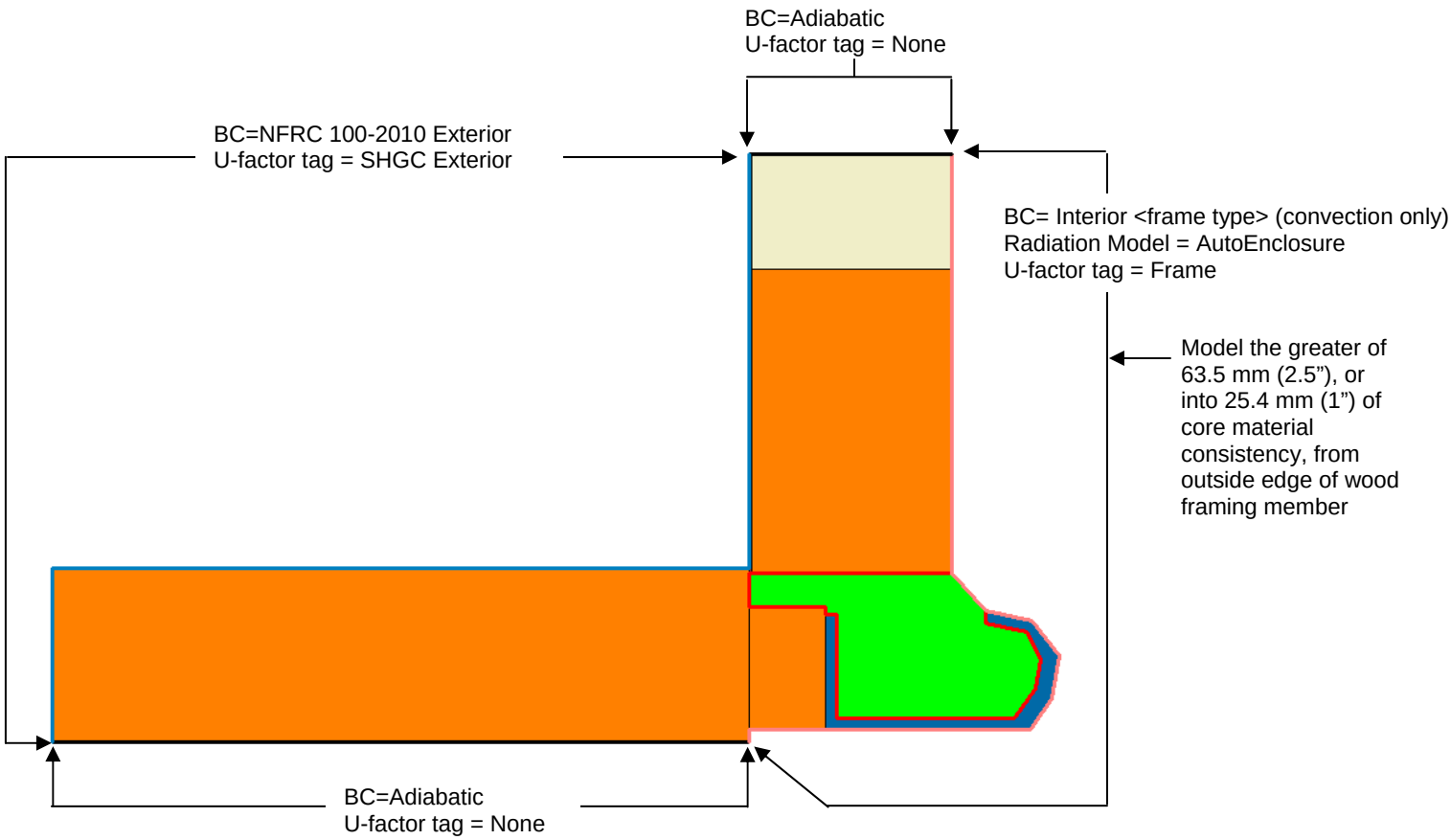


Figure 8-119 End Stile Model.

8.12.1.4. Meeting Rail / Door Panel Core Model

The Meeting Rail Model is combined with the Door Panel Core Model, as shown in the figure on the following page. The meeting rail model shall include 63.5 mm (2.5″) section of the each joining panel. The projected dimension of the panel core section shall be equal to:

([Height of the Panel]-5″) / 2

THERM File Properties:

- **Cross-section Type:** Horizontal Meeting Rail
- **Gravity Arrow:** Down

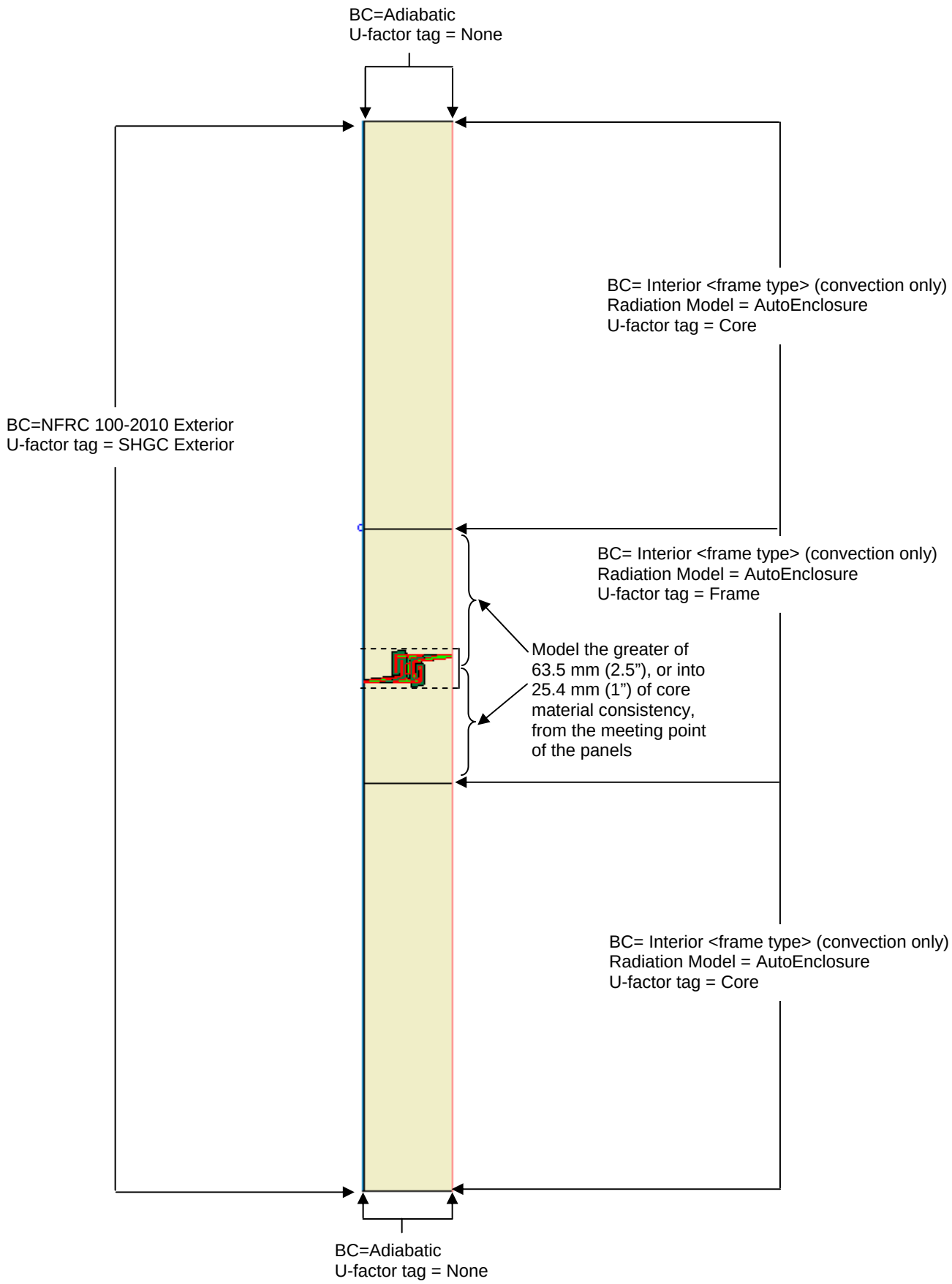


Figure 8-120 Meeting Rail and Door Panel Core Model.

8.12.1.5. Edge-of-Lite Model

The procedure for modeling edge-of-lite (edge-of-glazing) properties is the same procedure as for entry doors. See the entry door procedure in this manual for detailed instructions for modeling these cross-sections.

Below is a sample THERM cross section for the Door Lite Sill. See Section 9.5.4 for the complete example for Entry Doors.

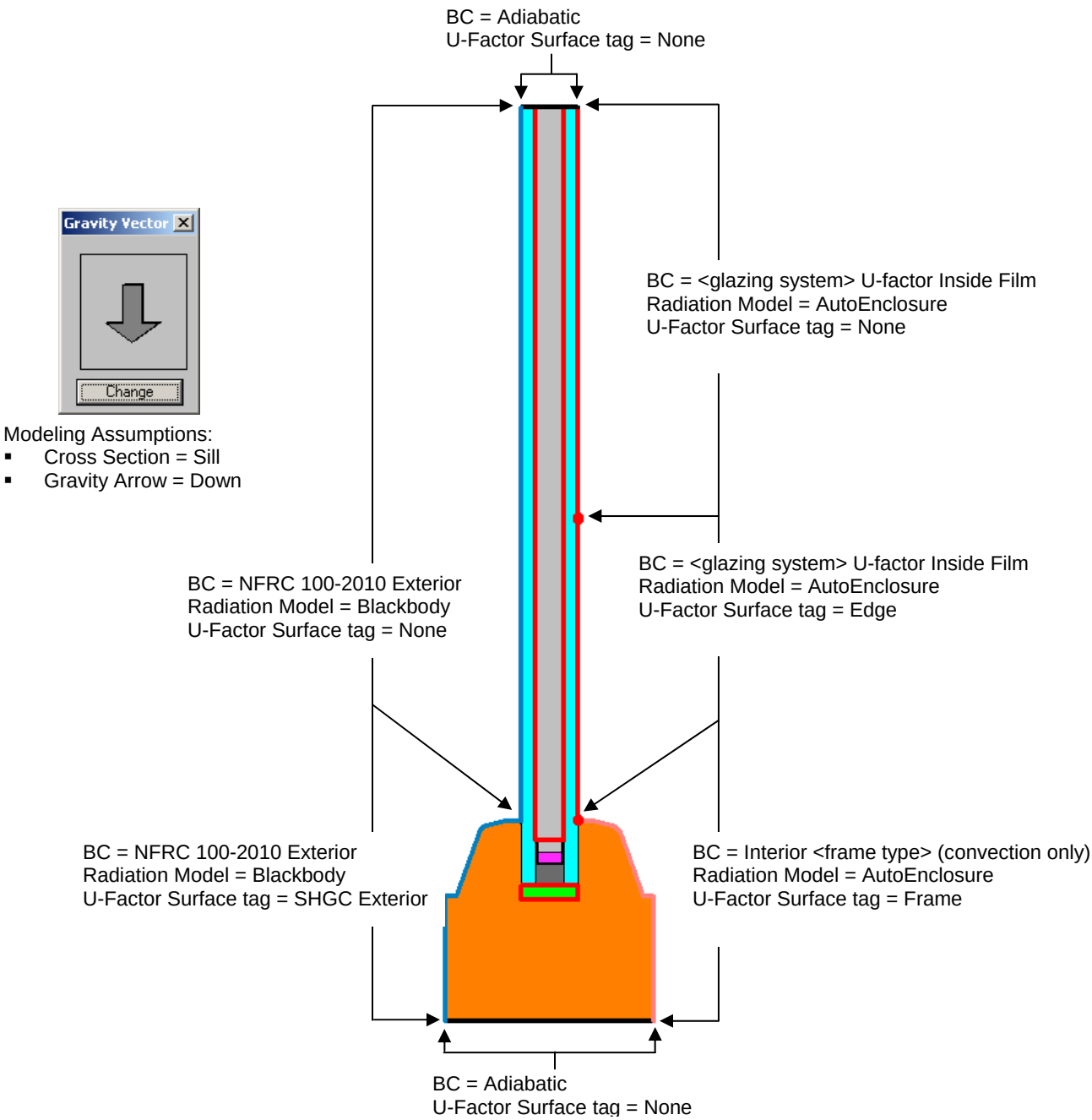


Figure 8-121 Edge-of-Lite model for the garage door lite.

8.12.2. Rolling Door

The overall product U-factor is calculated based on area weighted average of various component's U-factor. The components used for area weighting a rolling door are:

- Top Rail
- Bottom Rail
- End Stile
- Door Core

The U-factor of each component is calculated using two dimensional heat transfer software THERM.

The boundary condition details and other modeling assumptions used on the simulation models for door components are discussed in the following sections.

8.12.2.1. Top Rail Model

A nominal 2x4 wood block is used in the Top Rail Model as shown in the figure below. The torsion spring assembly, and any non-continuous hardware, shall not be included in this model. The boundary conditions (BC) and U-factor tags used in the model are described in the figure below.

THERM File Properties:

- **Cross-section Type:** Head
- **Gravity Arrow:** Down

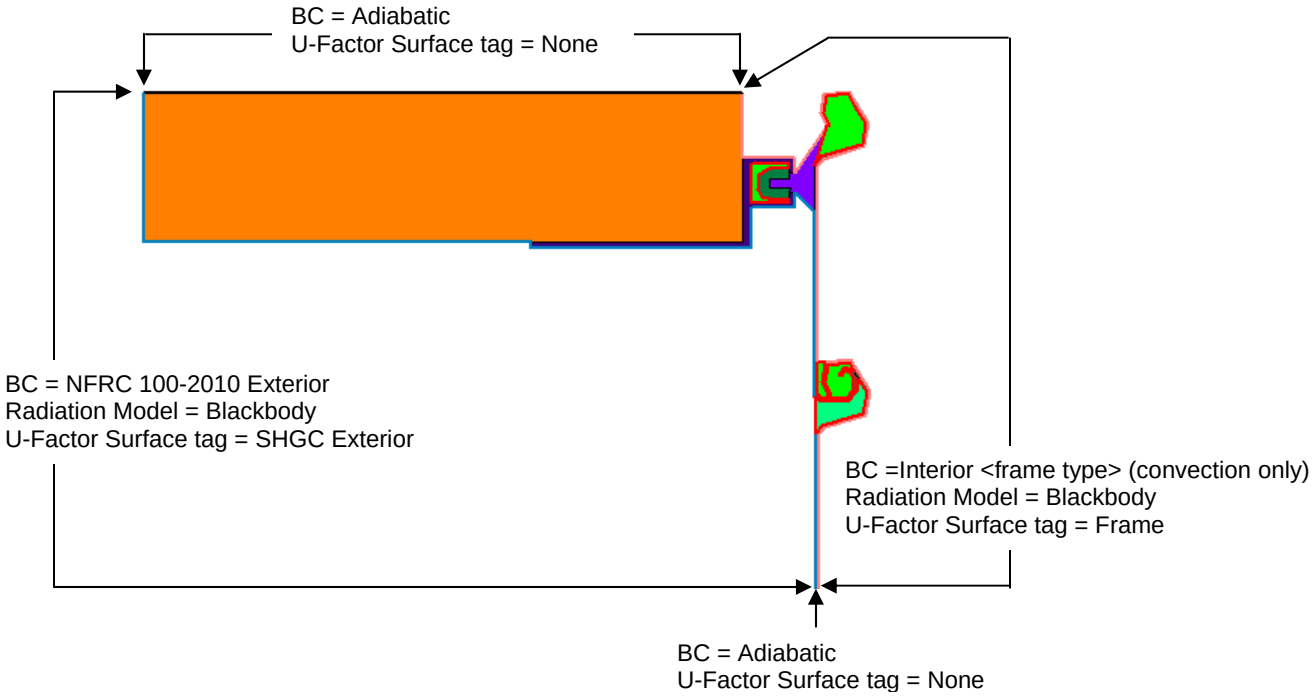


Figure 8-122 Top Rail Model for Rolling Door

8.12.2.2. Bottom Rail Model

A nominal 2 x 6 wood block is used in the bottom rail model of the rolling door. The figure below illustrates the boundary conditions and U-factor tags.

THERM File Properties:

- **Cross-section Type:** Sill
- **Gravity Arrow:** Down

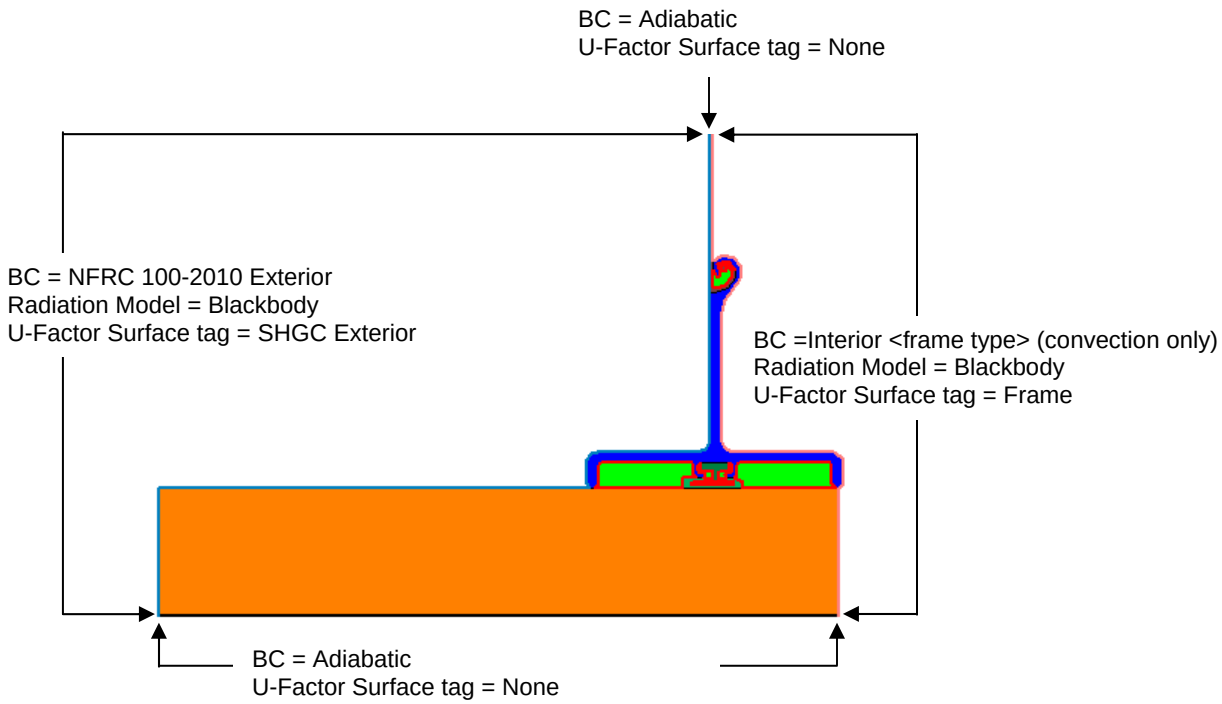


Figure 8-123 Bottom Rail Model for Rolling Door

8.12.2.3. End Stile Model

A nominal 2x4 wood block is used in the Stile Model. The boundary condition type and the U-factor tag used on Stile model are shown in the figure below

THERM File Properties:

- Cross-section Type: Jamb
- Gravity Arrow: Into the Screen

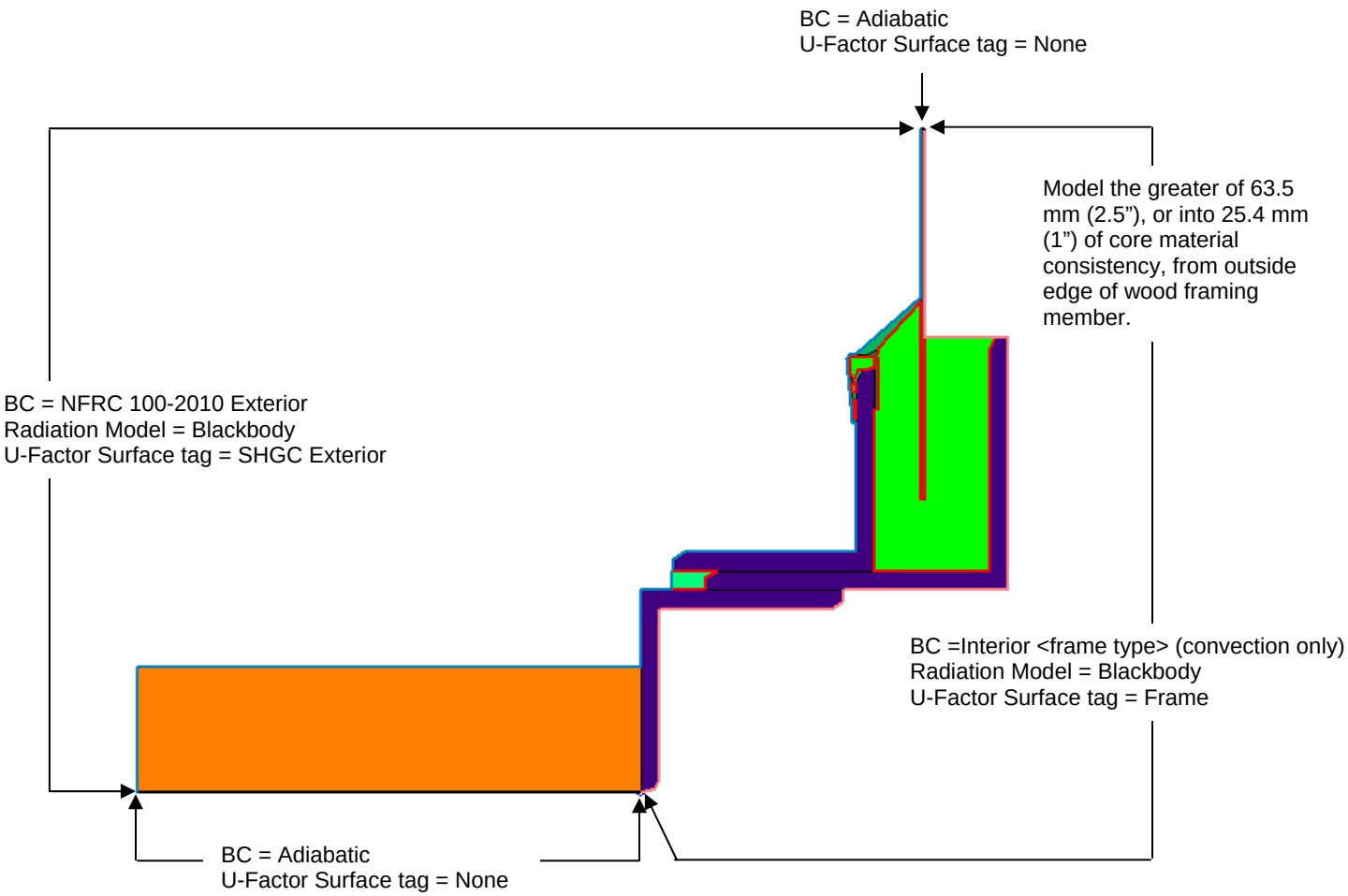


Figure 8-124 End Stile Model for Rolling Door

8.12.2.4. Door Core Model

The Door Core Model shall include two full slats and two half slats at each end. The details of the section where slats join shall be obtained from the manufacturer. The boundary conditions on door core model are specified in the figure below.

THERM File Properties:

- **Cross-section Type:** Horizontal Meeting Rail
- **Gravity Arrow:** Down

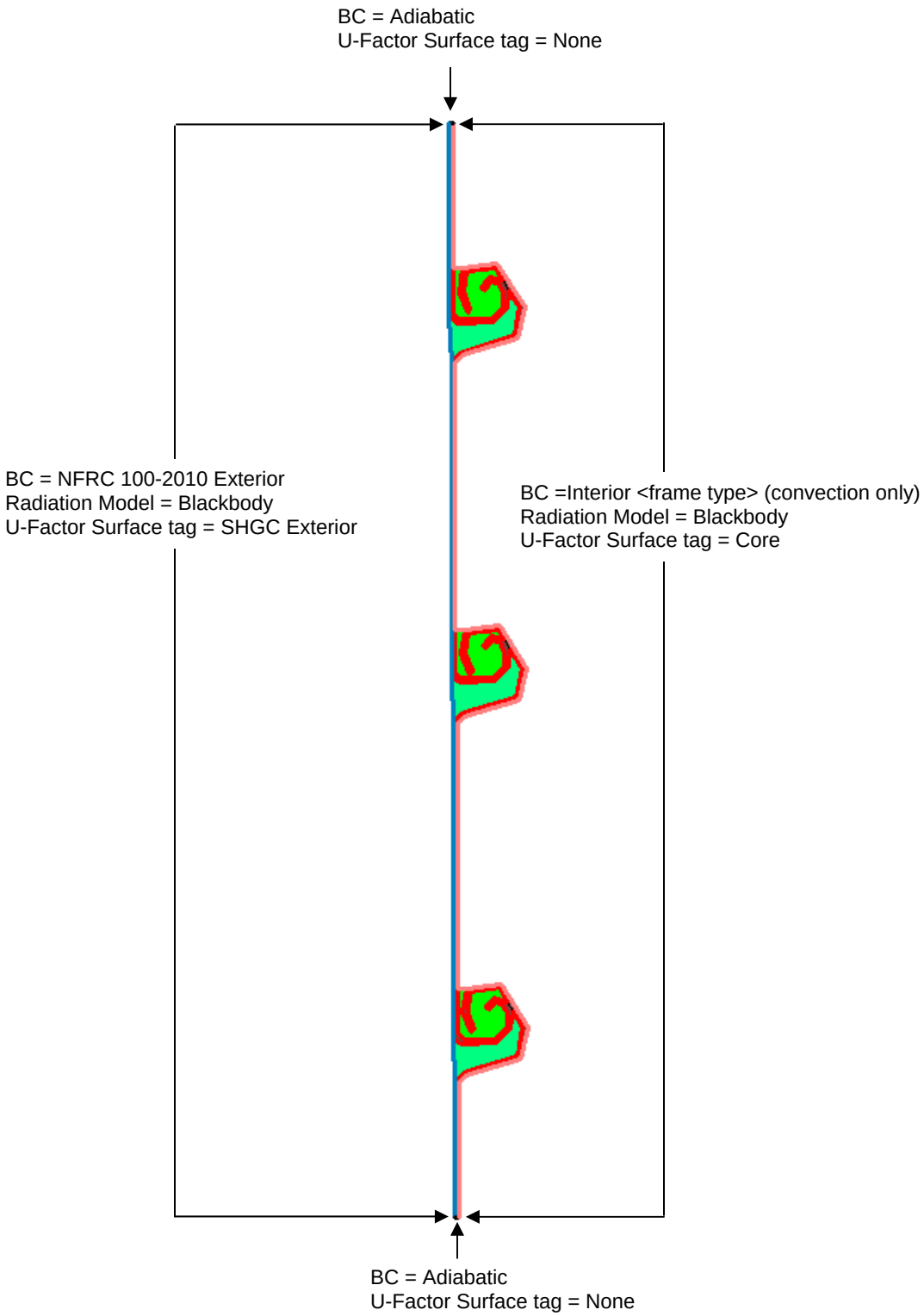


Figure 8-125 Door Core Model for Rolling Door

8.13. Creating a Laminate in Optics for NFRC

8.13.1. Overview

Optics5 can be used for the limited purpose of constructing laminates for NFRC certified simulations using the following criteria:

- Laminates *cannot* have embedded coatings, where embedded coatings are defined as a coating on a substrate that touches an interlayer
- Only NFRC glass layers with the NFRC approval indicator "#" can be used in these constructed laminates
- The glass layers can be tinted or coated as long as the coatings do not face the interlayer
- The interlayers in Optics5 do not have a "#" on them and therefore, only interlayers from the LBNL/NFRC "Approved Interlayer" list can be used (updated by LBNL with every IGDB release and available on the WINDOW Knowledge Base website), which means the data for those interlayers was submitted to the IGDB using the criteria specified in Section 1.2 of this document.

For NFRC verification of the laminate construction submitted by simulators:

- Laminates constructed by simulators in Optics5 will not have a # next to them. The simulator shall provide base properties for the complete laminate assembly, including solar transmittance (solar, T), visible transmittance (photopic, T), solar reflectance front (solar, Rf), solar reflectance back (solar, Rb), visible reflectance front (photopic, Rf), visible reflectance back (photopic, Rb), Emissivity front (EmitF), Emissivity back (EmitB). These values are reported on the Optics screen when the laminate is calculated, and also in the WINDOW Detailed Report from the Glazing System Library. This requirement is satisfied by submitting a WINDOW "mdb" database file which includes this laminate.
- An IA (or anyone else wanting to check the results) can recreate the laminate from the specified layers and verify the calculated values
- NFRC simulators shall assign numbers to the laminates starting with 30,000. The numbers do not have to be unique between simulation laboratories or even between projects in the same laboratory. These laminates are not stored in a central NFRC database.
- The naming convention for the laminate should describe the layers used to construct the laminate, using the IGDB Layer ID for glass layers and the interlayer name (from the Optics program) for the interlayer. If a glass layer is flipped, add the "F" designator to the end of the layer number. The total number of characters (not including extension, but including "/" separators in the name) cannot exceed 45.

  <glass layer ID><F if layer is flipped>/<interlayer name from Optics5>/<glass layer ID><F if layer is flipped>

  For example:

  102/030keepsafe/2026F

8.13.2. Laminate Interlayer Data

Optics can accurately calculate the optical properties of laminates as long as the component layers with the following characteristics (and only interlayers submitted with these characteristics will be included in the "Approved Interlayer List" for NFRC certification):

- Interlayers are measured with transparent glass with a solar transmittance Tsol > 0.820 and Tvis > 0.890. This ensures that a "constructed" laminate in Optics5 will always have a similar or lower transmittance than the reference laminate which determines the interlayer properties
- No glass layers have coatings next to interlayers (embedded coatings).
- Substrate layers (the base glass to which the interlayers are applied) are measured separately from the interlayers. This is the responsibility of the manufacturer submitting data to the IGDB, as discussed below.

As discussed in the LBNL document which contains guidelines for submitting data to the IGDB (*International Glazing Database: Data File Format, Version 1.4*, April 2003), "an interlayer is an adhesive layer used to join components in a laminate. The optical properties of laminate layers cannot be measured directly. Instead they are calculated from the spectral properties of a 'reference laminate' which consists of the interlayer laminated between two glass layers of known optical properties. To submit data for an interlayer, both the spectral optical properties of the reference laminate, and the glass layers used in the reference laminate should be submitted."

This means that in order for an interlayer to be added to the Optics5 "Interlayer" type, and therefore used in making laminate constructions in Optics5, the spectral data for a "reference" laminate which contains that interlayer is submitted to the IGDB as follows:

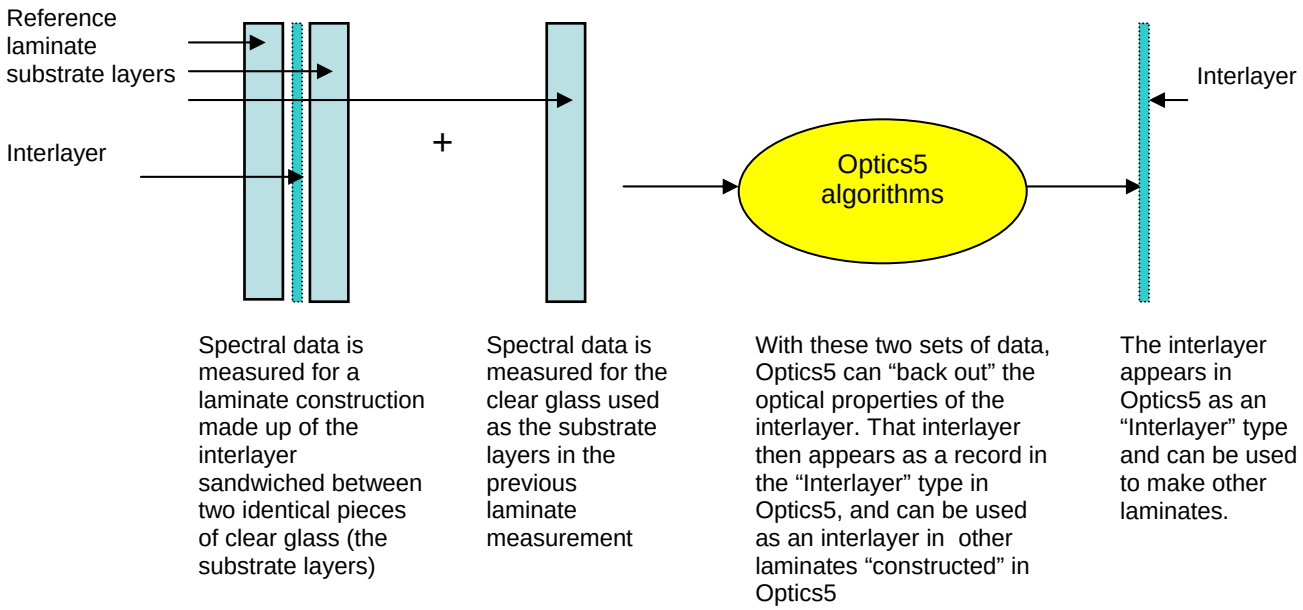


Figure 8-126. How Optics "deconstructs" measured data to obtain interlayer information.

Optics5 can do an accurate calculation for the interlayer properties from the reference laminate as long as the substrate glass layers have a high solar and visible transmittance, hence the requirement of Tsol > 0.820 and Tvis > 0.890. This ensures that laminates that are later created in Optics5 with this interlayer will almost always have a lower solar and visible transmittance then the reference laminate.

8.13.3. Constructing a Laminate in Optics5

8.13.3.1. Building a New Laminate

When Optics5 starts, you can start building a laminate immediately by switching to the 'Laminate' tab and adding layers (see "8.13.3.3. Add Layers to a Laminate").

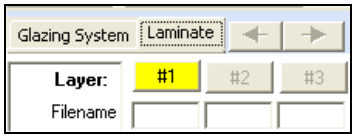


Figure 8-127. Click on the Laminate tab to start constructing a laminate.

If you have created a laminate already, but want to start over with an empty laminate:

- Make sure the 'Laminate' tab is selected
- Choose menu option **File|New Laminate**
- You will be prompted to save the current laminate if one already exists

Note: if you created new layers and did not save the layers or did not save the laminate (which would save any new layers), the new layers will be lost when you start a new laminate

8.13.3.2. Wavelength Sets

Use the NFRC default wavelength set, which is called "Optics5". This setting is shown on startup of the program, and also can be viewed (and changed if necessary) from the menu option **Tools|Select Wavelength Set**.

8.13.3.3. Add Layers to a Laminate

You can add monolithic, coated, and interlayer type layers to a laminate. There are a number of 'rules' for building laminates:

1. The first and last layer in a laminate must be a non-interlayer type (e.g. monolithic or coated)
2. You can place as many interlayers as you like adjacent to each other, but you must separate rigid non-interlayers with at least one interlayer.
3. For NFRC certified simulations, you can NOT place a coating next to an interlayer.

If you break rule 1 or 2, the operation will be cancelled.

Use the 'Add Interlayer' tab above the database to add interlayers. To add other layers, use the 'Add Glazing' tab. Only those database records with enough data to be loaded into a laminate will be shown in these views – if you want to see all records in the database, including those which cannot be used in laminates, use the 'View All' tab. If you try to load an invalid layer into a laminate from the 'View All' view of the database, an error message will be displayed.

8.13.3.4. Add Glazings to a Laminate

You can add monolithic, coated, and interlayer type layers to a laminate as long as you follow the laminate-building 'rules' (see "8.13.3.3. Add Layers to a Laminate" above).

To add layers from the current database to a laminate:

- Select the first available (unoccupied) layer in the laminate by clicking on its layer button – if you select an occupied layer, it will be replaced (see "8.13.3.8. Replace a Layer in a Laminate")

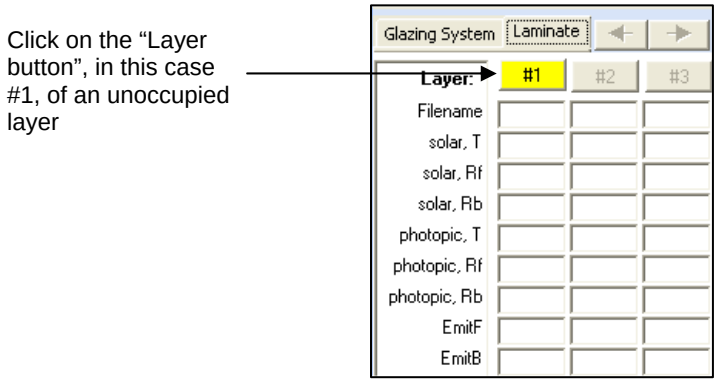


Figure 8-128. Click on the #1 layer button to add the first glass layer.

- Select the 'Add glazing' tab in the database

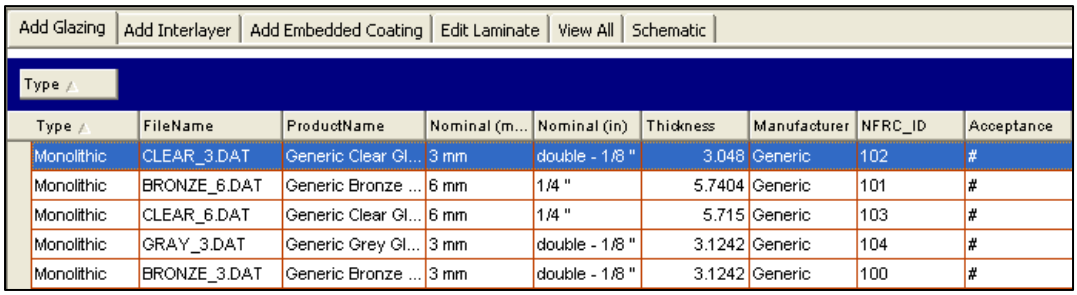


Figure 8-129. Select the glass layer from the Add Glazing tab.

- Double-click on the layer in the database
  or
- Using the mouse, drag the layer from the database over the layer button where you want to add the layer and release the mouse button
  or
- Select the layer in the database, then choose the menu option **Database|Add/Replace Layer**
  or
- Select the layer in the database, then right-click to display the pop-up menu then choose **Add/Replace Layer**

If you are replacing a layer, a dialog box will appear to confirm that you want to replace the existing layer.

Note: Select a layer in the database by clicking on it with the mouse, or by browsing to it by pressing the up and down arrow.

8.13.3.5. Add Interlayers

To add an interlayer to a laminate:

- Select the first available (unoccupied) layer by clicking on a layer button
- Select the 'Add Interlayer' tab
- Select the interlayer you want to add, and load it into the laminate (see "8.13.3.3. Add Layers to a Laminate")

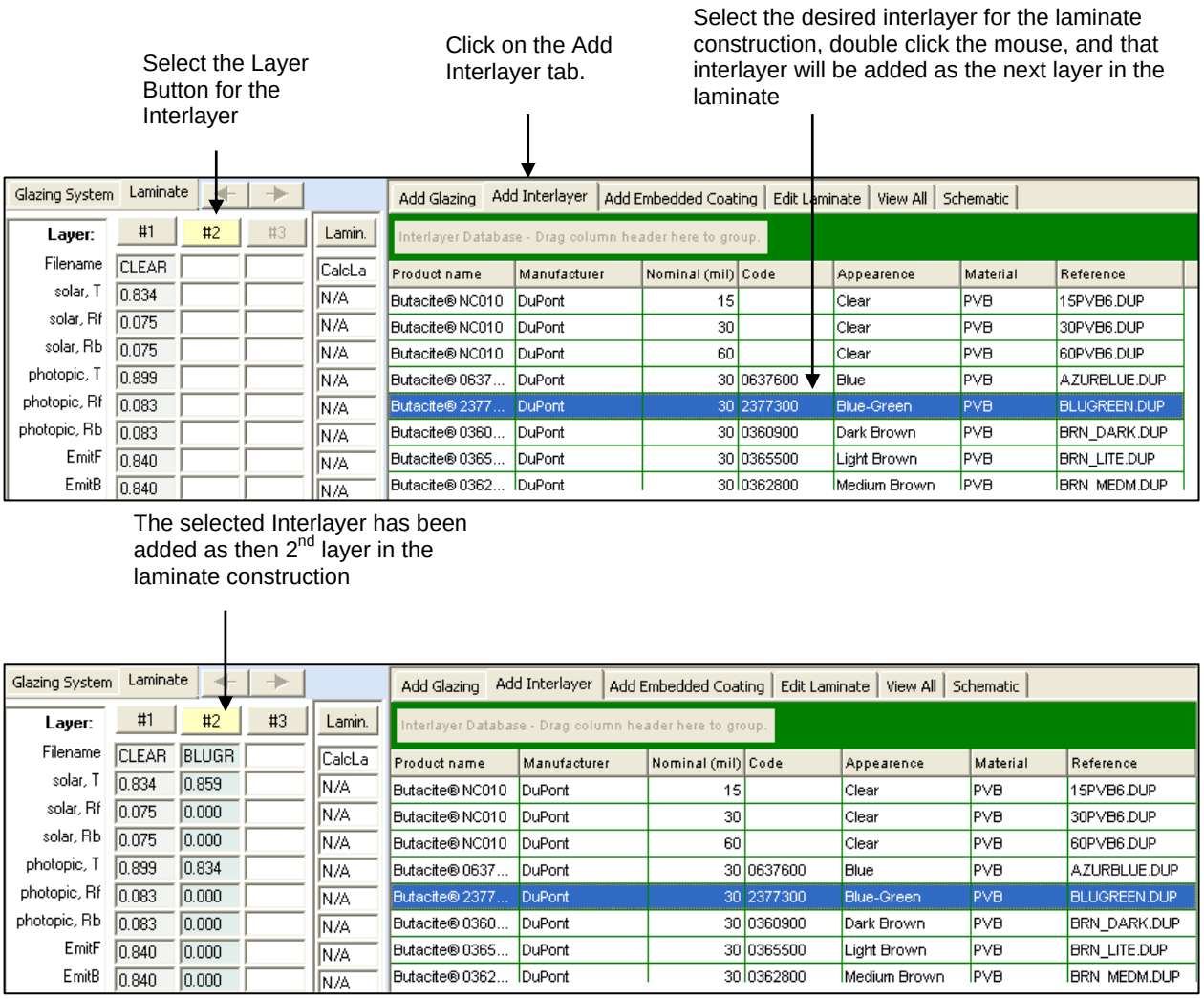


Figure 8-130. Select the desired interlayer from the Add Interlayer tab for layer #2.

8.13.3.6. Flip Layers in a Laminate

To flip layers in a laminate:

- Select the layer to flip by clicking a layer button
- Choose the menu option **Edit|Flip Layer**
  or
- Right-click on the layer button to display the pop-up menu and select **Flip Layer**

- If flipping the layer would place a coating adjacent to an interlayer, and this will break the laminate-building rules (see "8.13.3.3. Add Layers to a Laminate") and the laminate cannot be constructed for NFRC certification.

Note: Check the schematic view and the layer spectral averages if you are not sure which way a layer is oriented.

If any glass layers are flipped, make sure to add an "F" to the NFRC ID in the name of the final laminate.

8.13.3.7. View the Properties of a Laminate

To view the calculated spectral data, spectral averages and other properties of a laminate:

- Select the laminate by clicking on the 'Lamin.' layer button
- The laminate is now the current layer, so its spectral data and spectral averages are displayed in the lower part of the screen

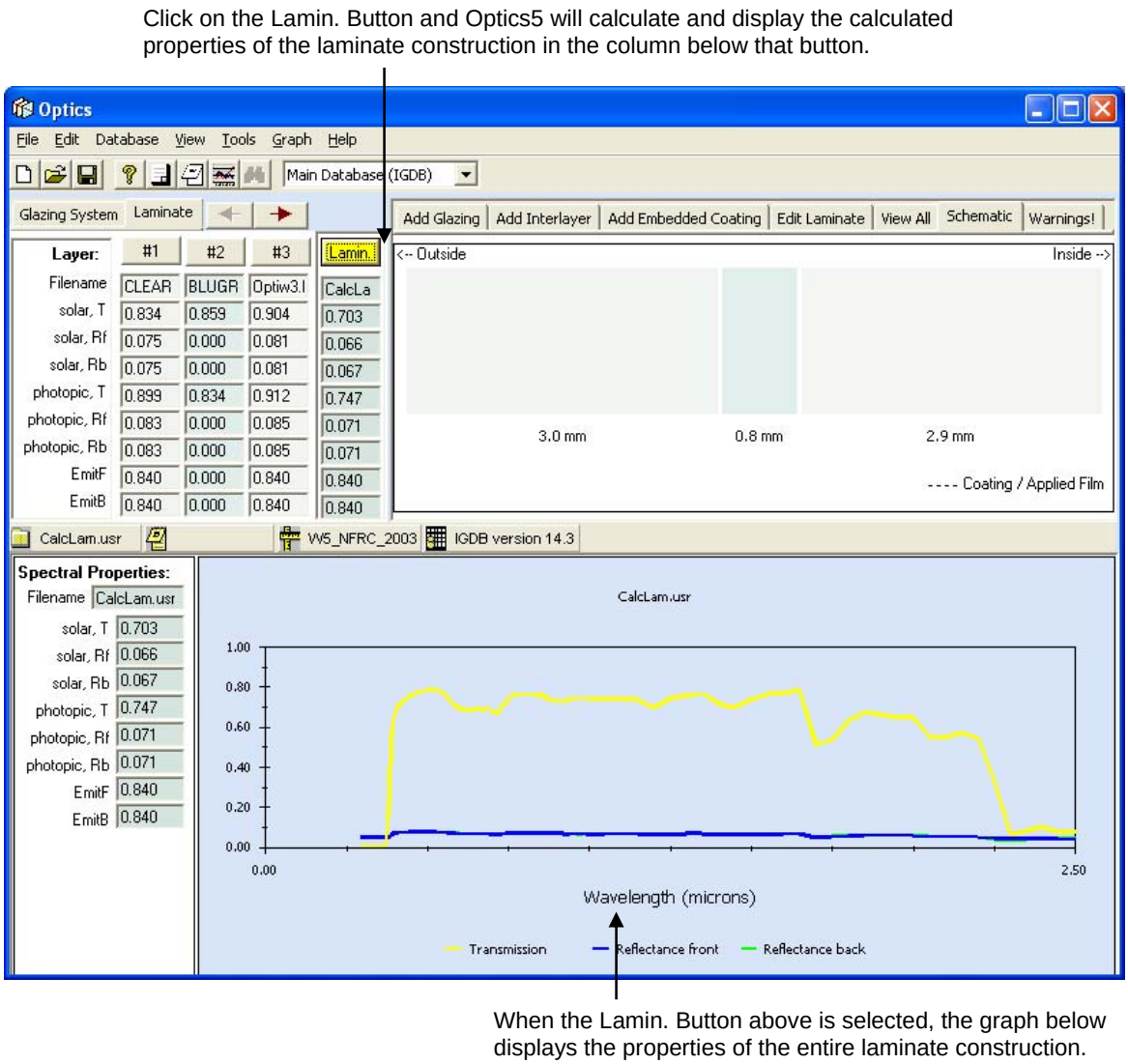


Figure 8-131. Click on the Lamin button to view the optical properties of the entire laminate structure.

- To view a schematic diagram of the laminate, select the 'Schematic' tab in the upper right part of the screen

- To view the spectral data in a table, choose menu option **View|Spectral Data Grid**.
- To view calculation warnings for the laminate data, select the 'Warnings' tab in the upper right part of the screen
- To see more information about the laminate, choose menu option **View|View Details**

8.13.3.8. Replace a Layer in a Laminate

Replace a layer in a laminate in the same way as you would replace a layer in a glazing system – you must respect the laminate-building rules (see "8.13.3.3. Add Layers to a Laminate").

You cannot insert layers into a laminate – you must delete and add layers from the interior side of the laminate to modify the structure.

8.13.3.9. Delete a Layer in a Laminate

You can only delete the last (interior side) layer in a laminate. To delete the last layer:

- Select the last layer by clicking the layer button
- Choose the menu option **Edit|Delete Layer**
  or
- Right-click on the layer button to display the pop-up menu and select **Delete Layer**

8.13.3.10. Save a Laminate

To save a laminate to the user database:

- Select the laminate by clicking on the 'Lamin.' layer button
- Click the 'Save' button on the toolbar:
  or
- Choose the menu option **File|Save *filename***
  or
- Right-click the layer button to display the pop-up menu and select **Save *filename***

Note: To save the laminate under a different name, choose the menu item **Save As…**

8.13.3.11. Edit a Laminate

To edit a laminate saved in the user database:

- Make sure the 'Laminate' tab is selected above the layer buttons
- Select the 'Edit Laminate' tab in the upper right part of the screen
  or
- Choose the menu option **File|Edit Laminate**
- Load the laminate you wish to edit like you would add a layer into any layer position – the current laminate will be cleared, and the saved laminate loaded.

Note: You cannot edit laminates in 'Glazing' mode, you must switch to 'Laminate' mode first. In order to use the edited laminate in a glazing system, save the laminate to the user database, switch to 'Glazing' mode and re-load the laminate layer into the glazing system from the user database.

Note: You cannot use a laminate as a component of another laminate

8.13.3.12. Calculation Warnings for Laminates

The optical properties of most laminates without coatings can be calculated without generating warnings, except that it is likely that some components will not have spectral data across the whole range of the selected wavelength set (see "8.13.3.2. Wavelength Sets"), so the wavelength set will be truncated.

8.13.3.13. Viewing Calculation Warnings for Laminates

To view calculation warnings for a laminate:

- Select the laminate by clicking on the 'Lamin.' layer button
- Select the 'Warnings' tab

The example below shows a warning message that says:

> Results could not be calculated at all wavelengths in the selected wavelength set. Wavelength set truncated to: 0.300 – 2.500 um

This message does not indicate a problem because the solar optical properties in WINDOW are calculated between 0.300 and 2.500 um.

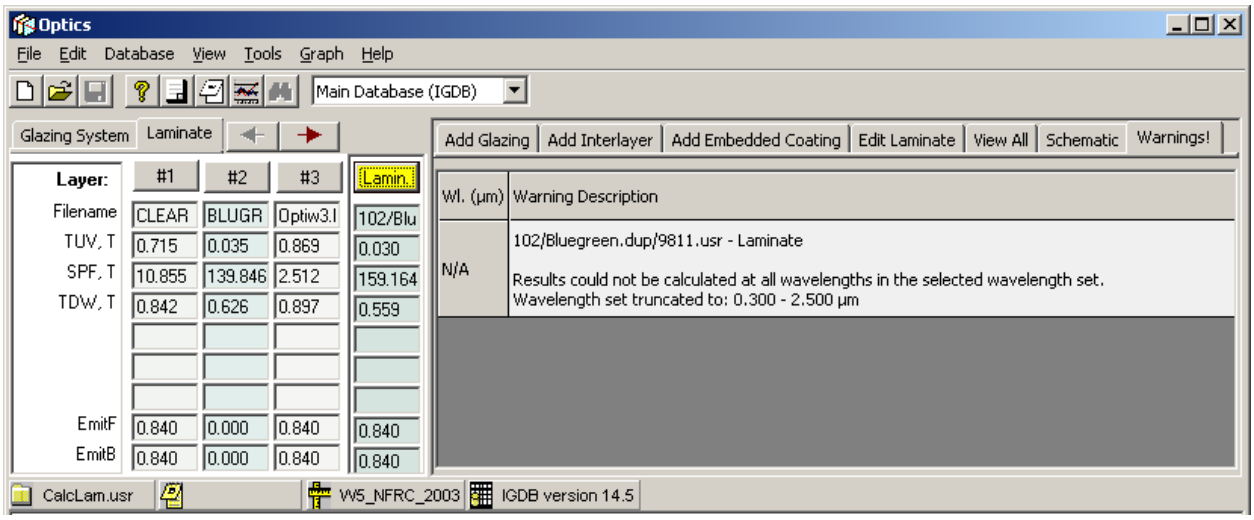


Figure 8-132. An example of a warning that is not relevant for the calculations WINDOW will be doing with the laminate.

8.13.3.14. Save the Laminate to a User Database to Import into WINDOW5

User databases have the same format as the IGDB, but they are used to store data that the user has imported, or generated with Optics5. It is not possible to add layers to the IGDB, so all new layers are saved to the user database.

The default user database is '`UserGlazing.mdb`' in the `'\LBNL Shared'` directory of your program installation. You can specify the location of the user database – this allows you to use as many user databases as you like (one at a time) with Optics5.

To create a new (empty) user database:

- Click on the Database menu, and select the choice "Create new user database".

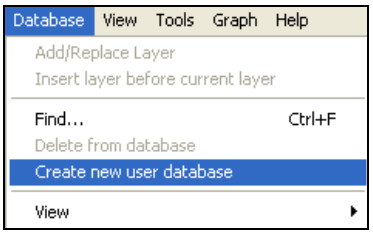


Figure 8-133.Use the Database/Create new user database option to create a blank user database.

- The program will ask you for a database name and location. Name the database as appropriate and put it in whatever directory is desired – the default directory for the default Optics User Database (called UserGlazing.mdb) is the "c:\Program Files\LBNL\LBNL Shared" directory, but any user database can be put in any directory, as long as the path is specified (Tools menu,

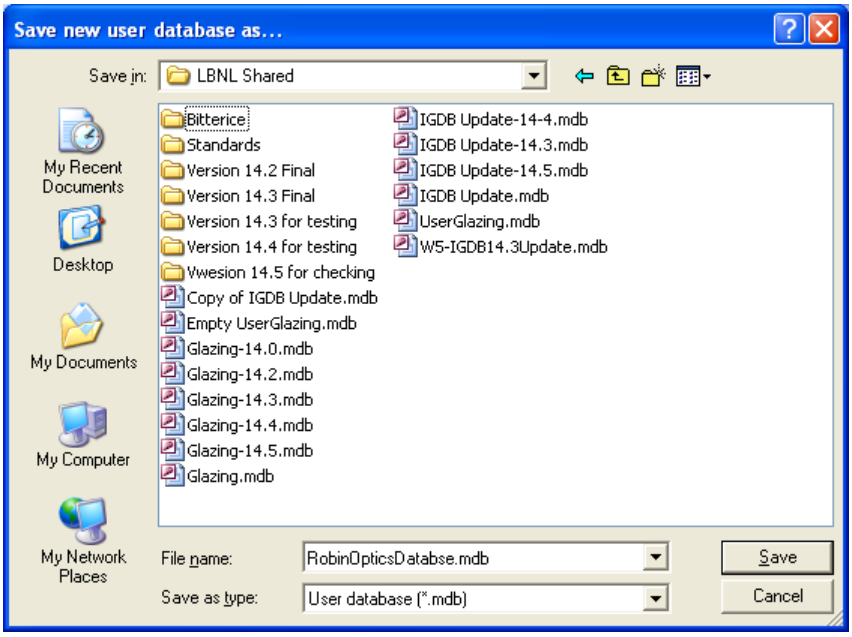


Figure 8-134.Specify the name of the new user database as well as the location where it will be stored.

- Set the default user database to the newly created database from Tool/Options

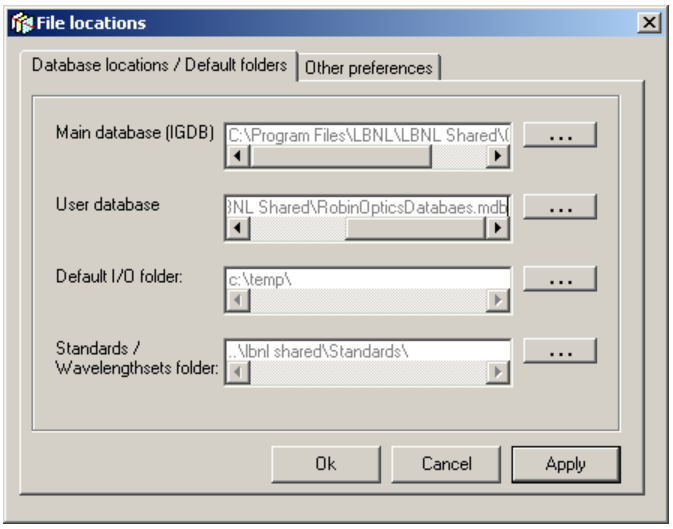


Figure 8-135.Define the location for the User Database from the Tool/Options menu, setting the "User database" field

You can save a layer to the user database if it has a different filename to any layer currently in the user database or in the IGDB. If you save a layer that has components (such as a coated layer that has a substrate, or a laminate which has component layers), the component layers will be saved to the user database at the same time (unless they already exist in the IGDB or user database). This allows you to load and edit those layers at a later time.

If you want to save an unmodified layer from the IGDB to the user database, you must change its filename first.

To save a layer to the user database:

- Select the layer or system to save by clicking on a layer button
- Click the 'Save' button on the toolbar:
  or
- Choose menu option **File|Save *filename***
  or
- Right-click to display the pop-up menu and select the option **Save *filename***
- If the layer or system you saved had components, or if the save operation fails, you will be asked 'Do you want to view the details of the save operation?'. If you answer yes, you can view information about components that were saved to the user database, and components that were not saved to the user database along with an explanation of why some components were not saved.

Note: to change the filename and save in one operation, choose menu option **Save As..** instead.

Note: You cannot save data for a layer with the same filename as another layer in the IGDB or your current user database. If a conflict is detected, Optics will ask you to rename the layer before saving it, or cancel the import. The most common reason a component is not saved is that its filename already exists in the IGDB or user database. In this case Optics assumes that the component layer information is already available and does not need to be saved again.

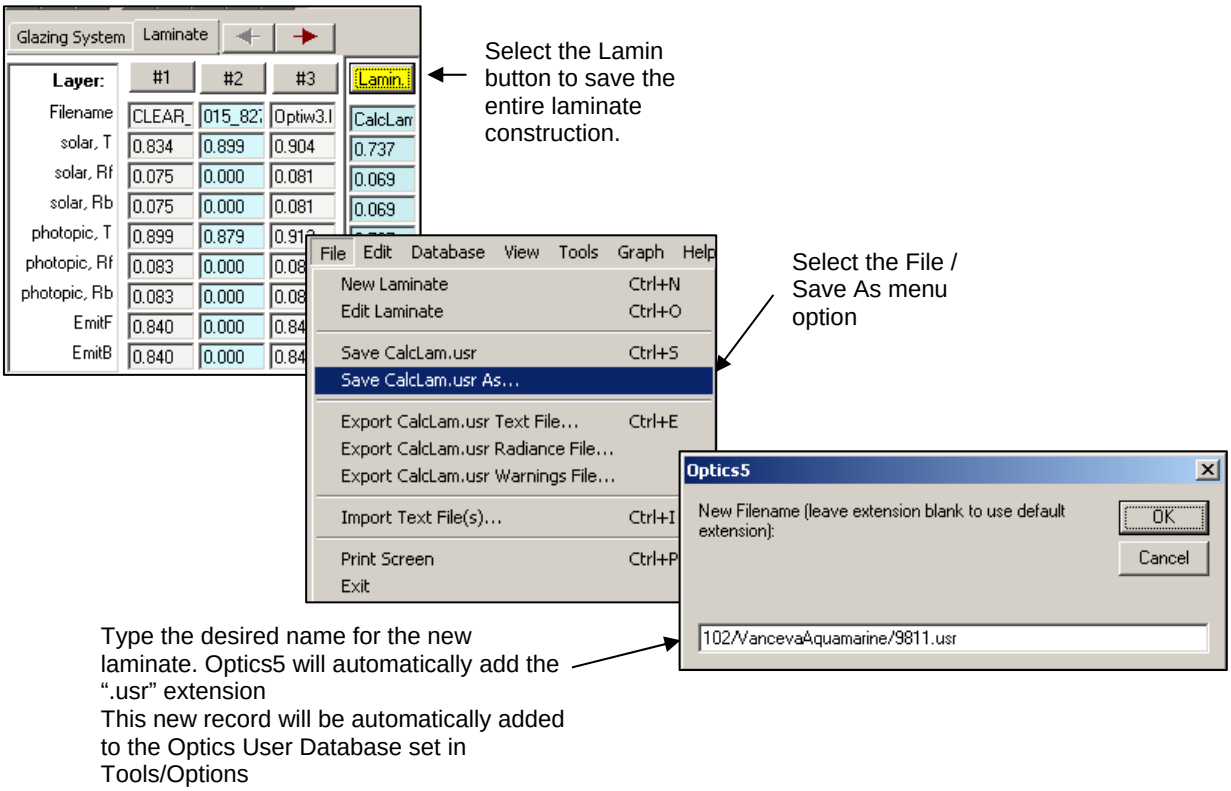
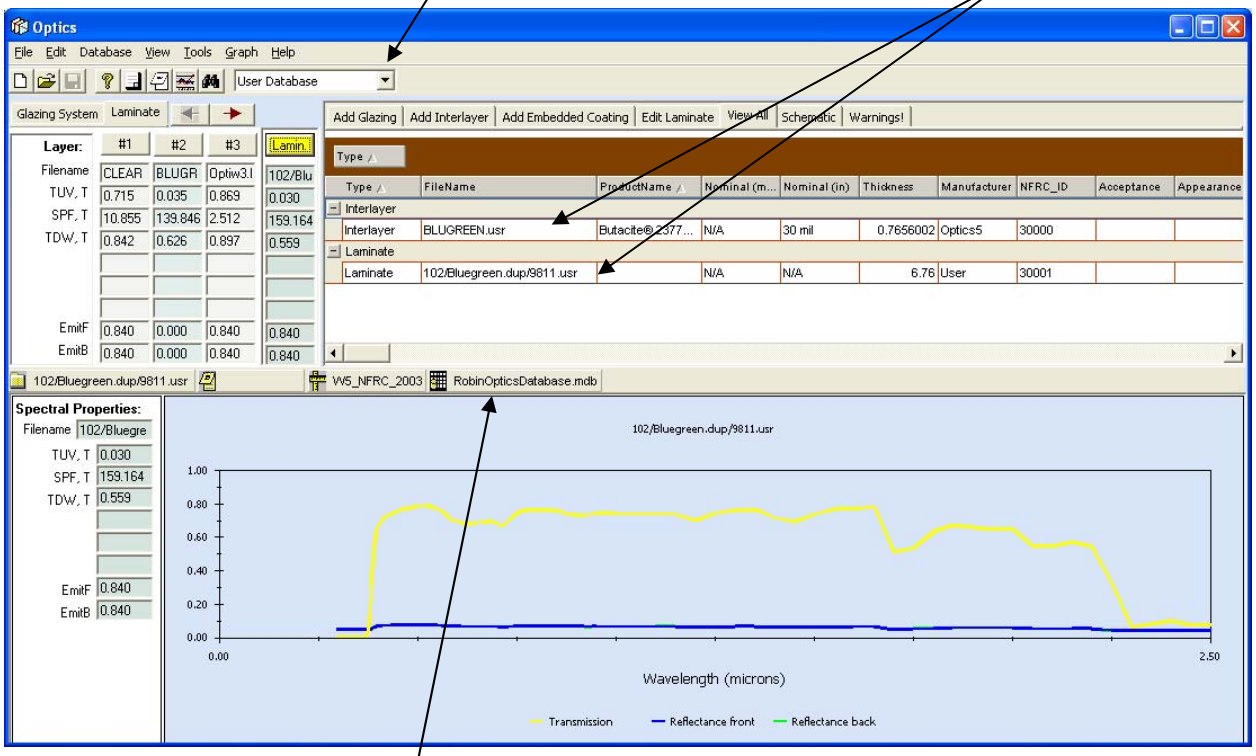


Figure 8-136. Save the final laminate using the naming convention of<glass layer ID>/<interlayer name/><glass layer ID>.

Select User Database from the pulldown list to see the records in the User Database.

The laminate construction (called in this case ClearLaminate.usr) as well as the Interlayer used in the laminate is saved in the User Database. The glass layers on either side of the Interlayer are not saved in the User Database because they are found in the IGDB



The name of the User Database is displayed on this button

Figure 8-137.Select the User Database to see the constructed laminates (and the associated interlayers)

8.13.3.15. Importing the Laminate into WINDOW from the Optics5 User Database

In WINDOW, in **File/Preferences**, go to the Optical Data tab, and set the second option, Optics5 User Database, to your Optics5 user database (which by default is called UserGlazing.mdb, but it can have any name with the "mdb" extension) -- you can browse to the file with the browse button (its default location is in Program Files\LBNL\LBNL Shared directory).

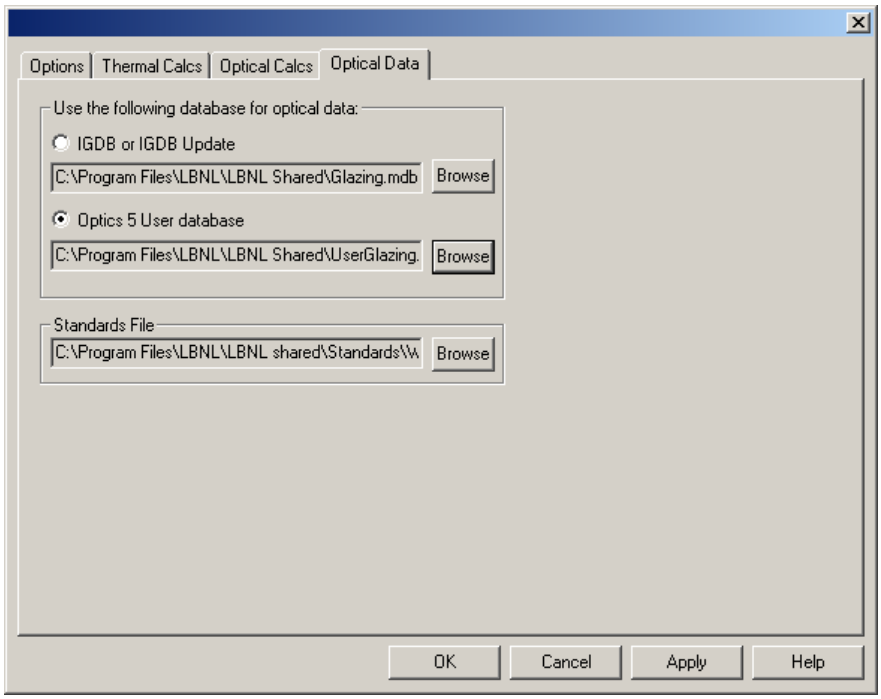


Figure 8-138. Using the File/Preferences menu, click on the radio button for the "Optics 5 User database" and use the Browse button to specify the file with the full directory path.

In WINDOW5, go to the **Glass Library List View**, click on the **Import** button, select "IGDB or Optics User Database" as the format, and click **OK**.

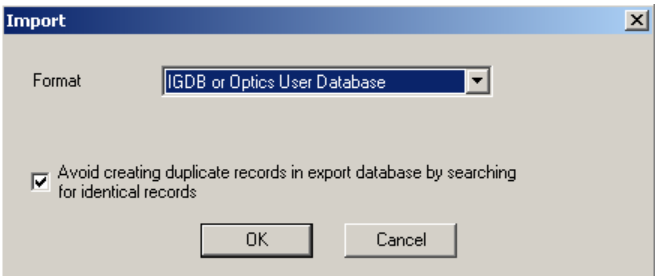


Figure 8-139. Import the data from the Optics User Database.

The program will open the user database set in the **File/Preferences** dialog box (the name will be displayed at the top of the dialog box) and you will see the glass layers that can be imported in to the existing library.

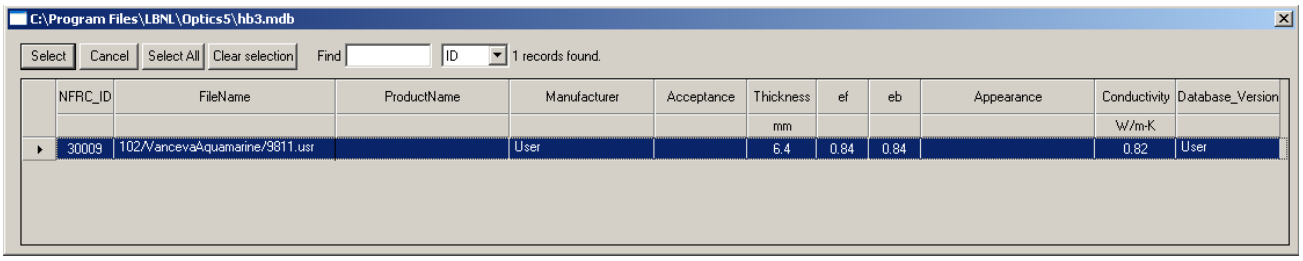
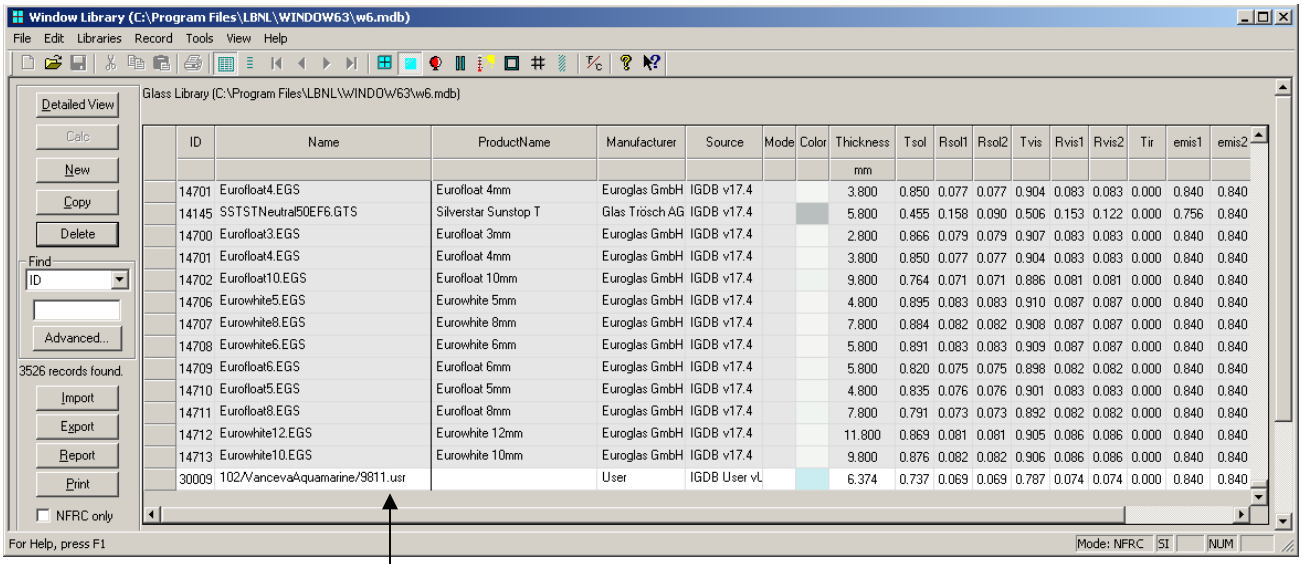


Figure 8-140. You will see all the entries in the specified user database.

You can select the records you want to import (use **Shift Click** to select contiguous records, **Ctl Click** to select multiple non-contiguous records, or **Select All** to select all records). Then click the **Select** button, which will import the selected records into the **Glass Library**.



The laminate has now been imported from the Optics5 user database to the WINDOW Glass Library. It can now be used in the Glazing System Library to create a glazing system.

Figure 8-141. The laminate has now been added to the WINDOW Glass Library.

8.14. Creating an Applied Film Layer in Optics for NFRC Certification

8.14.1. Overview

Glazing layers with applied films can be constructed using Optics5 for NFRC certified simulations using the following criteria:

- The substrate for the applied film *cannot* have embedded coatings, where embedded coatings are defined as a coating on a substrate that touches the applied film.
- Only NFRC glass layers with the NFRC approval indicator "#" can be used as the substrate for applied film layers
- The glass layers used as the substrate for the applied film can be tinted or coated as long as the coatings do not face the applied film
- Only the layers of the Type "**Applied Films**" in Optics5 that have a "#" on them and are also on the "Approved Applied Films List" (updated by LBNL with every IGDB release and available on the WINDOW Knowledge Base website) can be used. This means that the data for those applied films was submitted to the IGDB using the criteria specified in Section 1.2 of this document, and that the Applied Film manufacturers are participating in the NFRC rating program.

For NFRC verification of the laminate construction submitted by simulators:

- Glass Layers with an applied film constructed by simulators in Optics5 will not have a # next to them when imported into WINDOW 5. The simulator shall specify in simulation reports the NFRC ID's of the applied film and the substrate, which shall all meet the # criteria, such as:

  2802 / 5038
- The simulator shall provide the properties for the applied film layer, including solar transmittance (solar, T), visible transmittance (photopic, T), solar reflectance front (solar, Rf), solar reflectance back (solar, Rb), visible reflectance front (photopic, Rf), visible reflectance back (photopic, Rb), Emissivity front (EmitF), Emissivity back (EmitB). These values are reported on the Optics screen when the laminate is calculated, and also in the WINDOW5 Detailed Report from the Glazing System Library. This requirement can be met by submitting the Optics5 User Database containing the applied film glass layers with the certification documentation.
- An IA (or anyone else wanting to check the results) can open the Optics5 User Database to verify the film and substrates used, as well as recreate the applied film layer from the specified film and substrate to verify the calculated values

8.14.2. Film Data

There are two types of films in Optics 5; the difference between them is how they were measured for submittal to the International Glazing Database:

- **Films:** These films were measured without a substrate and may appear in and be inputs to Optics5 calculations. However, the IGDB submittal process no longer accepts this type of submittal, and **they cannot be used for the NFRC Applied Film procedure**. Data in this category can be resubmitted to the IGDB, measured as an applied film with a substrate, and thus be added to the Applied Film category.
- **Applied Films:** These films are measured with a substrate. For the purposes of the NFRC Applied Film procedure, the only films that can be used are those that were measured with a clear substrate, the substrate having the properties of Tsol > 0.820 and Tvis > 0.890

Optics5 can accurately calculate the optical properties of applied films on glass layers as long as the applied films were measured following the guidelines listed below (and only applied films submitted with these characteristics will be included in the "Approved Applied Films" list for use in NFRC certified product calculations):

8.14.2.1. IGDB Submittal for Applied Films

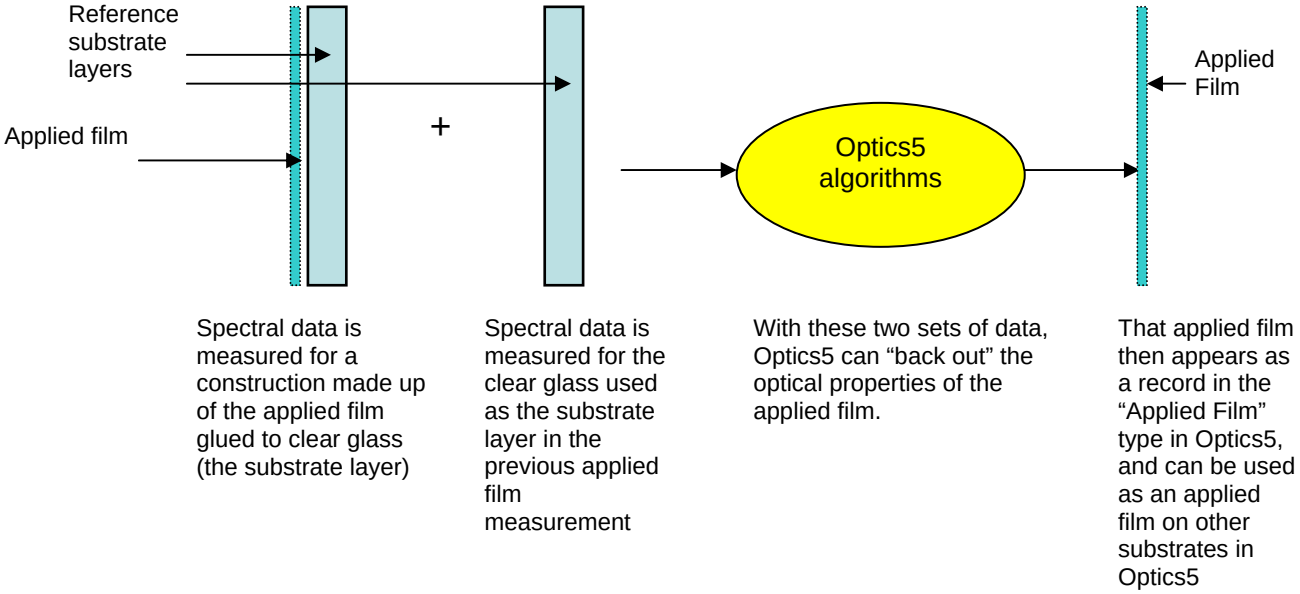
As discussed in the LBNL document which contains guidelines for submitting data to the IGDB (*International Glazing Database: Data File Format, Version 1.4*, April 2003), "an applied film glazing is an adhesive backed film applied to a Monolithic substrate." If the measured data submitted to the IGDB includes the substrate information, Optics5 can apply the film to another substrate.

This means that in order for an applied film to be added to the Optics5 "Applied Film" type, and therefore used in making applied film glass layers in Optics5, the spectral data for the "reference" substrate to which that applied film was attached, is submitted to the IGDB as follows:

- Applied films are measured with transparent glass with a solar transmittance greater than 0.820 (Tsol > 0.820) and a visible transmittance greater than 0.890 (Tvis > 0.890). Glass that meets this criteria includes 3mm clear glass, 3 mm low-iron glass, 6 mm low-iron glass. This ensures that an applied film layer in Optics5 will always have a similar or lower transmittance than the reference substrate which determines the applied film properties
- Substrate layers (the base glass to which the applied films are applied) are measured separately, without the applied films attached, and submitted to the IGDB. This is the responsibility of the manufacturer submitting data to the IGDB, as discussed below.

The applied film manufacturer can submit to the IGDB two spectral data files, single 3 mm clear with the applied film on a clear substrate and the clear substrate by itself. With this data in the IGDB, simulators, using this Applied Film Procedure, can then create the other two cases, the single 6 mm clear with the film, and the single 6 mm gray with the film, to do the SHGC and VT calculations.

This will allow a film manufacturer to submit to the IGDB several different films with the same clear substrate, if they are all measured on the same clear 3 mm substrate (from the same glass batch). For example, if a film manufacturer wanted to submit data for 20 different applied films, they would submit one spectral data file for the substrate of all 20 measurements (assuming the substrates for each film all came from the same glass batch), and 20 spectral data files, one for each film on the substrate, resulting in 21 files submitted.



Each of the 20 spectral data files for the films applied to the substrate would reference the substrate spectral data file.

Additionally, the glass manufacturer will not have to submit spectral data for the applied films attached to 6 mm clear or 6 mm gray cases, as they can be simulated in Optics5 from the applied film on the 3 mm clear substrate.

8.14.3. Using this Procedure for NFRC 200:

NFRC 200 specifies a procedure for calculating SHGC and VT for attachments, which applies to "Applied Films". This procedure specifies that reference glazing systems shall be calculated "with and without the film installed" from the following glass layers.

- Single 3 mm clear
- Single 6 mm clear
- Single 6 mm gray

The first case, "Single 3 mm clear" is what the applied film manufacturers submit to the IGDB and will be in that database. The other two cases, "Single 6 mm clear" and "Single 6 mm gray" can now be calculated with Optics5.

8.14.4. Creating a Layer with an Applied Film in Optics5

8.14.4.1. Adding an Applied Film to an Uncoated Layer

You can apply a film to a monolithic layer in Optics5 to create a new applied film layer.

To apply a film to a monolithic layer follow the steps below:

- Click on the **Glazing System** tab
- Add the desired layer to a layer column under the **Glazing System** tab
- Select the monolithic layer by clicking on the desired layer number button
- Add an Applied Film to the selected glazing layer in one of the following ways:
  - Choose the menu option **Edit|Change/Add Film**

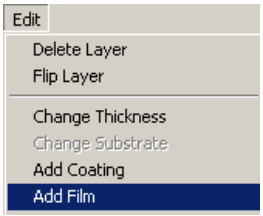


*Figure 8-142. Select a monolithic glass layer, click on the **Layer** button, and select the **Edit/Add Film** menu choice*

OR

  - Right click on the selected glazing layer button and select the choice "Add Film"
- **The Change Glazing** dialog box will appear. The film name box is highlighted in blue – click on it to select an applied film from the database (you must select an "Applied Film" layer , not a "Film" layer). You must choose a film that is on the "Approved Applied Films" list.
- The new film will be added to the side you select in the 'Apply Film to' section of the dialog box:
- You will be prompted to enter a new name for the glazing
- If you want to keep the new layer, save it to the user database (see "Saving Layers to the User Database").

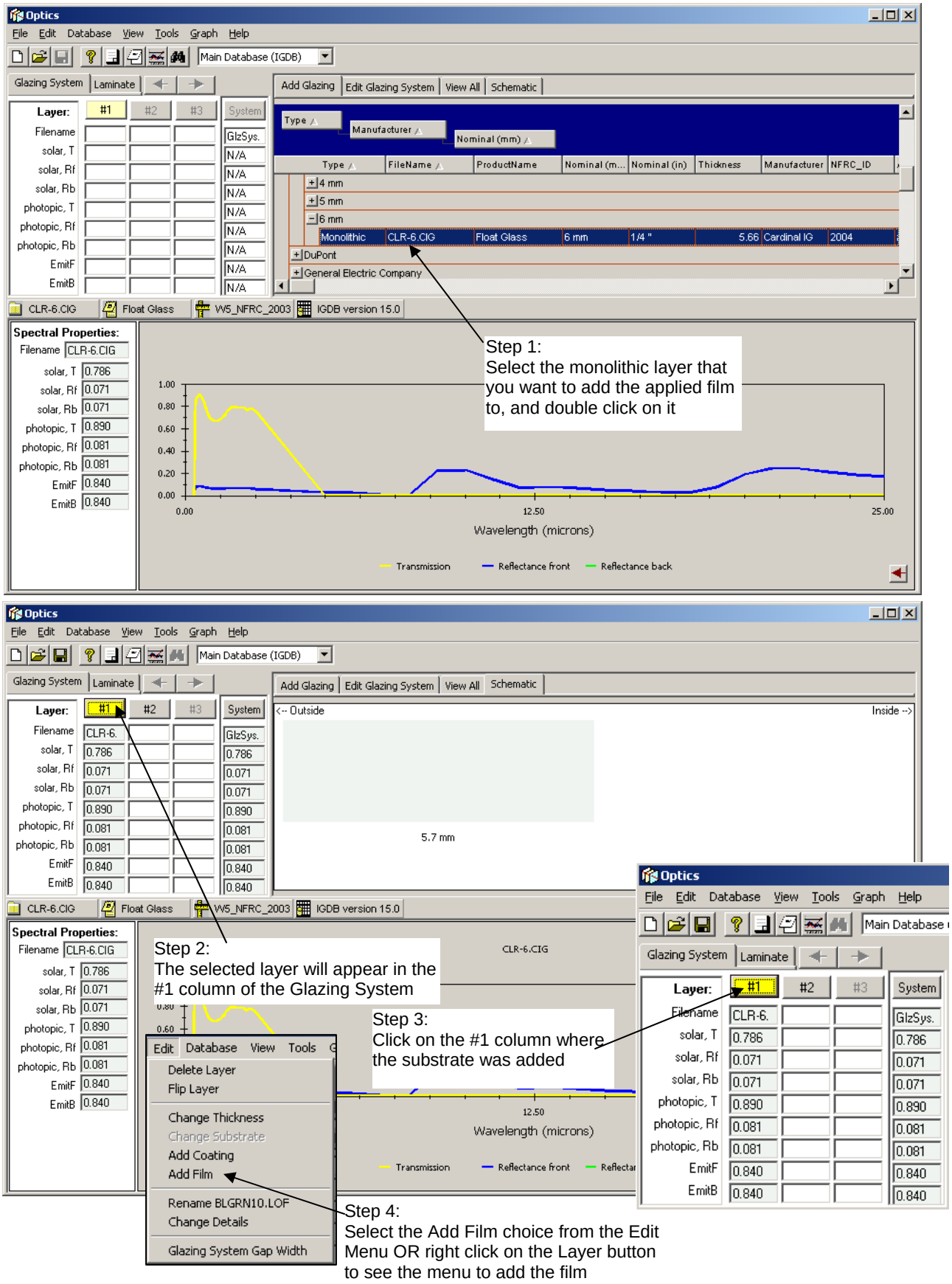


*Figure 8-143. Select a monolithic glass layer, click on the **Layer** button, and select the **Edit/Add Film** menu choice*

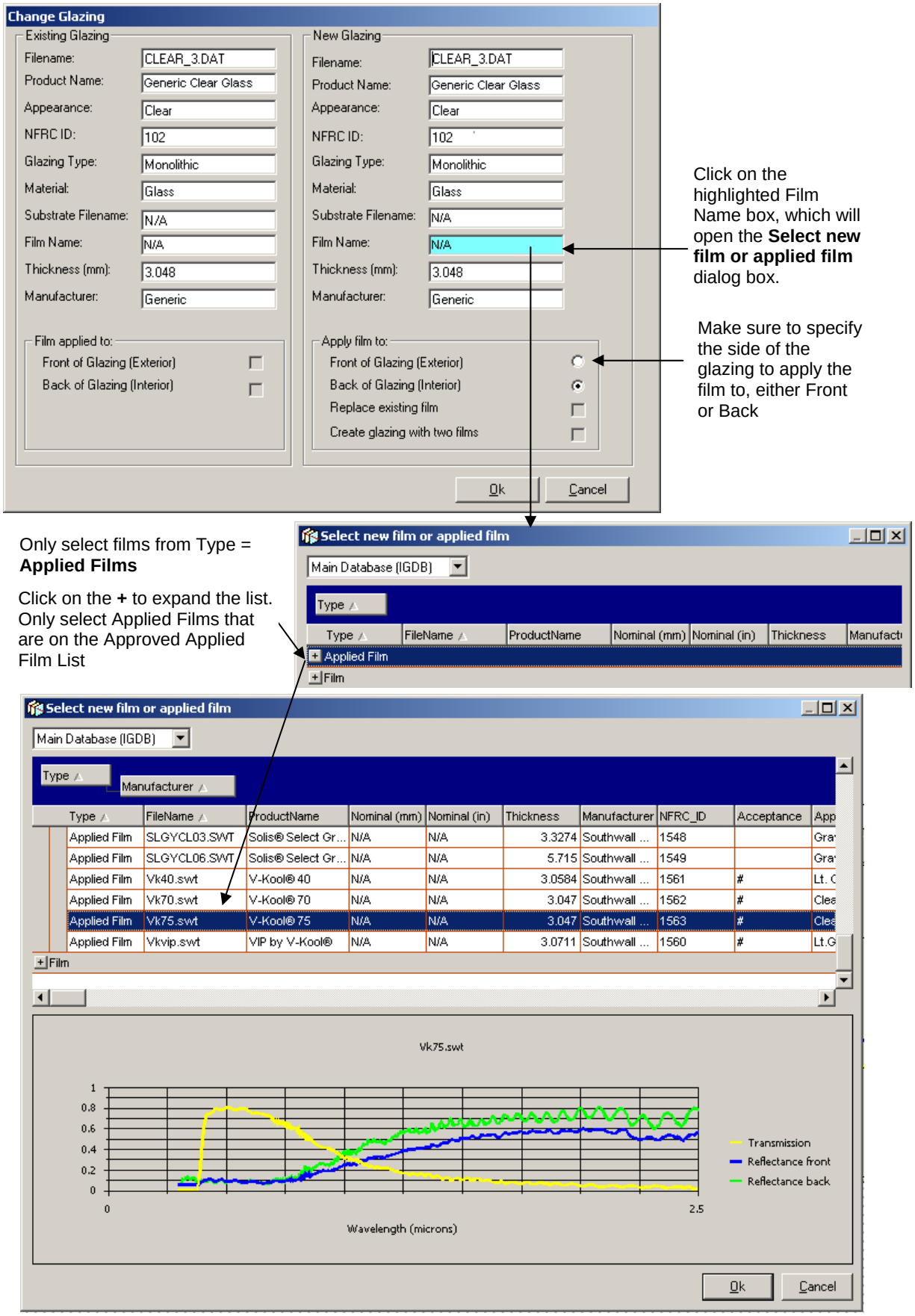


Figure 8-144. Choose the film to apply

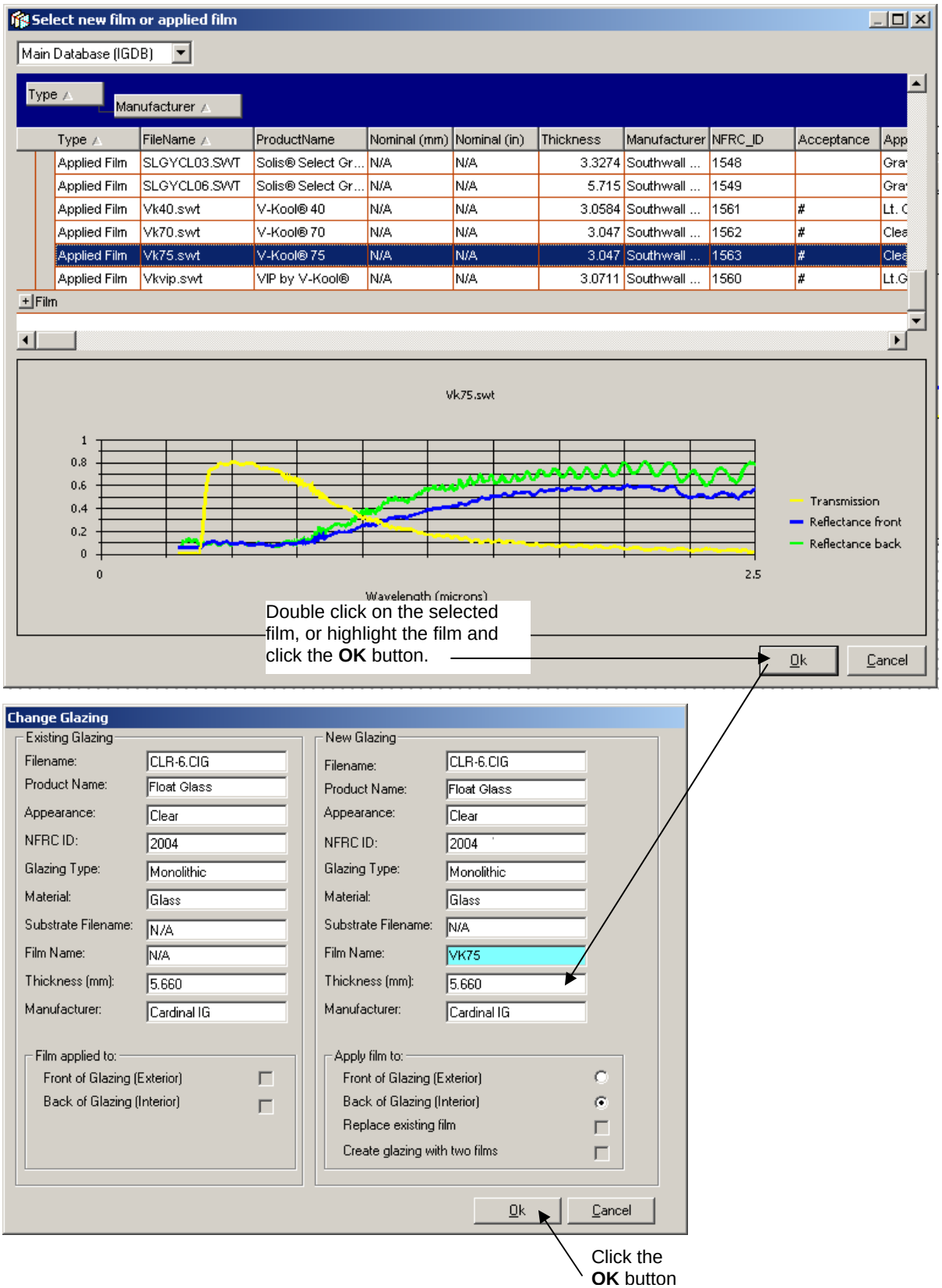
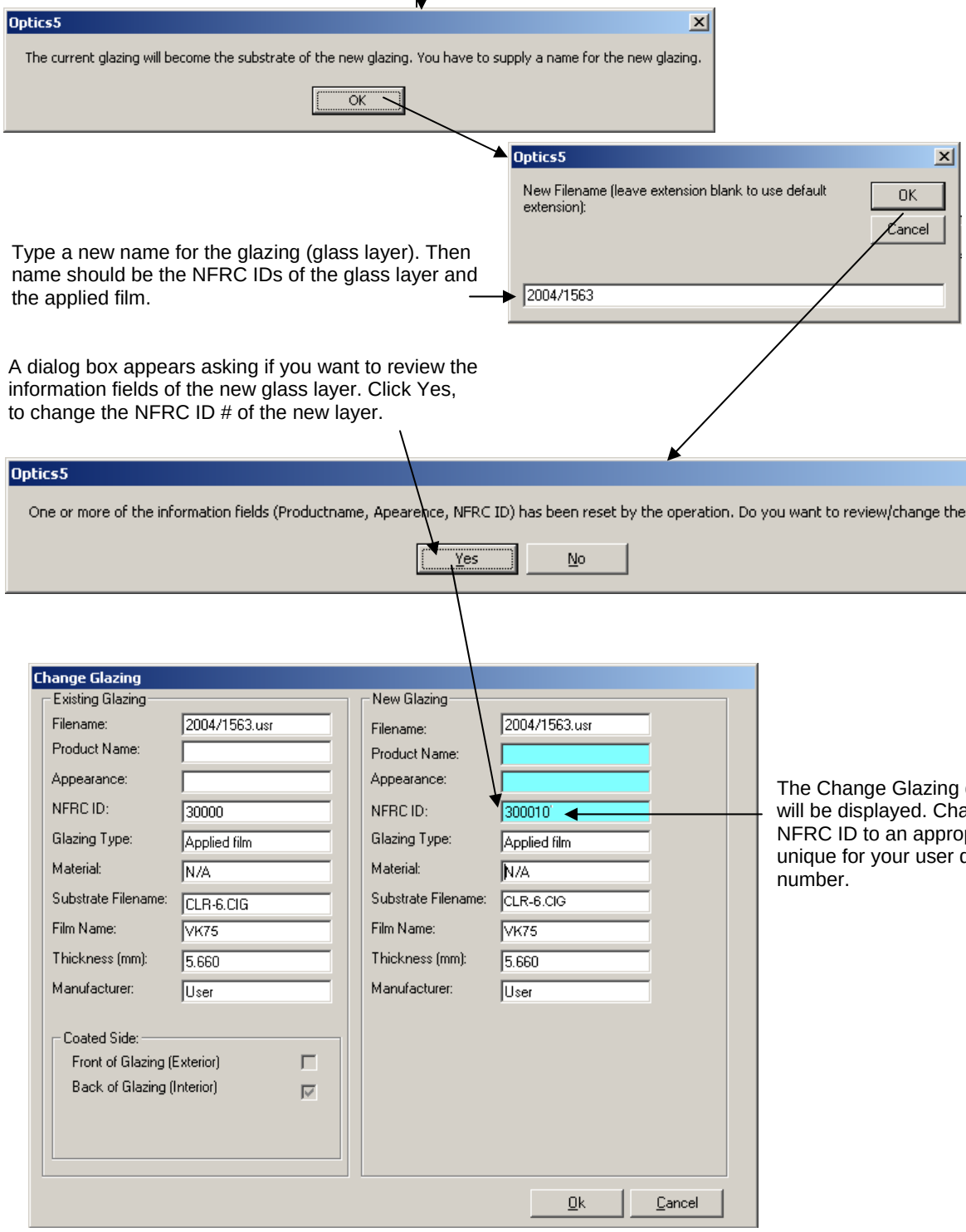


Figure 8-145. Apply the film to the substrate

The dialog appears saying a new name must be applied to the new glazing (glass layer)



Type a new name for the glazing (glass layer). Then name should be the NFRC IDs of the glass layer and the applied film.

A dialog box appears asking if you want to review the information fields of the new glass layer. Click Yes, to change the NFRC ID # of the new layer.

The Change Glazing dialog box will be displayed. Change the NFRC ID to an appropriate (and unique for your user database) number.

Figure 8-146. Give the new applied film layer a name and a new NFRC ID number if needed to ensure uniqueness.

8.14.4.2. Adding an Applied Film to a Coated Layer

You can apply a film to the uncoated side of a coated glazing, creating a double-coated layer with the coating on one side and the film on the other.

To apply a film to a coated layer:

- Click on the **Glazing System** tab
- Add the desired layer to a layer column under the **Glazing System** tab
- Select the coated layer by clicking on the desired layer number button
- Choose the menu option **Edit|Change/Add Film**
- OR
- Right click on the selected glazing layer button and select the choice "Add Film"
- The Change Glazing dialog box will appear. The film name box is highlighted in blue – click on it to select an applied film from the database (you must select an "Applied Film" layer , not a "Film" layer). You must choose a film that is on the "Approved Applied Films" list.
- The new film will be applied to the uncoated side of the glazing to create a double-coated layer with the film on one side and the coating on the other – this is indicated in the 'Apply Film to' section of the dialog box.
- You will be prompted to enter a new name for the glazing. Use the naming convention specified in the beginning of this document, i.e., NFRC IDs for both the glazing layer and the applied film.
- If you want to keep the new layer, save it to the user database (see "Saving Layers to the User Database").

8.14.4.3. Adding an Applied Film to a Laminate

In the same manner as adding an applied film to either a coated or an uncoated layer, a film can be applied to a laminate. This laminate can already exist in the IGDB or can be a laminate constructed using the NFRC Laminate Procedure. The laminate is treated as a glass layer in the Glazing System tab, and the applied film is then added to that layer.

8.14.4.4. Change a Film

To change the film applied to an applied film layer:

- Select the applied film layer by clicking on the appropriate layer button
- Choose the menu option **Edit|Change/Add Film**
- The Change Glazing dialog box will appear The film name box is highlighted in blue – click on it to select an applied film from the database (you must select an "Applied Film" layer , not a "Film" layer). You must choose a film that is on the "Approved Applied Films" list.
- The new film will replace the current film – this is indicated in the 'Apply Film to' section of the dialog box
- You will be prompted to enter a new name for the glazing. Use the naming convention specified in the beginning of this document, i.e., NFRC IDs for both the glazing layer and the applied film.
- If you want to keep the new layer, save it to the user database (see "Saving Layers to the User Database").

8.14.4.5. Saving Layers to the User Database

You can save a glazing layer with an applied film to the user database if it has a different filename from any layer currently in the user database or in the IGDB. If you save a layer that has components (such as a glazing layer that has an applied film), the component layers will be saved to the user database at the same time (unless they already exist in the IGDB or user database). This allows you to load and edit those layers at a later time.

To save a layer to the user database:

- Select the layer or system to save by clicking on a layer button
- Click the 'Save' button on the toolbar:
  or
  Choose menu option **File|Save** *filename*
  or
  Right-click to display the pop-up menu and select the option **Save** *filename*
- If the layer or system you saved had components, or if the save operation fails, you will be asked 'Do you want to view the details of the save operation?'. If you answer yes, you can view information about components that were saved to the user database, and components that were not saved to the user database along with an explanation of why some components were not saved.

Note: to change the filename and save in one operation, choose menu option **Save As..** instead.

Note: You cannot save data for a layer with the same filename as another layer in the IGDB or your current user database. If a conflict is detected, Optics will ask you to rename the layer before saving it, or cancel the import. The most common reason a component is not saved is that its filename already exists in the IGDB or user database. In this case Optics assumes that the component layer information is already available and does not need to be saved again.

8.14.4.6. Renaming a Layer

To rename a layer with an applied film:

- Select the layer you want to rename by clicking on a layer button.
- Choose menu option **Edit|Rename** *filename*
  or
  Right-click on the layer button to display the pop-up menu, and select item **Rename** *filename*
- Enter a new filename and click 'OK'

If you want to save the layer under the new name, save it to the user database (see "Saving Layers to the User Database"). You could also achieve the same result by using the File|Save As… menu option to rename and save the layer in one operation.

8.15. Framed Intermediate Pane

8.15.1. Overview

For a product that has an intermediate pane with it's own frame, the modeling steps are as follows:

In WINDOW:

- Create the glazing system, including the intermediate pane.

In THERM:

- Model the head, sill and jamb sections including the intermediate pane and frame, using the glazing system created in WINDOW. Model caming, if applicable, as shown in the Dividers section (8.3.4) of this manual

In WINDOW:

- Import the THERM cross sections into the Frame (and Divider if modeling caming) Libraries.
- Model the whole product using the Glazing System, Frame and Divider components.

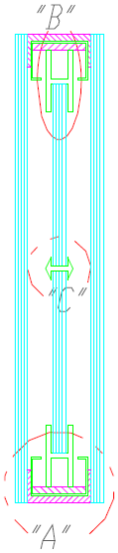


Figure 8-147. An example of a framed intermediate pane. Section A is modeled for the Sill/Jamb, Section B is modeled for the Head, and Section C is modeled as a Divider.

8.15.2. THERM Modeling Details

The THERM modeling is relatively straightforward, with a few details to be aware of shown below.

The head and sill are modeled normally, except that the extra frame for the intermediate pane is also modeled. The sightline will remain defined as the highest interior point on the window/door frame.

Example Sill

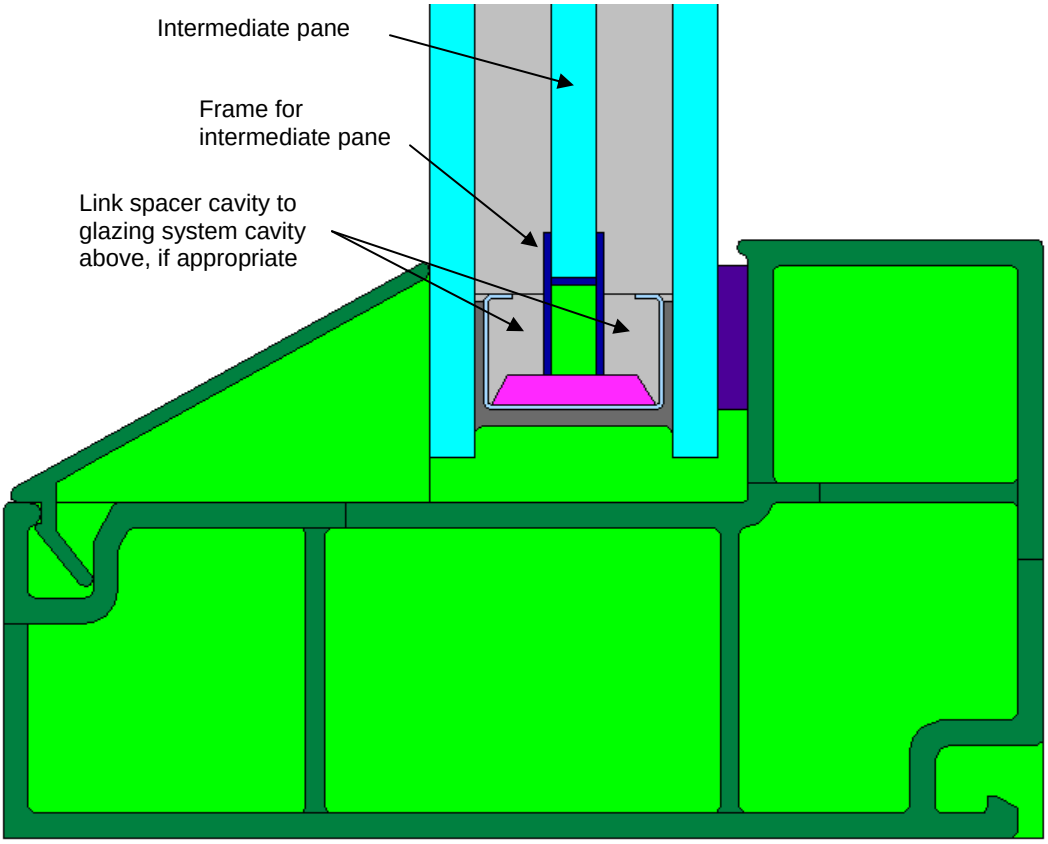


Figure 8-148. Example sill with framed intermediate pane

Example Head

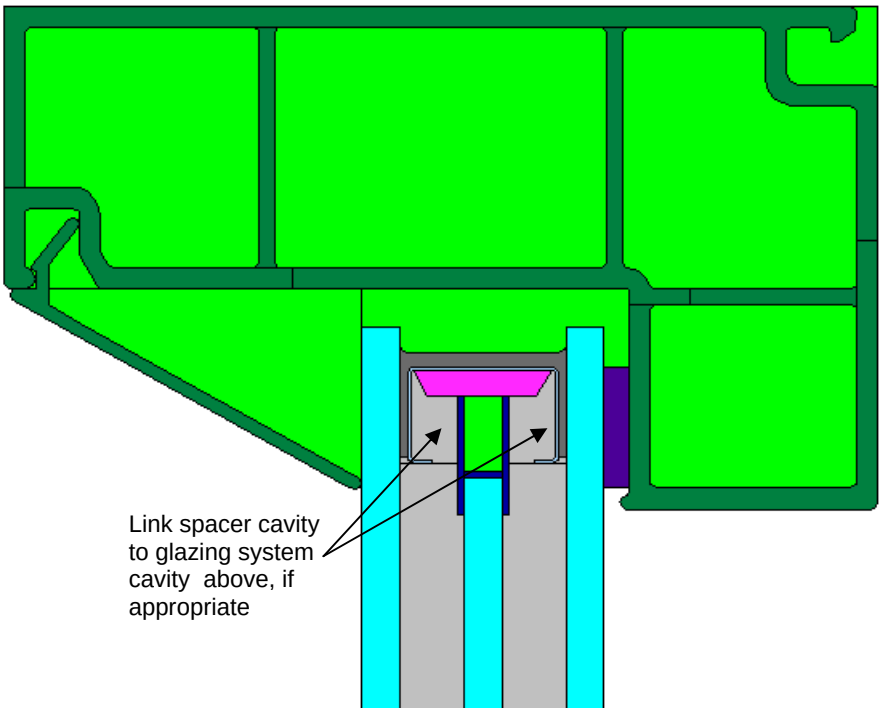


Figure 8-149. Example head with framed intermediate pane

Example Caming / Divider

Caming, if it exists, is modeled as a Divider.

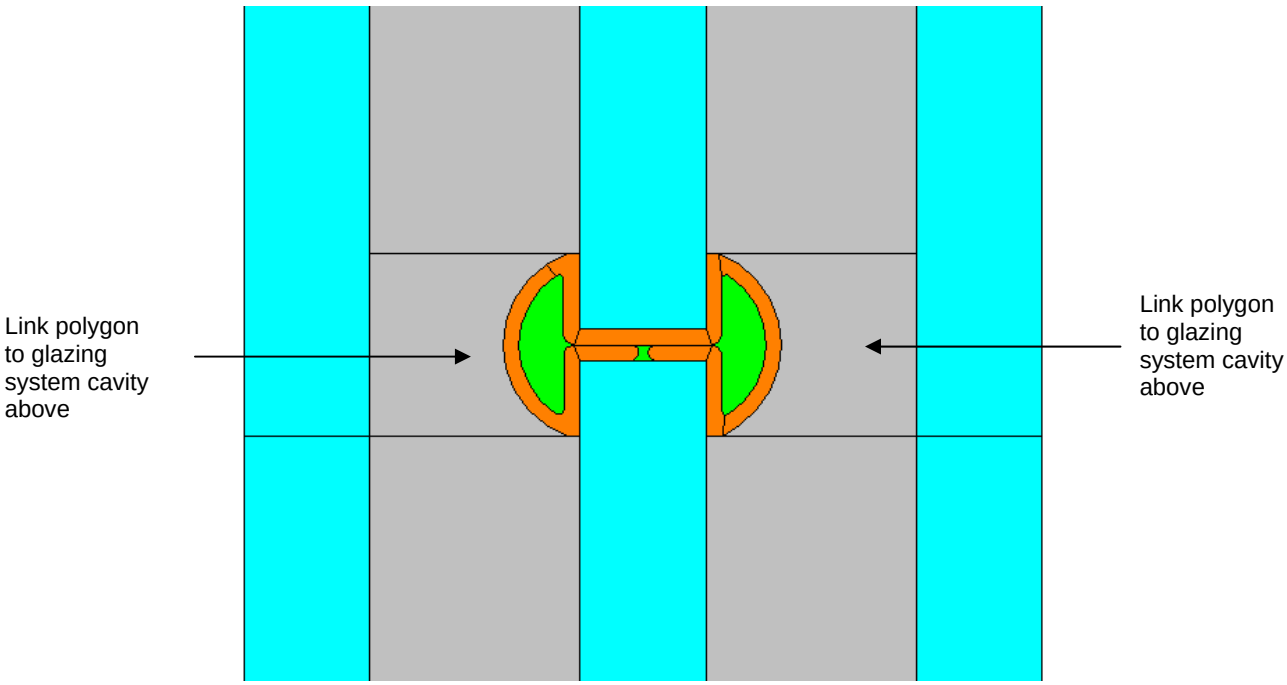


Figure 8-150. Example caming with framed intermediate pane