# AERC WINDOW/THERM Simulation Manual

December 13, 2017

This page left intentionally blank

# Contents

# 1. Introduction

## 1.1. AERC Product Modeling Using THERM and WINDOW

The Lawrence Berkeley National Laboratory (LBNL) software tools, Berkeley Lab WINDOW (further referred as WINDOW in this manual), THERM, and AERCalc, are used to model products for AERC certification. LBNL maintains two databases, the Complex Glazing Database (CGDB) and the International Glazing Database (IGDB), which contain AERC approved materials and material combinations that are used in THERM and WINDOW to model AERC certified products. Several thermal, optical and energy performance indices are calculated and reported using these tools. U-factor is used as a thermal metric, visible transmittance (VT) as an optical metric, solar heat gain coefficient (SHGC) as a mixed thermal and optical metric, and a duo of newly developed annual energy performance indices, EPc and EPh, as metrics for cooling and heating energy performance respectively. U-factor, SHGC, and VT are calculated by WINDOW and THERM, while EPc and EPh are calculated by AERCalc based on detailed product information from WINDOW. Technical details about the mathematical model and algorithms are available in the WINDOW and THERM technical documentation as well as the AERC 2 Appendix A for EPc and EPh.

This manual discusses the modeling details and assumptions for these software tools when utilized for AERC Certification. More detailed information about modeling glazing, shading, and window products can be found in the WINDOW and THERM User's Manuals.

## 1.2 Modeling Overview

Throughout this manual, glazing (IGDB) and shading (CGDB) databases will be referenced. While both databases exist as self-contained, downloadable and installable files, this manual will generally refer to them as they are shown in the WINDOW program, i.e., in the Glass Library (IDGB), the Shading Material Library (CGDB), and the Shading Layer Library (CGDB). These libraries will need to be periodically updated through regular releases of IGDB and CGDB by LBNL.

While most shading materials will be directly measured and stored in the Shading Layer Library, some products are stored in the Glass Library or will need to be defined from materials in the Shade Material Library that are then used to define the product in the Shading Layer Library. Examples of products defined from the Shade Material Library in combination with the Shading Layer Library are Venetian blinds, cellular shades, and pleated shades. More than one shading material may be needed to define some products (e.g., Cellular shades). Refer to *Section 5*, *Preparing Shading Layers for Submission to the CGDB*, for details on preparing these shade layers. Glass Library records are used to define surface applied films, storm windows, and window panels. Procedures for submitting shading materials for CGDB are provided in https://windows.lbl.gov/submitting-data-0, and the procedure for submitting glazing materials for IGDB is provided in https://windows.lbl.gov/submitting-data.

The process for modeling attachment products is as follows:

**WINDOW:**

- **Shading Layer Library:**
    - Select the appropriate record from the Shading Layer Library. Shading layers qualified for use in simulations of products submitted for AERC certification have the "@" mark of approval in the Certification column of the library. One shading layer is typically used per certified product, but Slat type shades require four Shading Layers (one layer at each required slat tilt) for certification.

- **Glass Library:**
    - For use with storm windows and window panels. Select the appropriate layer from the Glass Library. Products qualified for use in AERC simulations bear the NFRC # mark of approval in the Mode column of the library.
- **Glazing System Library:**
    - Define a glazing system from the AERC base glazing system(s), detailed in AERC 1 for baseline window B and add the shading product from the Shading Layer Library.
    - Calculate the glazing system (including shading)

**THERM:**

- Model the frame components, i.e., Sill, Jamb and Head, starting from the standard AERC THERM frame models.
- Import the glazing system (that includes the shading system) from WINDOW and calculate the results for each frame component.

**WINDOW:**

- **Frame Library:** import the three THERM frame component files for baseline window B, provided in AERCalc installation directory (list names of files)
- **Window Library:** create a whole window for the product
    - Assign frame components from Frame Library
    - Assign glazing from Glazing System Library
    - Name the whole window with the convention needed for import into AERCalc

      <product name>::<shade type><slat tilt>::BW-<basecase window ID>
      *Note: <slat tilt> is provided only when shade type is VB or HB.*
    - Calculate the product

**AERCalc:**

- Import the desired products from the WINDOW Window Library into the AERCalc Product library
- Calculate the Energy Performance values for heating and cooling, EPh and EPc

# 2. Center-of-Glass (COG) Modeling

## 2.1. Overview

WINDOW consists of a series of libraries that are described in detail within the WINDOW User's Manual. This manual describes creating glazing systems with AERC approved shading layers in the WINDOW Glazing System Library. The specific settings and preferences for AERC certified simulations, as described in the AERC1 technical document, are presented.

Some shading products are directly measured and stored in the WINDOW Shading Layer Library, some products are defined from materials in Shading Material library as well as the Shading Layer Library, whereas storm windows and window panels are defined in the Glass Library. The following products are included in the AERC certification process:

- Cellular Shade
- Slat Shade
- Roller Shade
- Storm Window and Window Panel
- Pleated Shade
- Solar Screen
- Surface Applied Film

## 2.2. WINDOW Glass Library

The Glass Library contains the thermal and optical properties of glazing materials. The solar, visible, and thermal infrared optical properties of a glazing as well as the thickness and thermal conductivity are displayed.

Record s from the Glass Library are used to construct the standard glazing systems to model with shading products, as well as modeling the following attachment products:

- Storm Windows
- Window Panels
- Surface Applied Films

Three standard glass layers are used in baseline windows A-F, listed in AERC 1, Appendix A. These layers are in the International Glazing Database (IGDB).

| IGDB ID | Nominal Thickness [mm] | Product Name | Manufacturer |
|---|---|---|---|
| 102 | 3 | Generic Clear Glass | Generic |
| 103 | 6 | Generic Clear Glass | Generic |
| 2011 | 3 | LoE2 272 on 3 mm Clear | Cardinal Glass Industries |

The *WINDOW User Manual* contains information about importing glass layers from the IGDB into the WINDOW Glass Library.

## 2.3. WINDOW Glazing System Library

The Glazing System Library is used to create glazing systems to determine the center-of-glass performance metrics, which are then used in THERM to determine edge-of-glass and frame performance, and finally used in the Window library to determine whole window performance metrics.

Glazing Systems for modeling AERC certified products consist of one or more glass layers from the Glass Library as defined in AERC 1, Appendix A, a shading layer as defined in the Shading Layer Library, and gaps between the layers as defined by a thickness and a gas from the Gas Library. When the glazing layers and gaps have been defined, the results are calculated using the Calc button. The *WINDOW User Manual* contains full details on constructing glazing systems within the Glazing System Library. Figure 2-1 shows the Glazing System library detail view of the AERC standard double-clear glazing system with room-side cellular shade (Shade 3).

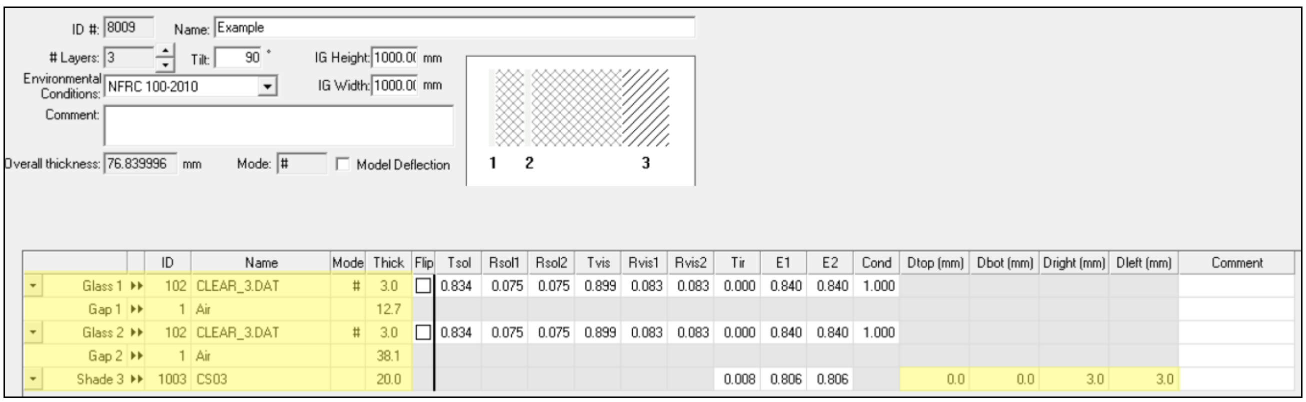



*Figure 2-1. Glazing System library detailed view. The baseline glazing and shading layers are selected from the Glass Layer and Shading Layer libraries respectively. The Gap width from the glass to the shade is entered based on the shade type. The perimeter gap widths (Dtop, Dbot, Dright, and Dleft) between the frame and the shade with continuous hardware are entered based on the shade mounting.*

### 2.3.1. Shading System Perimeter Gaps

Perimeter gap widths between the frame and the shade are defined for each shading system according to Figure 2-2. Perimeter gaps are the minimum distance from the end of the shade (continuous hardware included) to the frame or glazing. Dtop is the distance at top of shade, Dbot is distance at bottom of shade, and Dleft & Dright are distances on the left and right of shade. AERC 1 defines typical perimenter gap distances based on product type. Perimeter gaps for non-typical product are calculated based on Figure 2-3. The figures illustrate a roomside interior shading system, but the defined gap distances also apply to exterior mounted shades.

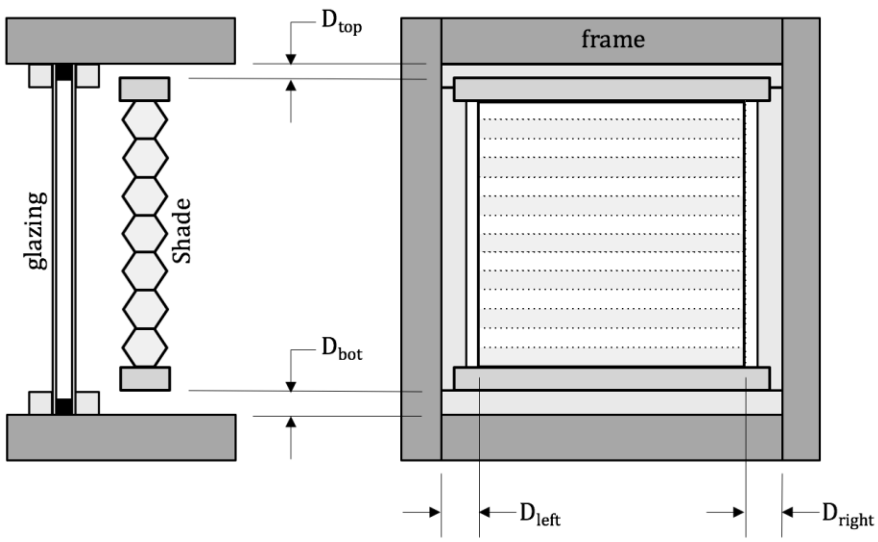



*Figure 2-2. Perimeter gap widths between frame and shade with continuous hardware. The figure illustrates the nominal gap distance of a roomside interior shading system. The actual perimeter gap is the minimum distance defined by Figure 2-3. The defined gap distances apply to both interior and exterior shade mounting locations.*

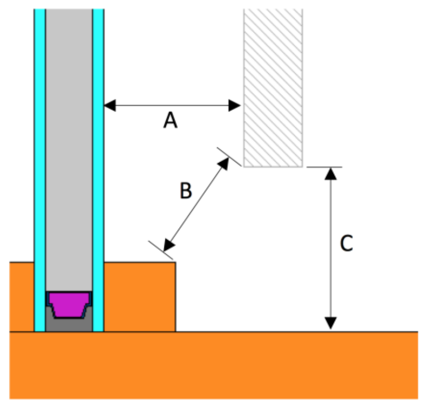



*Figure 2-3. Perimeter gaps (Dtop, Dbot, Dleft, Dright) are measured from end of shade (continuous hardware included) to frame or glazing. These dimensions are the minimum of A, B, and C at each location.*

## 2.4. WINDOW Shading Layer Library

The Shading Layer Library allows for the definition of seven shading layer types, which can be selected from the Type pull-down list. Currently, AERC uses six of these layer types for modeling AERC certified products. The layer types used by AERC are listed below:

- Homogeneous diffusing shade
- Perforated screen
- Shade with XML data
- Therm file (*.thmx)
- Venetian blind, horizontal
- Venetian blind, vertical

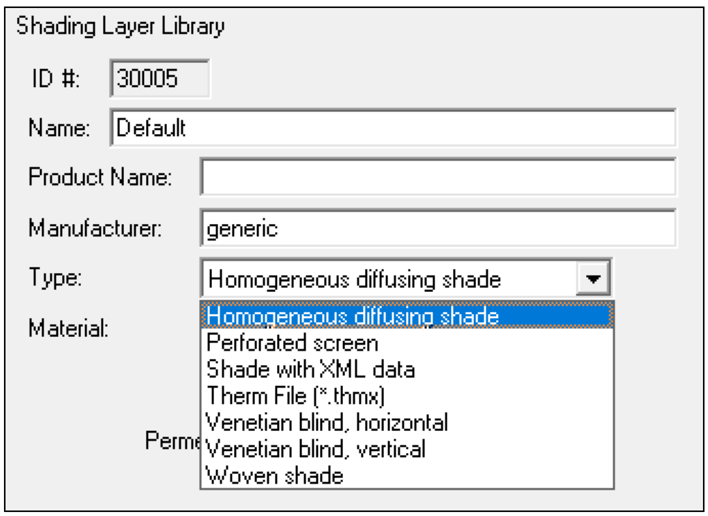



*Figure 2-4. Type field from the Shading Layer Library*

## 2.5. WINDOW Preferences

This section outlines the settings required for AERC calculations within WINDOW. See the *WINDOW User Manual* for full details on modifying preferences settings.

### 2.5.1. Options

Use Nominal Glass Thickness = Checked

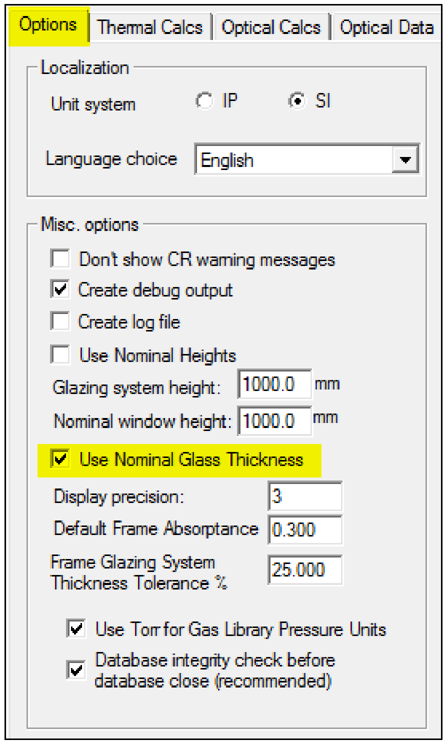



*Figure 2-5. WINDOW Preferences menu, Options tab*

### 2.5.2. Thermal Calcs

All options set to **ISO 15099**

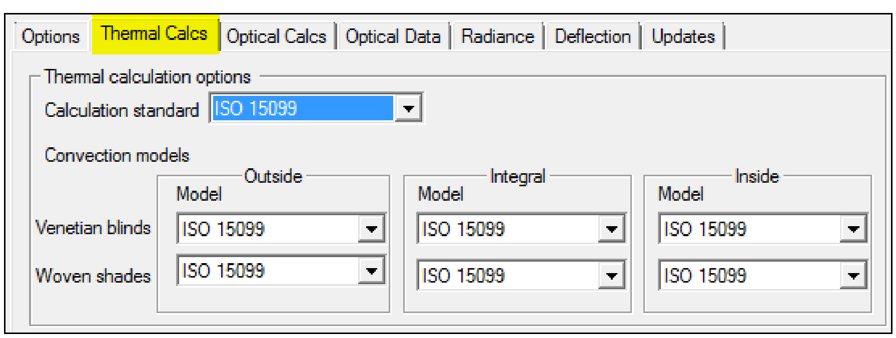



*Figure 2-6. WINDOW Preferences menu, Thermal Calcs tab*

### 2.5.3. Optical Calcs

Optical calculation options

- Spectral data = Condensed spectral data
- Number of visible bands = 5
- Number of IR bands = 10
- Angular basis = W6 standard basis

Venetian blind calculation methods

- Solar/Visible range = Directional diffuse
- FIR range = Directional diffuse
- # of segments = 5

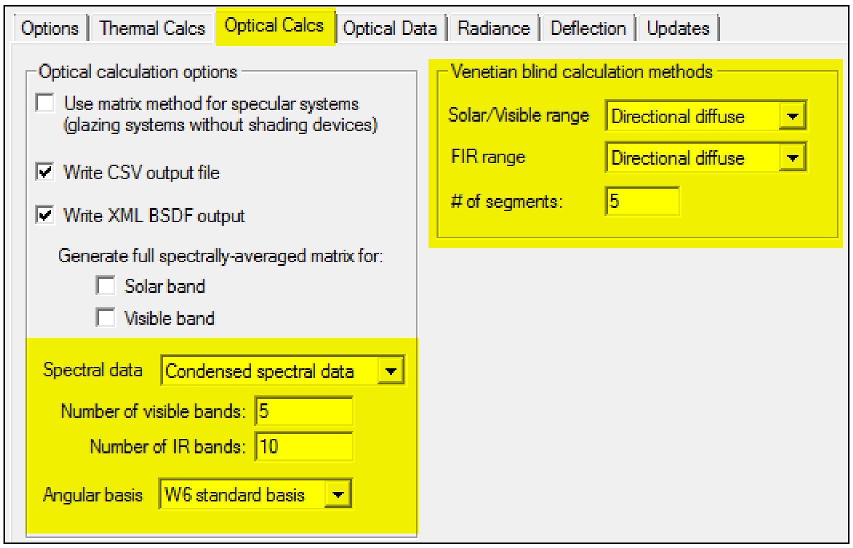



*Figure 2-7. WINDOW Preferences menu, Optical Calcs tab*

## 2.6. Modeling procedures by shade type

All shading system layers are measured and accepted per AERC 1.1 and include an @ in the Shading Layer Library Certification field. AERC simulators must ensure the CGDB is updated to the latest version prior to simulation.

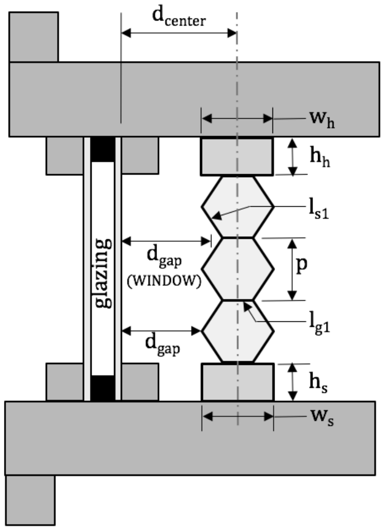
This section provides a quick reference table to the modeling procedures for AERC shading types followed by detailed steps for simulating AERC systems from approved shading layers.

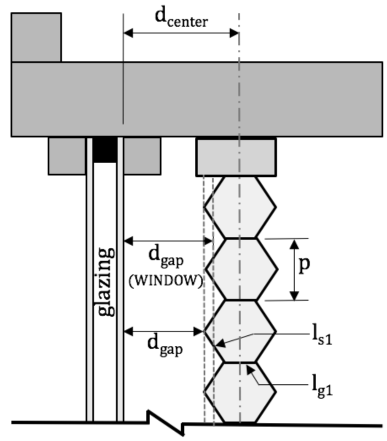
<table>
<tr><th>Type</th><th>Material Properties</th><th>Geometry</th><th>WINDOW Shading Layer Library Type</th><th>Glazing System gap<br>$d_{gap(WINDOW)}$</th></tr>
<tr><td>Cellular Shade</td><td>Measured fabric material(s)</td><td>Drawn in THERM</td><td>Therm file (*.thmx)</td><td>Average gap distance from glass to shade surface</td></tr>
<tr><td>Pleated Shade</td><td>Measured fabric material</td><td>Drawn in THERM</td><td>Therm file (*.thmx)</td><td>Average gap distance from glass to shade surface</td></tr>
<tr><td>Slat Shade</td><td>Measured slat material</td><td>Defined in Shading Layer Library</td><td>Venetian blind, horizontal<br>Venetian blind, vertical</td><td>Distance from glass to nearest slat surface, varies with tilt.</td></tr>
<tr><td rowspan="2">Roller Shade</td><td>Measured fabric material</td><td>N/A</td><td>Shade with XML data</td><td rowspan="2">Distance from glass to nearest shade surface</td></tr>
<tr><td>Measured bulk material</td><td>Defined in Shading Layer Library</td><td>Woven shade<br>Homogeneous Diffusing Shade<br>Perforated Screen</td></tr>
<tr><td rowspan="2">Solar Screen</td><td>Measured fabric material</td><td>N/A</td><td>Shade with XML data</td><td rowspan="2">Distance from glass to nearest shade surface</td></tr>
<tr><td>Measured bulk material</td><td>Defined in Shading Layer Library</td><td>Woven shade<br>Homogeneous Diffusing Shade<br>Perforated Screen</td></tr>
<tr><td>Storm windows / Window panel</td><td>Measured product in glass library</td><td>N/A</td><td>N/A</td><td>Distance from glass to nearest SW/WP glass surface</td></tr>
<tr><td>Surface applied films</td><td>Measured product in glass library</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
</table>

## 2.6.1. Cellular Shades

### WINDOW Glazing System

- Construct the baseline glazing system
- Add the shading system in the one of the following positions as appropriate:
  - Interior
  - Exterior
- Gaps
  - Gap between glass and shade that is entered into WINDOW, dgap(WINDOW), is calculated based on average gap distance, where dgap is the distance between glass and closest point on shade as defined by AERC 1. See Figure 2-8 for further details.
  - Set to **Air** (ID = 1)
- Dtop, Dbot, Dright, Dleft
  - Values are per AERC 1.




$$d_{gap} = d_{center} - \frac{l_{g1}}{2} - \sqrt{l_{s1}^2 - \left(\frac{p}{2}\right)^2}$$

$$d_{gap(WINDOW)} = d_{center} - \frac{l_{g1} + \sqrt{l_{s1}^2 - \left(\frac{p}{2}\right)^2}}{2}$$

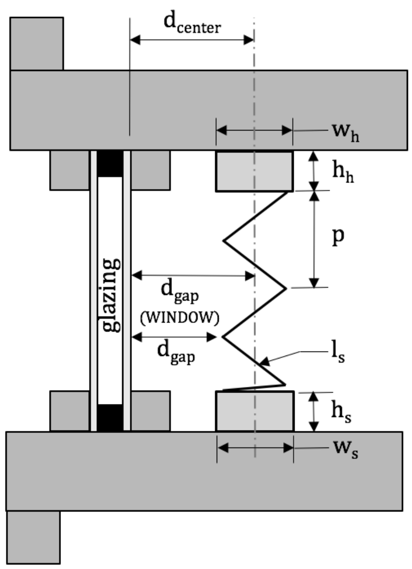
$$d_{gap(WINDOW)} = d_{gap} + \frac{l_{g1} + \sqrt{l_{s1}^2 - \left(\frac{p}{2}\right)^2}}{2}$$

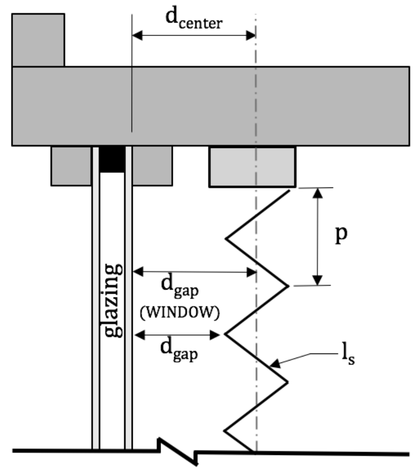
*Figure 2-8. Distance between the glazing and the shade layer for cellular shades.*
*The equivalent gap distance, dgap(WINDOW), is defined and entered in WINDOW in place of the AERC 1 defined dgap in cases where the gap width is variable due to the surface profile of the shade.*

### 2.6.2. Pleated Shades

#### WINDOW Glazing System

- Construct the baseline glazing system
- Add the shading system in one of the following positions as appropriate:
  - Interior
  - Exterior
- Gaps
  - Gap between glass and shade that is entered into WINDOW, dgap(WINDOW), is calculated based on average gap distance, where dgap is the distance between glass and closest point on shade as defined by AERC 1. See Figure 2-9 for further details.
  - Set to **Air** (ID = 1)
- Dtop, Dbot, Dright, Dleft
  - Values are per AERC 1.




$$d_{gap} = d_{center} - \frac{\sqrt{l_s^2 - \left(p/2\right)^2}}{2}$$

$$d_{gap(WINDOW)} = d_{center}$$

$$d_{gap(WINDOW)} = d_{gap} + \frac{\sqrt{l_s^2 - \left(p/2\right)^2}}{2}$$

*Figure 2-9. Distance between the glazing and the shade layer for pleated shades.*
*The equivalent gap distance, dgap(WINDOW), is defined and entered in WINDOW in place of the AERC 1 defined dgap in cases where the gap width is variable due to the surface profile of the shade.*

### 2.6.3. Slat Shades

**WINDOW Glazing System**

- Construct the baseline glazing system
- Add the shading system in one of the following positions as appropriate:
  - Interior
  - Exterior
- Gaps
  - Gap between glass and shade that is entered into window, dgap(WINDOW), is calculated based on the distance from the glass to the nearest slat surface (dependent on slat tilt).
  - Inital dgap is set based on zero slat tilt. Subsequent dgaps are calculated based on actual tilt.
  - Set to **Air** (ID = 1)
- Dtop, Dbot, Dright, Dleft
  - Values are per AERC 1.

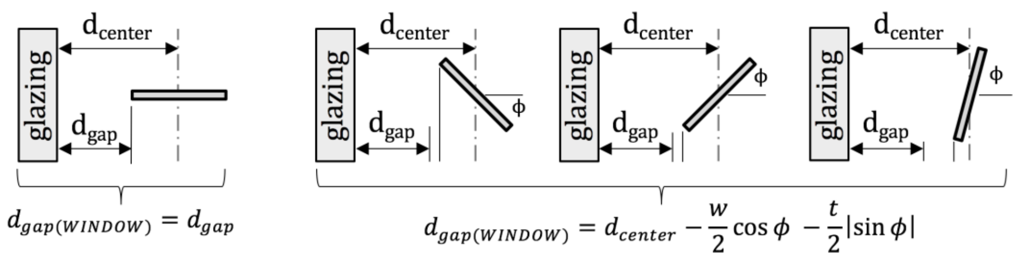



*Figure 2-10. Distance between glazing and shade layer for slat shades. Inital dgap is set based on zero slat tilt. Subsequent dgaps are calculated based on tilt. dgap(WINDOW) is the gap distance entered into WINDOW, while dgap is the distancebetween glass and shade defined by AERC 1.*

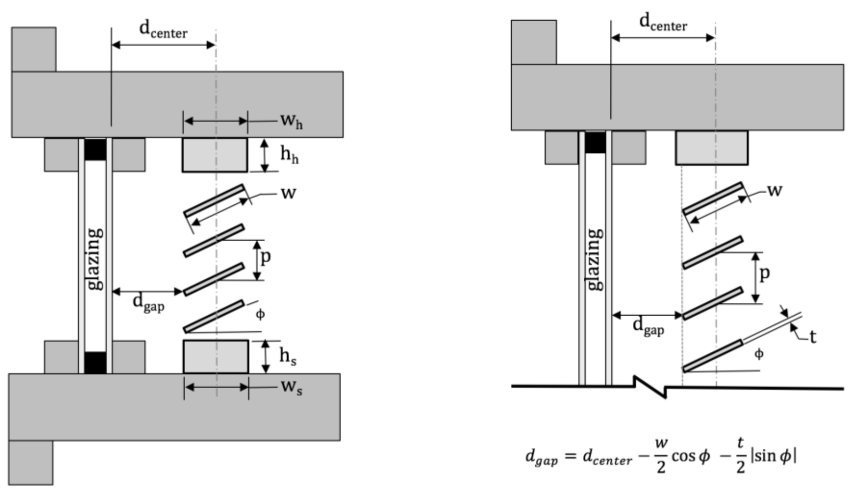



*Figure 2-11. Distance between glazing and shade layer for slat shades. Inital dgap is set based on zero slat tilt. Subsequent dgaps are calculated based on tilt.*

### 2.6.4. Roller Shades

#### WINDOW Glazing System

- Construct the baseline glazing system
- Add the shading system in one of the following positions as appropriate:
  - Interior
  - Exterior
- Gaps
  - Glazing system gap between glass and shade calculated based on actual geometry
  - Set to **Air** (ID = 1)
- Dtop, Dbot, Dright, Dleft
  - Values are per AERC 1.

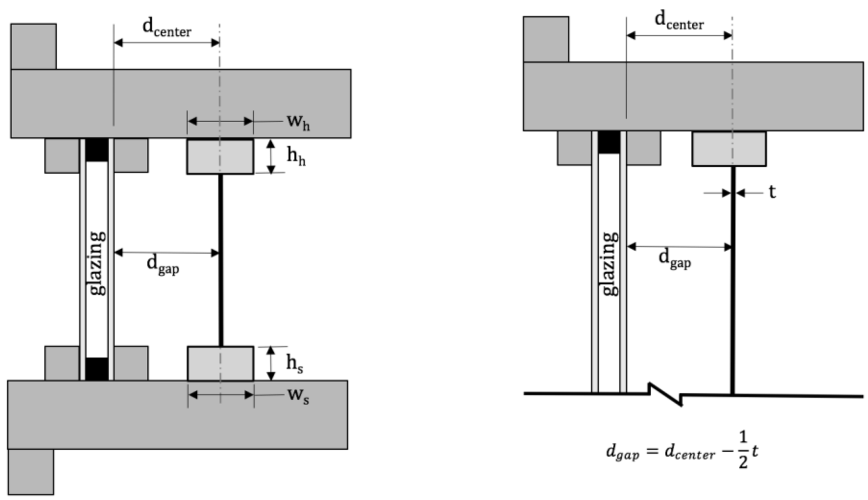



*Figure 2-12. Distance between glazing and shade layer for roller shades.*

## 2.6.5. Solar Screens

### WINDOW Glazing System

- Construct the baseline glazing system
- Add the shading system in the appropriate position:
    - Interior
    - Exterior
- Gaps
    - Glazing system gap between glass and shade calculated based on actual geometry
    - Set to **Air** (ID = 1)
- Dtop, Dbot, Dright, Dleft
    - Values are per AERC 1.

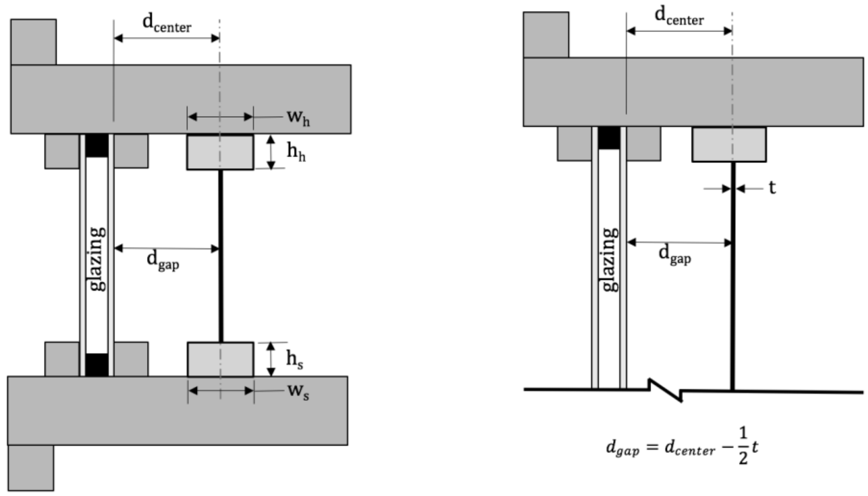



*Figure 2-13. Distance between glazing and shade layer for solar screens.*

### 2.6.6. Storm Windows and Window Panels

#### WINDOW Glazing System

- Construct the baseline glazing system
- Add the storm window or panel system in the one of the following positions as appropriate:
  - Interior
  - Exterior
- Gaps
  - Glazing system gap, dgap, between glass and panel is based on AERC 1
  - Set to **Air** (ID = 1)

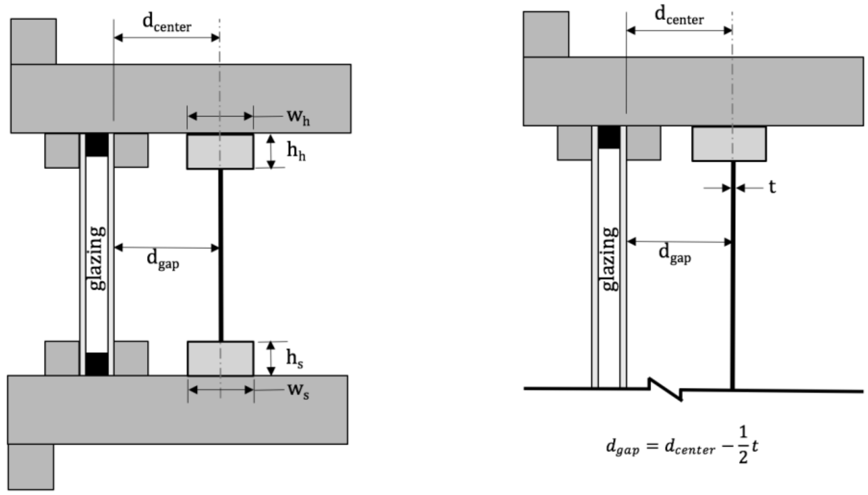



*Figure 2-14. Distance between glazing and shade layer for storm windows and window panels.*

### 2.6.7. Surface Applied FIlms

**WINDOW Glazing System**

- Glazing layer of baseline system is replaced with glazing layer containing surface applied film on baseline glass in the appropriate position:
  - Interior
  - Exterior

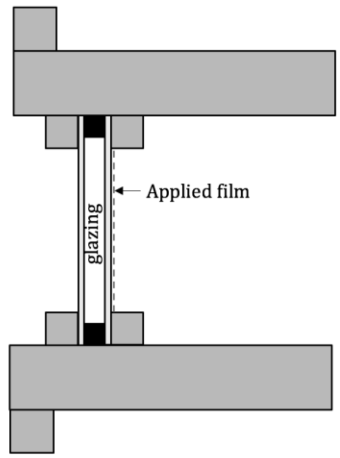



*Figure 2-15. Applied film on interior glazing surface.*

# 3. Edge-of-Glazing (EOG) and Frame model

## 3.1. Overview

THERM and WINDOW are utilized to determine the two-dimensional heat transfer through the edge-of-glazing (EOG) and frame of window systems. This document describes frame components and edge-of-glazing in THERM with specific settings and preferences related to AERC modeling as described in AERC technical documents AERC 1 and AERC 2. All THERM simulation described in this document is performed with Radiance mode (under Options/Preferences) turned off. Full simulation guides for WINDOW and THERM are found within the WINDOW and THERM User Manuals.

## 3.2. Frame templates

For the convenience of the simulator, template glazings (in a WINDOW database) and frame profiles (THERM files) are provided by AERC, for each of the AERC baseline window systems. The template frame profiles are modified for each shade system to include appropriate hardware and continuous shade accessories. The proper simulation and boundary condition settings for AERC compliance are outlined in the following sections.

## 3.3. Shade position

Shades are either operable (may be positioned on two or more states) or non-operable (fixed position). All operable shades must be simulated in multiple states, as defined by AERC 1 and AERC 2. Different fenestration attachment product types have different degrees of freedom for operation (e.g. retraction, slat angle). With respect to EOG modeling with THERM, the two states that typically involve geometry changes to the frame are:

- "fully closed" shall mean deployed to cover the window opening to the fullest extent allowed by the attachment product design
- "fully opened" shall mean retracted as far as possible to cover the window opening to the smallest extent allowed by the attachment product design. The AERC simulation method does not currently model shades in the fully open state. The baseline window system (without a shading system) is considered identical to a shading system in the fully opened position.

### 3.3.1. Shade position: Fully closed shade

This section describes the settings for modeling the edge-of-glass and frame performance metrics for a glazing system with the shade system in the fully closed position.

#### 3.3.1.1. Center-of-Glass

The center-of-glass is modeled with the shading system included per the requirements outlined in *Section 2, Center-of-Glass Modeling*.

#### 3.3.1.2. Shading system sight line

The highest frame dimension, with frame hardware included, defines the **sight line to bottom of glass** dimension. This is illustrated in the figure below for (a) and (b). The **sight line to shade edge** dimension is defined if the top of the shading system (including hardware) is different than the sight line. This is illustrated in (c) and (d) in the figure below.

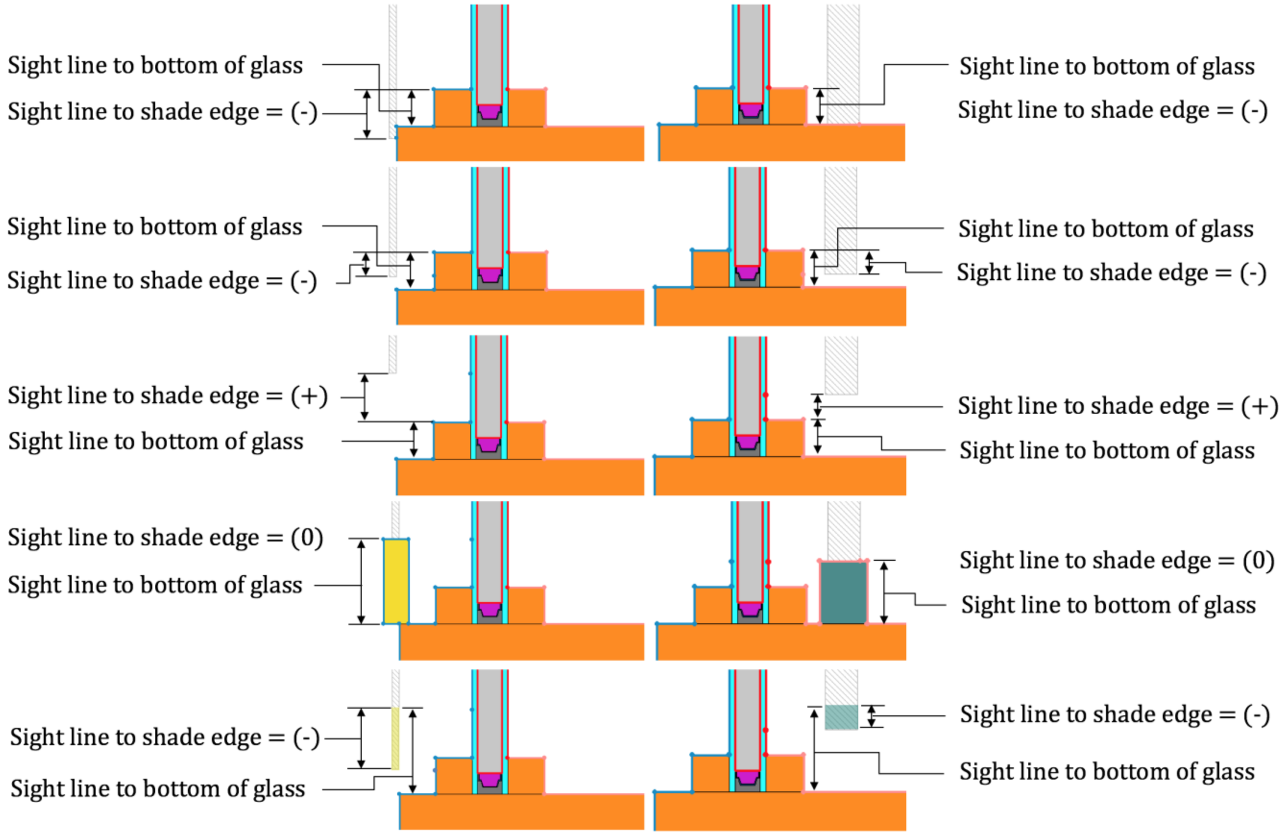



*Figure 3-1. Sight line definitions for a frame with a shading system. The sight line to shade edge is positive if the shade end is above site line, negative if the shade end is below sight line, or zero if the shade end defines the sight line.*

### 3.3.1.3. Shading system hardware

If there is a gap larger than 5 mm between the shade hardware and the base frame (Dtop, Dbot, Dleft, or Dright depending on cross section) then the hardware is not modeled. Air cavities that are open to the exterior within a frame cross-section, shall be modeled according to *ISO 15099, Section 6.7.1* which states that cavities greater than 2mm but equal to or less than 10 mm shall be modeled as slightly ventilated air cavities. The THERM Material Library has a default material for this case, called "Frame Cavity Slightly Ventilated NFRC 100", which will be used to fill the entire cavity. Any cavity less than 2 mm is modeled as "Frame Cavity NFRC 100". A cavity open to the exterior is never modeled if its width is greater than 10 mm or its width is greater than its depth. The figure below illustrates the four possible frame cavity scenarios for hardware on a head profile section.

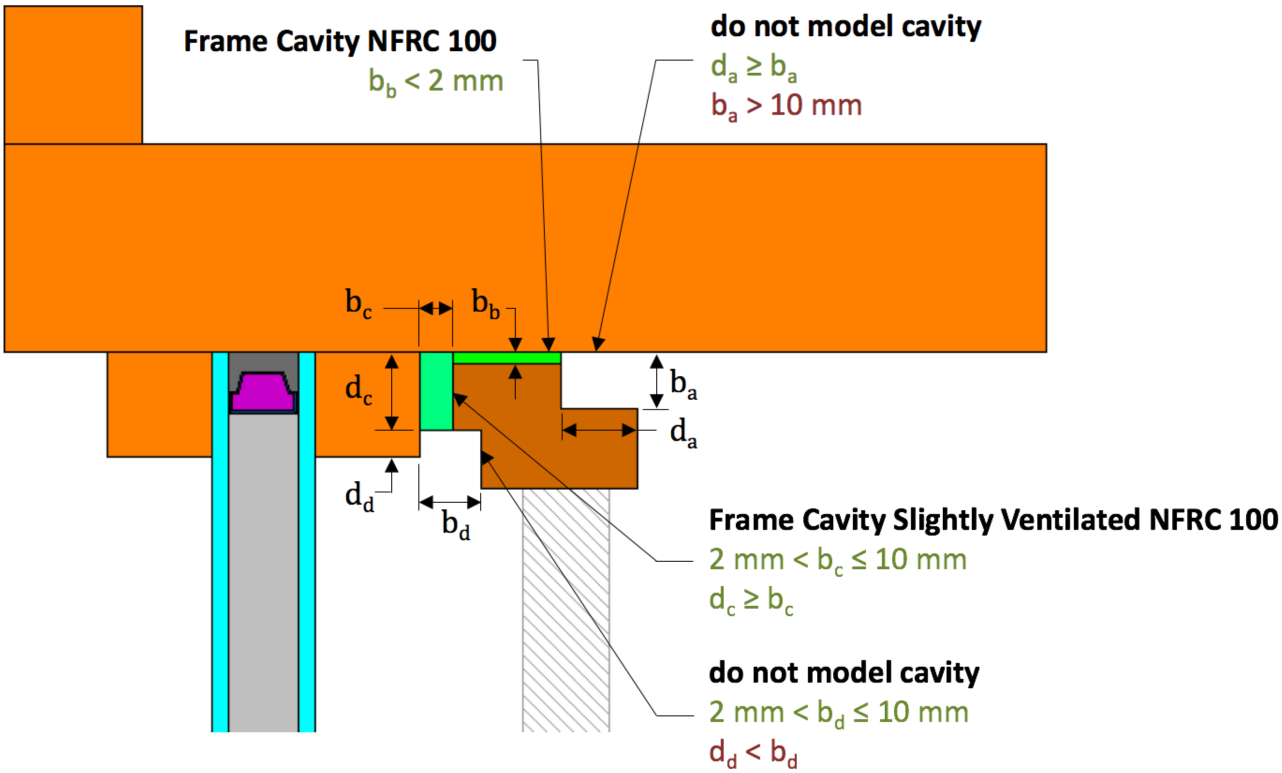



*Figure 3-2. Four different potential frame cavity configurations are illustrated.*
*The gap between frame and hardware (bb) is less than 10 mm so the shade hardware is modeled.*

#### 3.3.1.4. Boundary condition assignments

Shade layers are not explicitly modeled in THERM. When a WINDOW glazing system with shade layer is inserted into a THERM file, THERM draws a graphic representation of the shade, but does not create a polygon for it. The space between the shade and the glazing system or frame is not modeled as a frame cavity, and the effect on the glazing system or frame is accounted for by assigning a Shading Modifier when defining the boundary conditions. The **Shading Modifier** is automatically created when the glazing system is inserted, and will be available from the **Shading Modifier** pulldown menu in the **Boundary Condition** dialog box. All boundaries that fall on or between the glazing system and the shade layer are assigned the modifier.

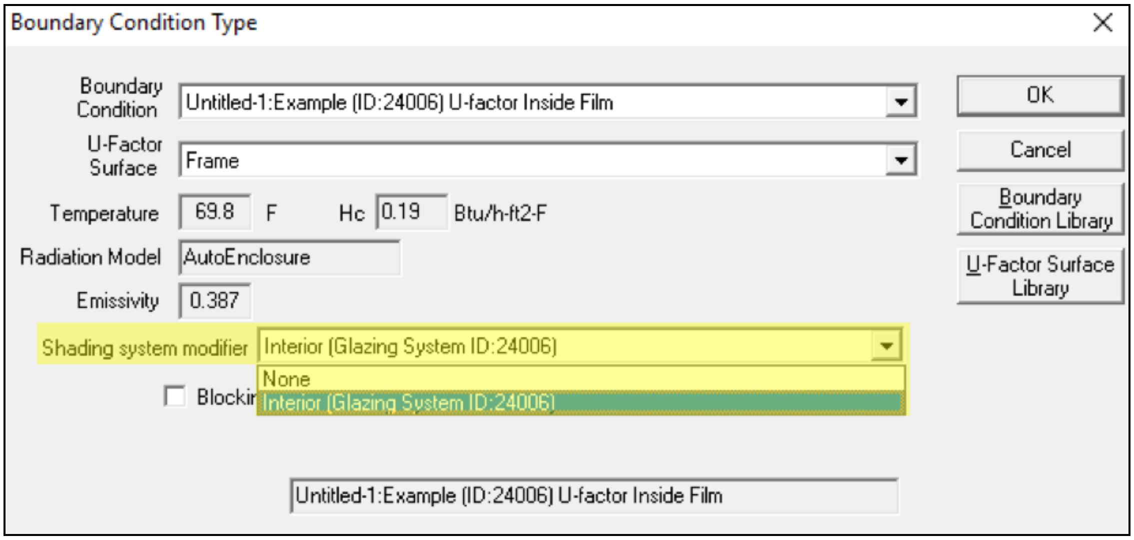



*Figure 3-3. Boundary Condition Dialoge Box. Shading system modifier is available for glazing systems that contain shade layers.*

The boundary condition settings for room-side and outside mounted shade layers are shown in the Figures 3-4 through 3-13 below. The top of glazing and bottom of frame are designated adiabatic. These boundary conditions are shown only in Figure 3-3 for brevity, but are typical for all configurations shown.

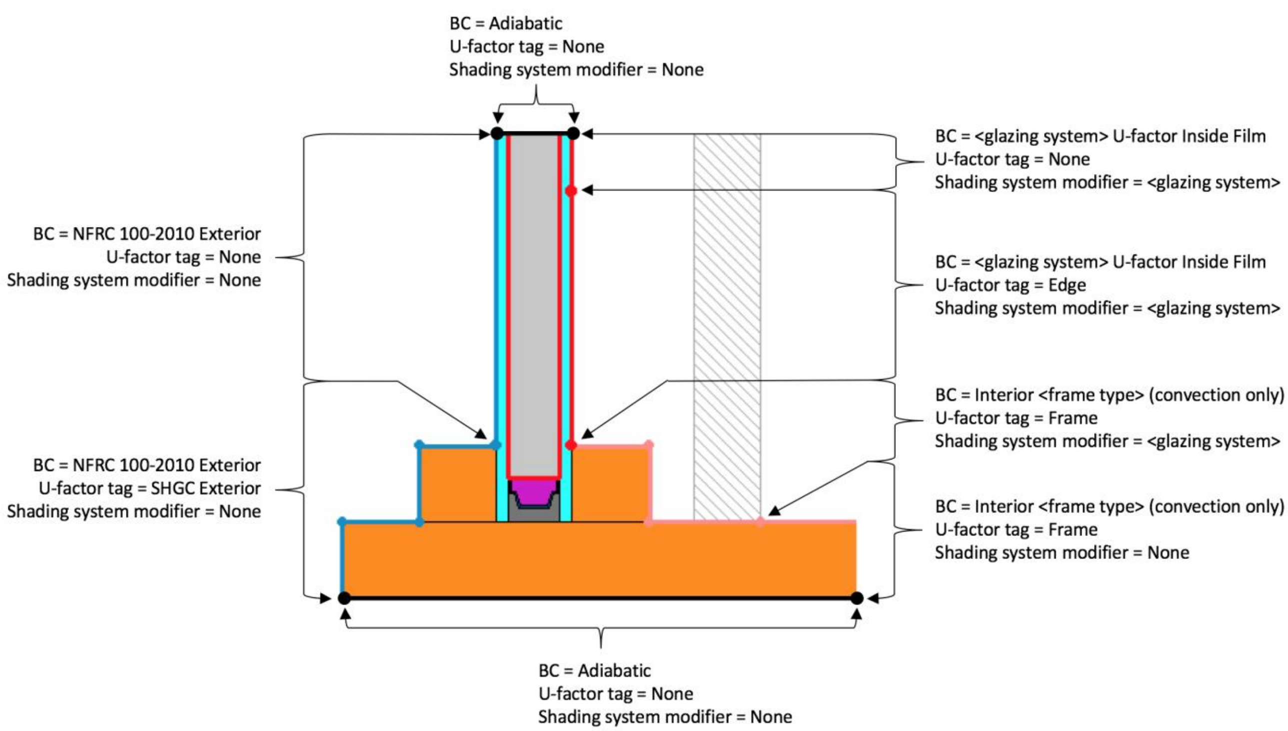



*Figure 3-4. Standard boundary condition assignments for interior attachment with no perimeter gap and no hardware. Adiabatic boundary conditions on the top and bottom are identified.*

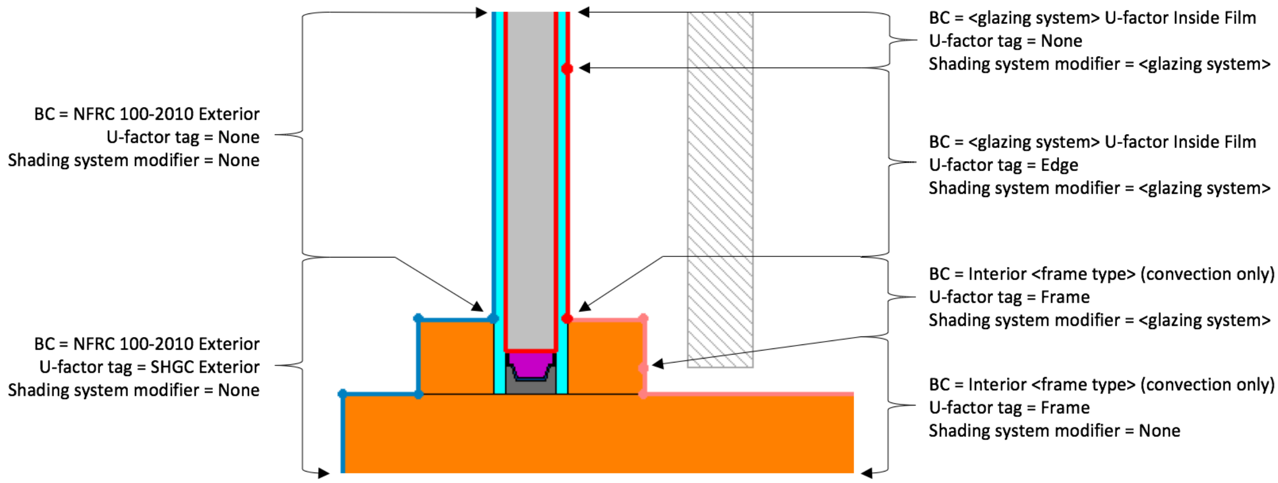



*Figure 3-5. Standard boundary condition assignments for interior attachment with perimeter gap less than sight line and no hardware.*

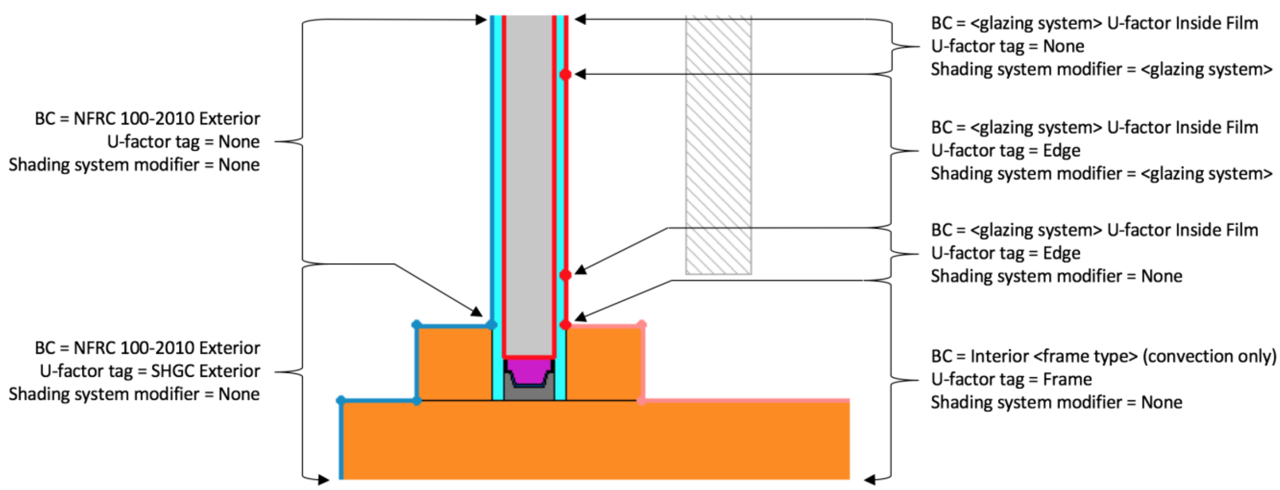



*Figure 3-6. Standard boundary condition assignments for interior attachment with perimeter gap greater than sight line and no hardware*

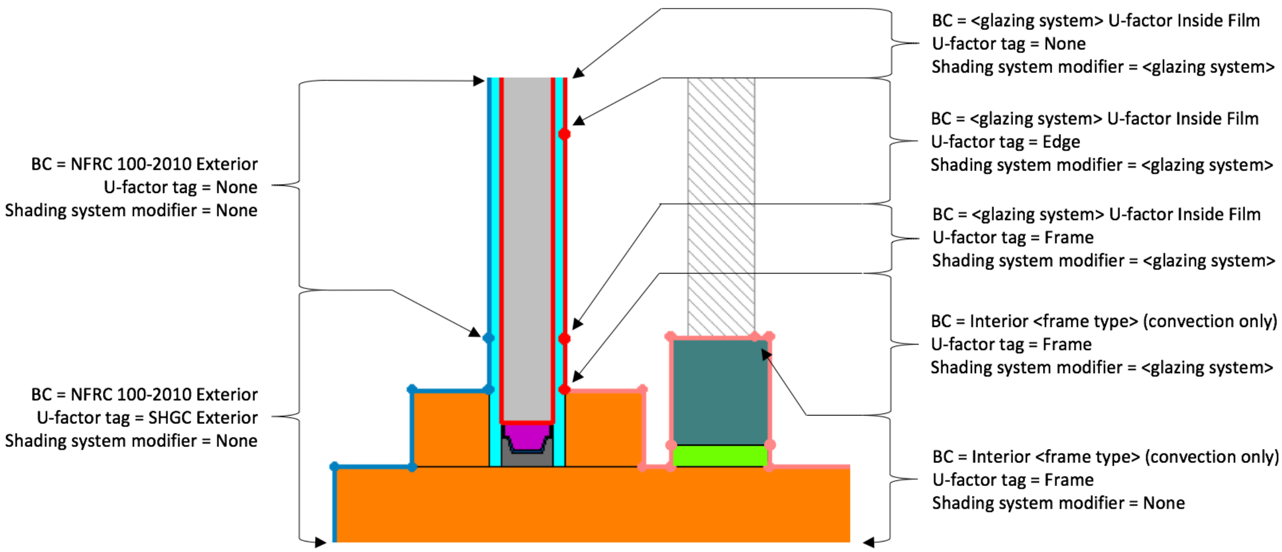



*Figure 3-7. Standard boundary condition assignments for interior attachment with perimeter gap ≤5mm and hardware top greater than frame sight line*

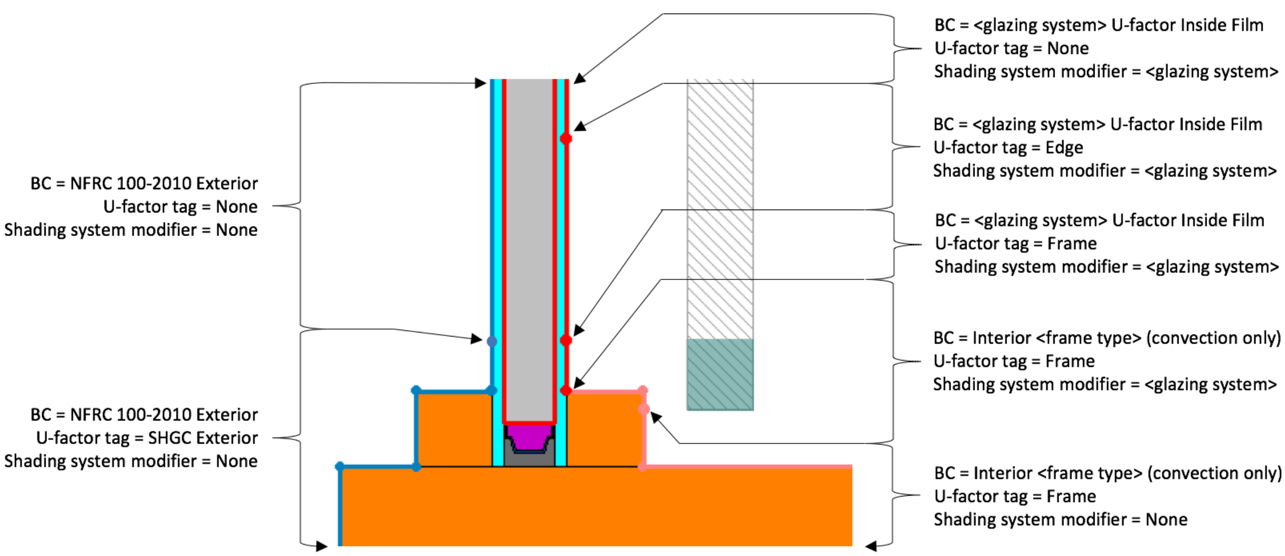



*Figure 3-8. Standard boundary condition assignments for interior attachment with perimeter gap >5mm and hardware top greater than frame sight line. Hardware is not modeled explicitly (shown transparent here for clarity), top and bottom are projected to define boundary conditions*

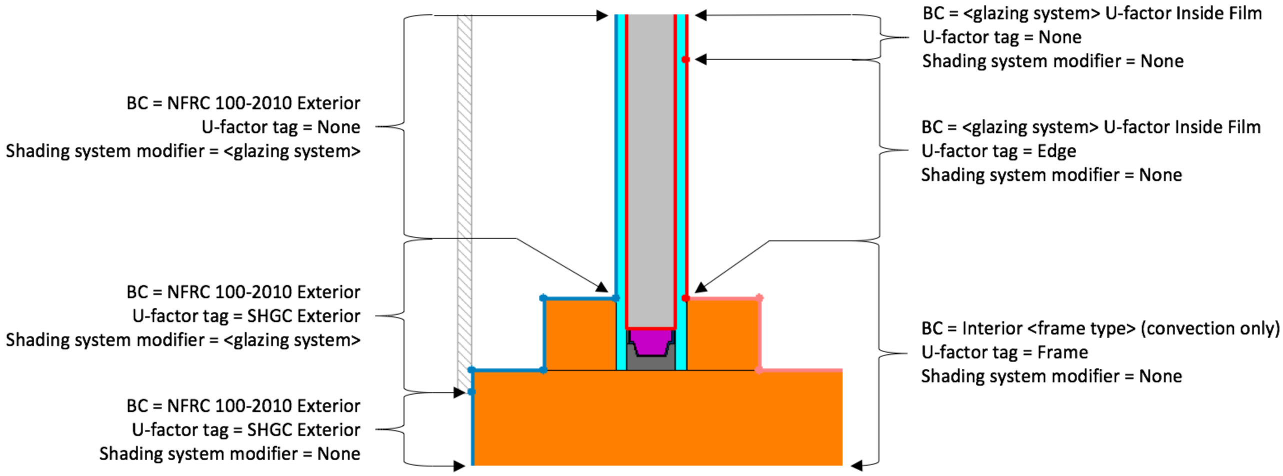



*Figure 3-9. Standard boundary condition assignments for exterior attachment with no perimeter gap and no hardware*

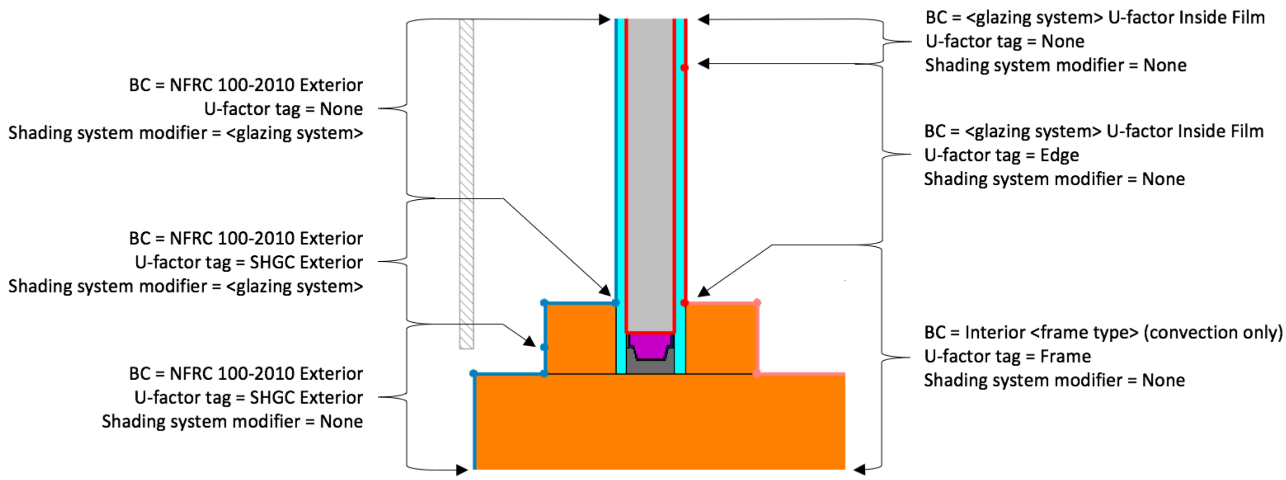



*Figure 3-10. Standard boundary condition assignments for exterior attachment with perimeter gap less than sight line and no hardware*

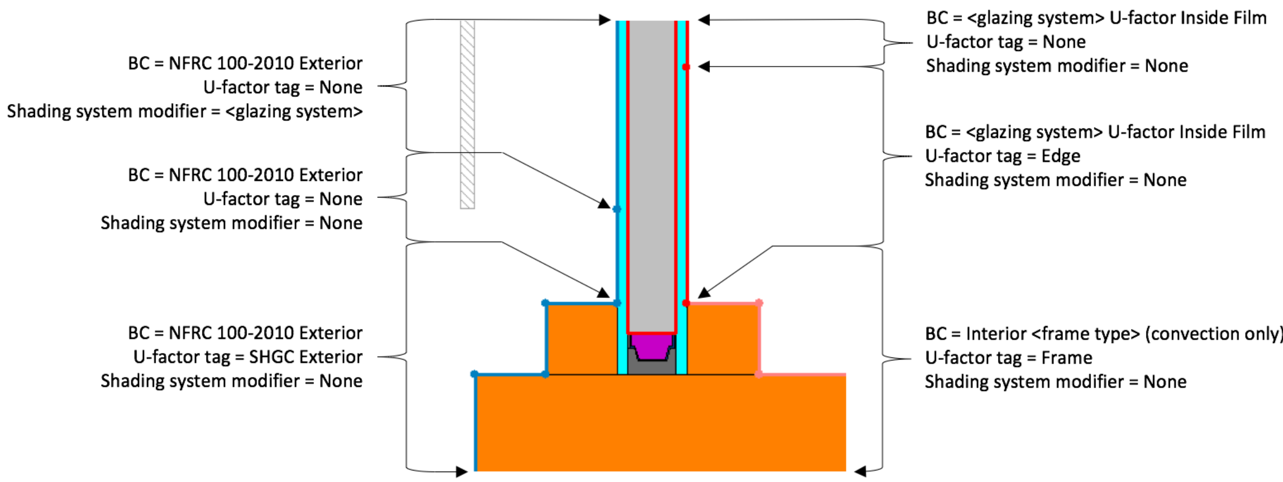



*Figure 3-11. Standard boundary condition assignments for exterior attachment with perimeter gap greater than sight line and no hardware*

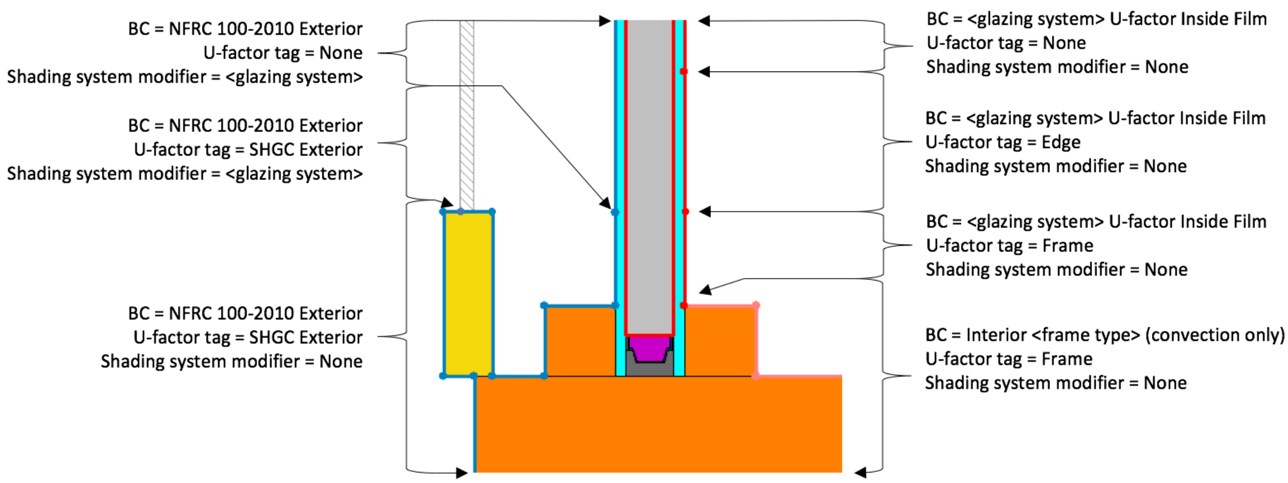



*Figure 3-12. Standard boundary condition assignments for exterior attachment with perimeter gap ≤5mm and hardware top greater than frame sight line*

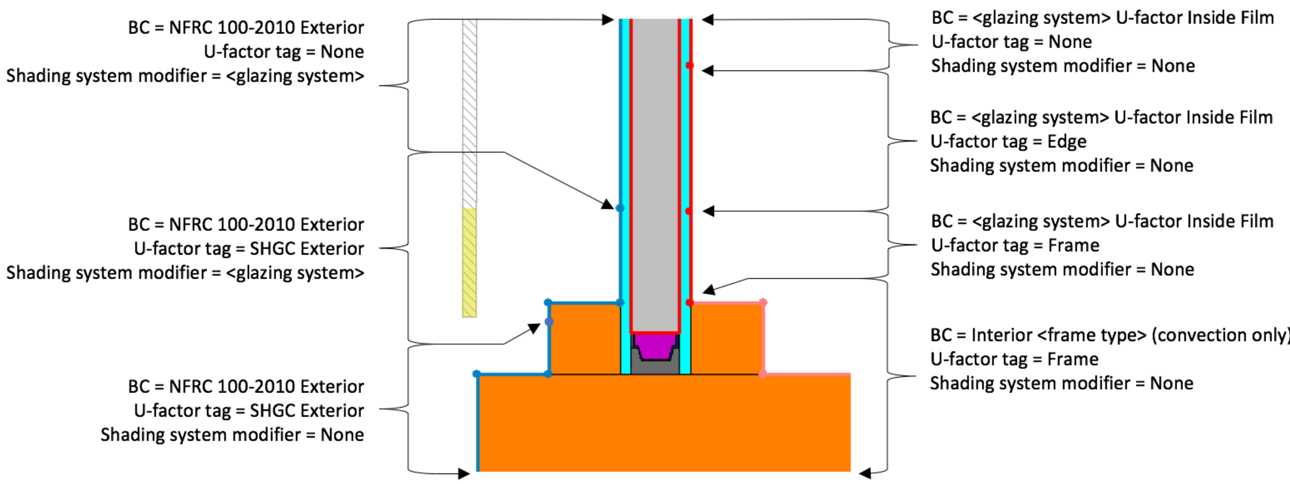



*Figure 3-13. Standard boundary condition assignments for exterior attachment with perimeter gap >5mm and hardware top greater than frame sight line. Hardware is not modeled explicitly (shown transparent here for clarity), top and bottom are projected to define boundary conditions*

## 3.4. Glazing Options with Shading Systems

The Glazing Options functionality within THERM may be used for glazing systems with shading to create multiple edge-of-glass glazing systems. The functionality is limited to properly assigning boundary conditions on the glazing surfaces only. The shading modifier must be manually applied to frame surfaces for THERM files generated by the Glazing Options feature, where applicable, before the calculation is performed.

## 3.5. Special Cases

Shading systems with non-typical EOG geometry or boundary conditions are outlined in this section.

### 3.5.1. Intermediate framing or hardware

Shading systems may include intermediate (not located on the perimeter) framing or hardware, see Figure 3-14. A common example of this is triple-track storm windows. EOG simulations of these products are modified to account for the increased frame dimensions. Figures 3-15 and 3-16 illustrate how the projected frame dimension of the intermediate members are added to the sill and jamb profiles respectively. Shading systems incorporating both vertical and horizontal intermediate members should use both sill and jamb methods. The average distance to the baseline glazing is used to determine dgap for the system if there are multiple shade planes.

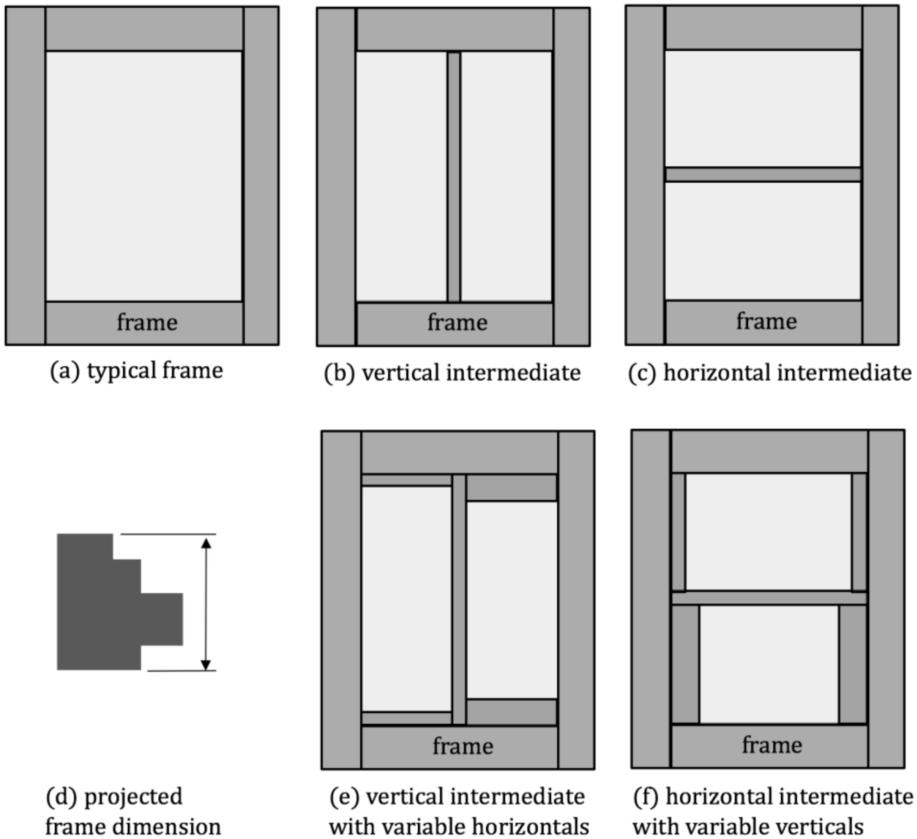



*Figure 3-14. Illustration of (a) typical shade with perimeter only frame members, frame with (b) vertical intermediate framing, (c) horizontal intermediate framing, (d) the projected frame dimension used to determine height or width of the framing, (e) vertical intermediate with variable height horizontal frame, and (f) horizontal intermediate with variable width vertical frame.*

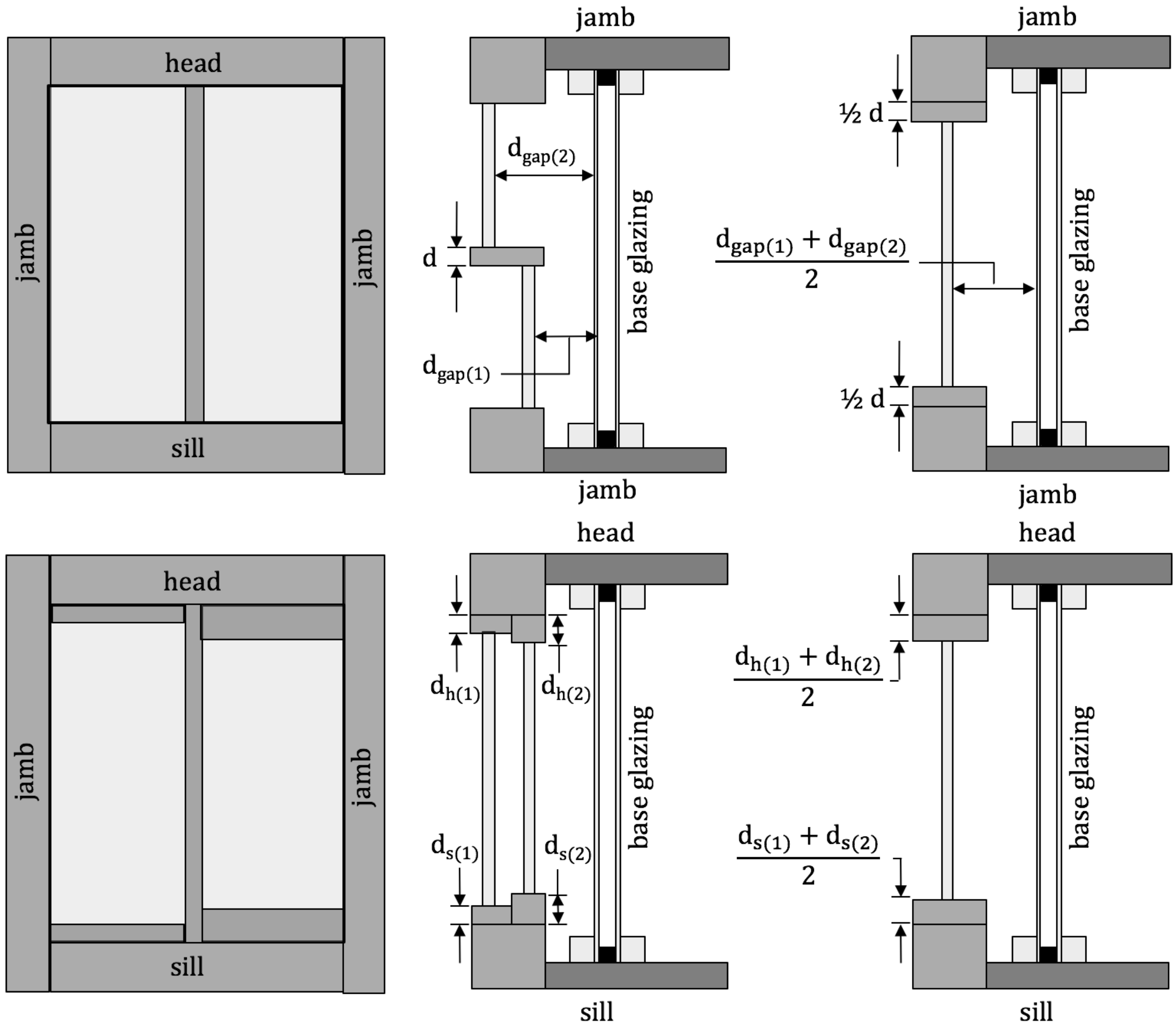



*Figure 3-15. Illustration of a shade with vertical intermediate framing or hardware. ½ the projected width of the intermediate member is added to each jamb profile and the average height of variable height horizontals is added to the head and sill profiles. The average gap from shade plane to base glazing is used to determine the equivalent dgap of the system.*

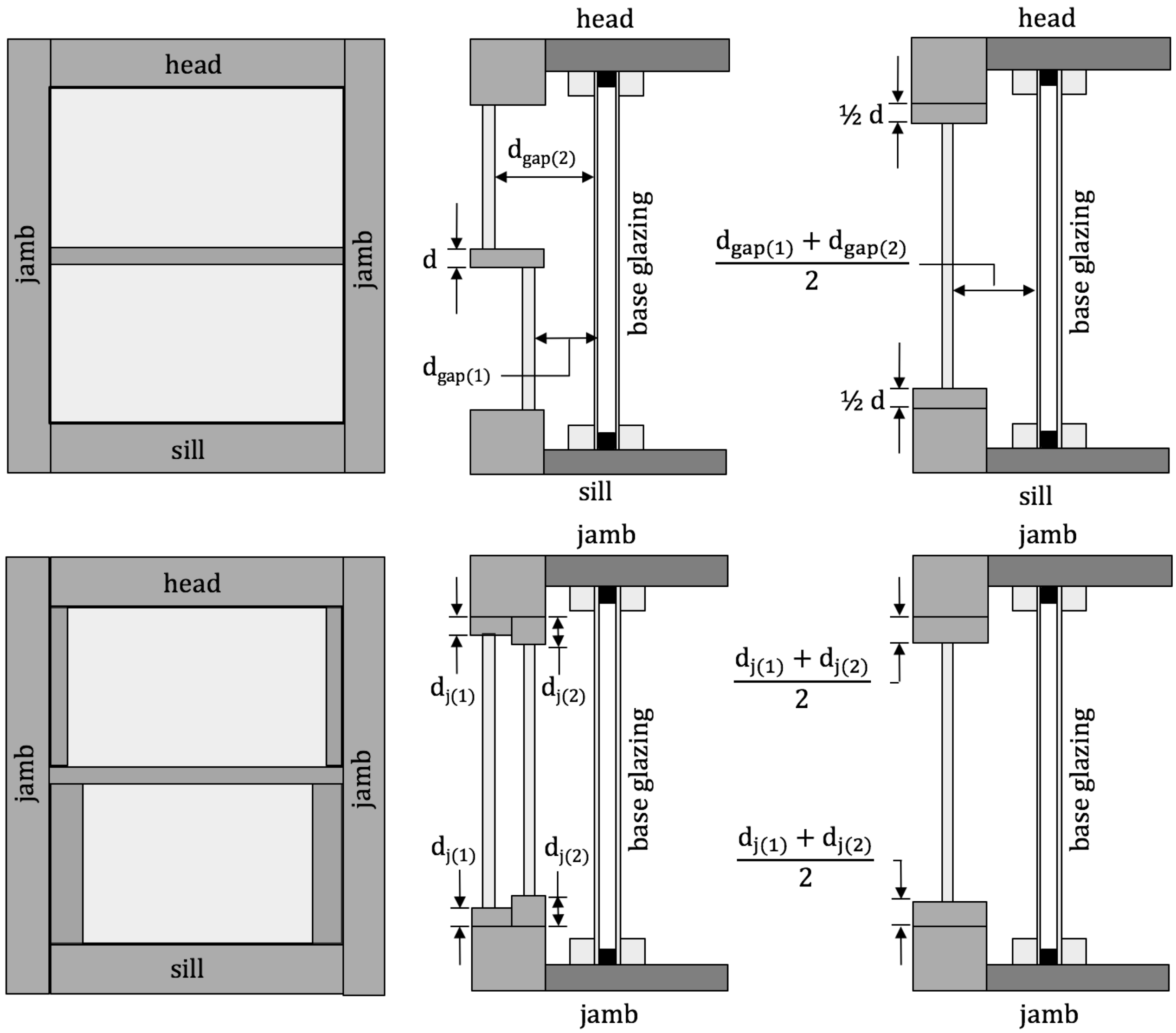



*Figure 3-16. Illustration of a shade with horizontal intermediate framing or hardware. ½ the projected height of the intermediate member is added to the head and sill profiles and the average width of variable width verticals is added to each jamb profile. The average gap from shade plane to base glazing is used to determine the equivalent dgap of the system.*

# 4. Whole Window Model in WINDOW

## 4.1. Overview

When the glazing system + shading system has been defined in WINDOW, and the frame models have been created in THERM, they are brought together in the WINDOW Window Library to create a whole window model. This is explained in more detail in the WINDOW User Manual.

## 4.2. Frame Library: Import the THERM files

Import the THERM files into the WINDOW Frame Library.

## 4.3. Window Library: Create the Whole Window

Define the whole window in the WINDOW Window Library.

Make sure to name the window with the following naming convention, which is required when importing the window into the AERCalc software.

<product name>::<attachment type><slat tilt>::<attachment position>::BW-<basecase window ID>

Each element is separated by a double colon

| **Element** | **Description** |
|---|---|
| <product name> | The name of the product. Make sure not to use any of the following characters<br>/ \ < > “ |
| <attachment type> | Attachment Type abbreviation<br>SS: Solar Screen<br>CS: Cellular Shade<br>PS: Pleated Shade<br>RS: Roller Shade<br>AF: Applied Film<br>WP: Window Panel<br>VB: Venetian Blind<br>VL: Vertical Louver |
| <slat tilt> | Slat tilt, used only for Venetian Blinds and Vertical Louvers<br>0<br>45<br>-45<br>90 |
| <attachment position> | The position of the attachment relative to the glazing system<br>I: Indoor<br>O: Outdoor |
| BW-<basecase window ID> | The AERC Base Case window abbreviation. The only choice now is<br>BW-B |

Below is an example of the name of a shade product in the WINDOW Window Library with the name

1 cell Light Indoor::CS::I::BW-B

**Name** = 1 Cell Light Indoor

**ShadeType** = CS (Cellular Shade)

**SlatTilt** = not there, this is not a slat shade

**Attachment Position** = I (Indoor)

**BW Basecase window ID** = BW-B

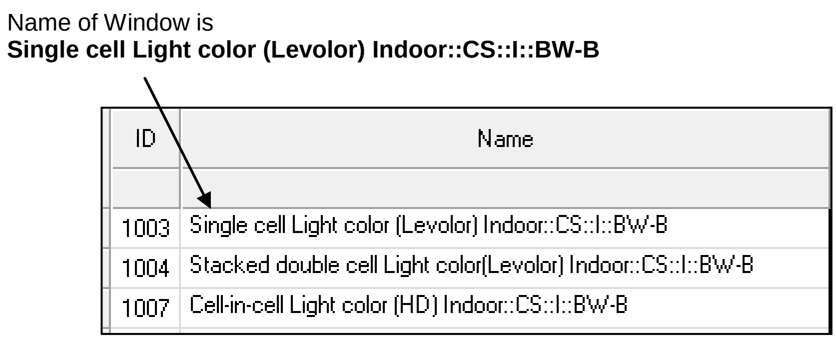



*Figure 4-1. Window Library with whole product calculation and the correct Name format.*

### 4.3.1. Glazing System

Clicking the glazing system in the image shows the glazing system being modeled, in this example

ID 1003: Single cell Light color (Levolor) Indoor::CS::I::BW-B

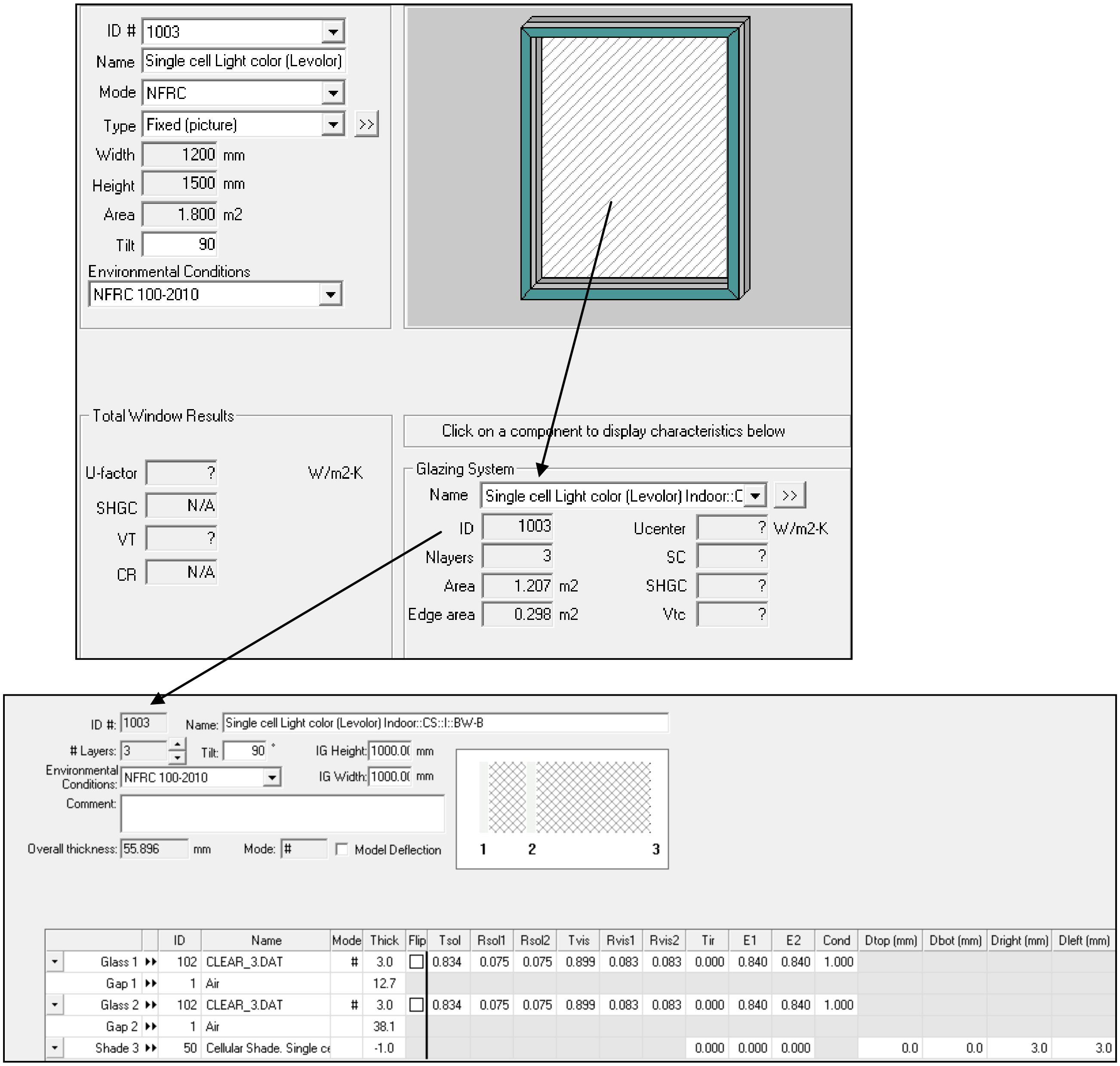



*Figure 4-2. The glazing system defined with the attachment is referenced from the Window library.*

### 4.3.2. Frames

The THERM files imported into the WINDOW Frame Library are used to create the whole window

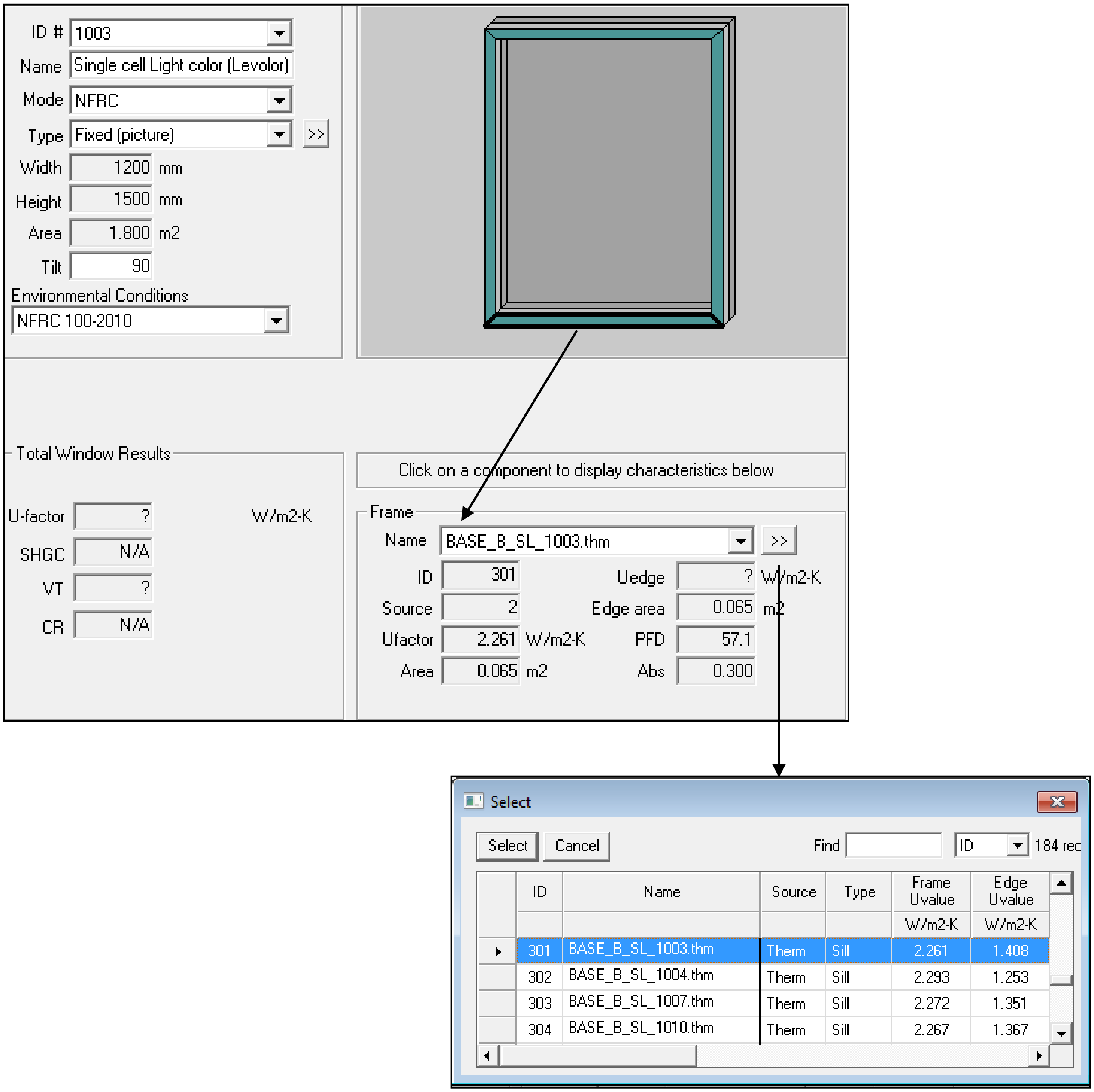



*Figure 4-3. THERM files imported into the WINDOW Frame Library are referenced for the Head, Jamb and Sill components of the window.*

# 5. Prepare Shading Layers for Submission to the CGDB

## 5.1. Overview

Shading products, and their associated materials, must be submitted through AERC for inclusion in the CGDB. The AERC approved CGDB records are then imported into the WINDOW Shade Material and Shading Layer libraries for use in glazing systems as discussed in the *2. Center-ofGlass (COG) Modeling* document.

Submitting products to the CGDB generally starts with material measurements per AERC 1.1. The measured material properties are then imported to WINDOW to create shading materials and/or shading layers. The six Shading Layer Types utilized in WINDOW for AERC siulations are first described in detail and then the detailed steps for constructing shading layers for each AERC shading type are outlined in this section.

## 5.2. WINDOW Preferences

The settings required to prepare AERC Shading Layers for submittal to the CGDB are the same WINDOW preference settings as described in Section 2.5 of the *Center-of-Glass (COG) Modeling* document. In addition to those settings, Radiance must be enabled for creating some shading layers such as cellular and pleated shades. The Radiance program is used in conjuction with shade THERM files to create the genBSDF files WINDOW uses for whole product optical calculations. See the *WINDOW User Manual* for full details on modifying preferences settings.

**Radiance**

WINDOW→Preferences→Radiance tab→Enable Radiance = Checked

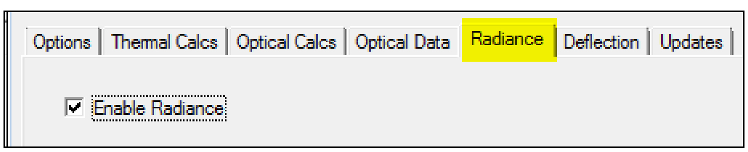



*Figure 5-1. WINDOW Preferences menu, Radiance tab*

## 5.3. WINDOW Shading Layer Library Types

This section describes the WINDOW Shading Layer Library "types" that are utilized to model the AERC defined shading products for submittal to the CGDB. Defining AERC products with these WINDOW Shading Layer Types is decribed in Section 5.4.

### 5.3.1. Homogeneous diffusing shade

Used to define the following AERC products for submittal to the CGDB:

- Roller Shade
- Solar Screen

For Shading Layer Type **Homogeneous diffusing shade**, no geometry is defined. The appropriate bulk material of the diffusing shade is measured per AERC 1.1 and the measurement results are imported into the Shade Material Library. The Shade Material Library record is referenced when defining the Shading Layer Library record for that product. This type of shade material represents a perfectly Lambertian diffusing material. The Permeability Factor is entered manually when defining the Shading Layer Library record, as determined per the requirements defined in AERC 1.1.

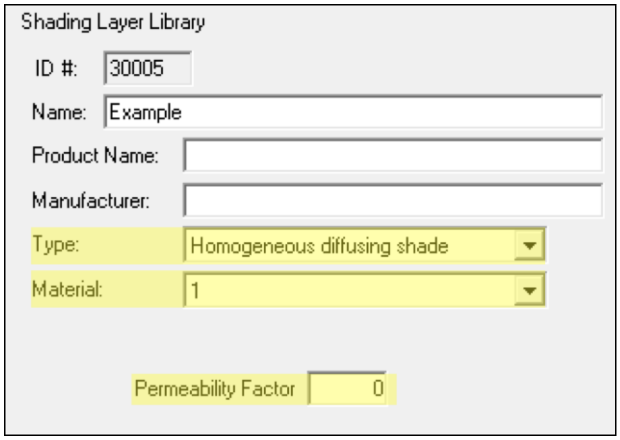



*Figure 5-2. Homogeneous diffusing shade option from Shading Layer Library. Material is selected from Shade Material Library and Permeability factor is entered.*

### 5.3.2. Perforated screen

Used to define the following AERC products for submittal to the CGDB:

- Roller Shade
- Solar Screen

For Shading Layer Type **Perforated screen**, the bulk screen material is measured according to AERC 1.1, and imported into the Shade Material Library. This bulk material is without perforations and should represent a perfectly Lambertian diffusing material.

That material is then referenced when defining the Shading Layer Library record for the product, where the geometry of the perforations is defined. Perforations must be in a regular repeating pattern of a single shape (circular, square, or rectangular). Non-regular patterns can be approximated by determining the equivalent area. Refer to the *WINDOW User Manual* for details on how to calculate the equivalent area for special cases.

The Permeability Factor is calculated automatically by WINDOW based on the geometry of defined perforations.

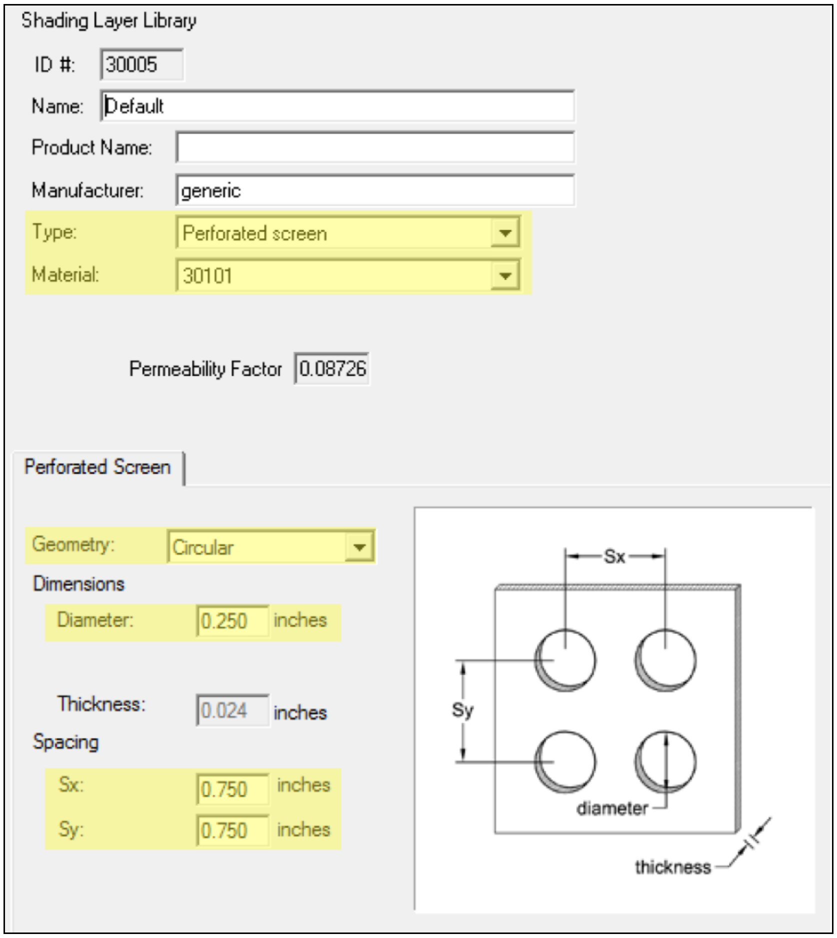



*Figure 5-3. Perforated Screen option from Shading Layer Library. Material is selected from Shade Material Library and Permeability factor is calculated from input dimensions and spacing.*

### 5.3.3. Shade with XML data

Used to define the following AERC products for submittal to the CGDB:

- Roller Shade
- Solar Screen

For Shading Layer Type **Shade with XML data**, the geometry of the layer, thermal properties, and optical properties of the shade material are all defined within an XML formatted file. The thermal and optical properties in the XML file are measured according to AERC 1.1.

The Permeability Factor is determined per the requirements defined in AERC 1.1 and included in the XML file. The value from the XML file is displayed in the Shading Layer Library detail view.

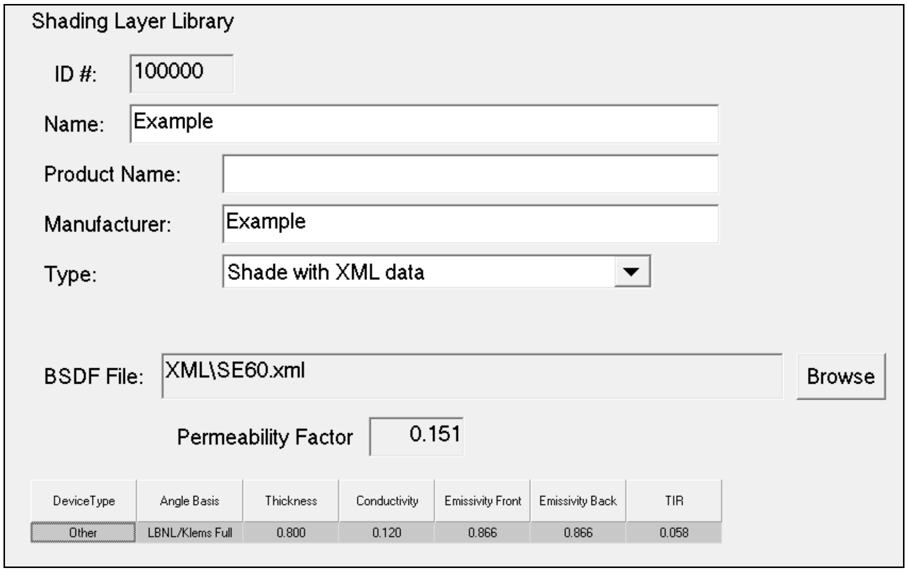



*Figure 5-4. Shade with XML data option from Shading Layer Library. XML file is selected from the Browse button and layer properties are populated from file.*

### 5.3.4. Therm File (*.thmx)

Used to define the following AERC products for submittal to the CGDB:

- Cellular Shade
- Pleated Shade

For Shading Layer Type **Therm File (*.thmx)**, the geometry of the layer is defined within the THERM software program. The process for defining layer geometry of cellular shades and pleated shades is provided in Chapter 19.4 of the *WINDOW 7 User Manual*. The materials used in the THERM file must represent a perfectly Lamberitan diffusing material and must be measured according to AERC 1.1, and these are then referenced in the Shade Material Library for the product.

The Permeability Factor for each material in the system is determined per the requirements defined in AERC 1.1 and entered into the Shading Layer Library definition for the product. For single layer systems, such as pleated shades, the permeability factor of the single material is entered. For multiple layer systems, the shade material with the lowest permeability factor in the airflow critical path is used. The critical path for several systems is illustrated in the figure below.

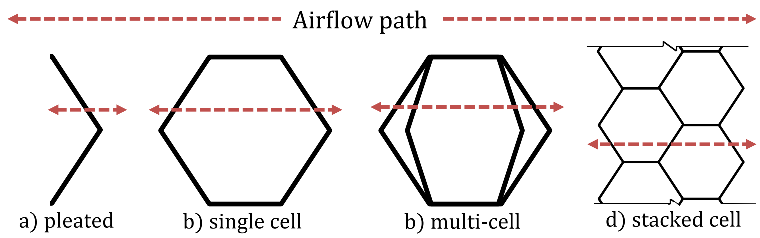



*Figure 5-5. Airflow critical path through cellular shade sytems. The shade material with the lowest permeability factor in the airflow critical path determines the Permeability Factor.*

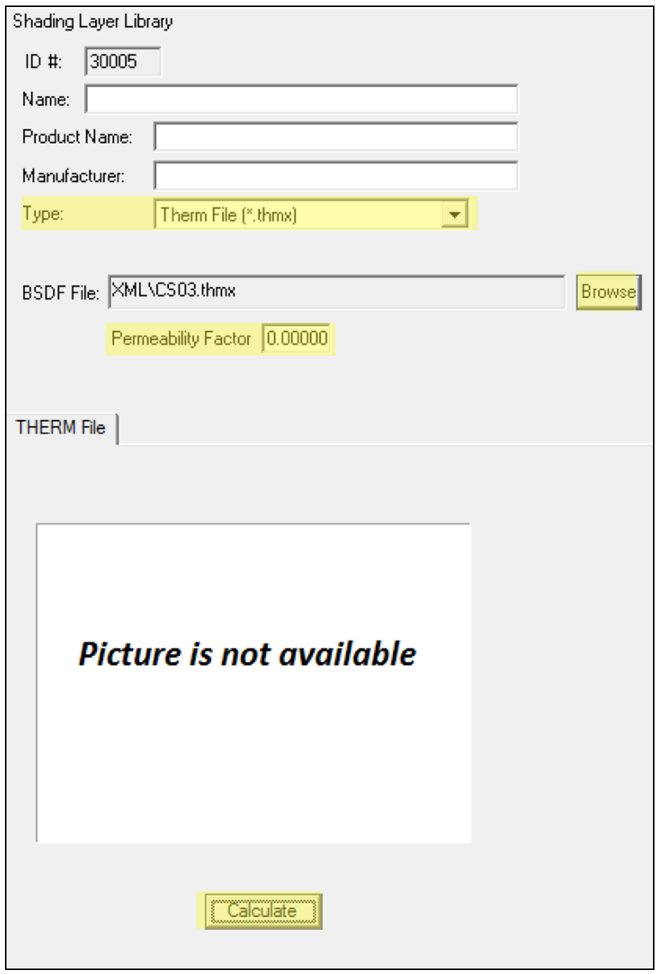



*Figure 5-6. Therm File (*.thmx) option from Shading Layer Library. THMX file is selected from the Browse button. Permeability Factor is entered based on the airflow critical path. Optical properties are then calculated with the Calculate button.*

### 5.3.5. Venetian blind, horizontal

Used to define the following AERC products for submittal to the CGDB:

- Slat Shade

For Shading Layer Type **Venetian blind, horizontal**, the bulk material of the slat, without any perforations and which represents a perfectly Lambertian diffusing material, must be measured according to AERC 1.1 and imported into the Shade Layer Library. That material is then referenced in the Shading Layer Library, where the geometry of the layer is also defined. In the Shading Layer Library, the slat width (w), slat spacing (p), tilt angle (ϕ), blind thickness (t), and rise (r) are defined according to the Figure below. The blind thicknessis defined in the Shade Material Library.

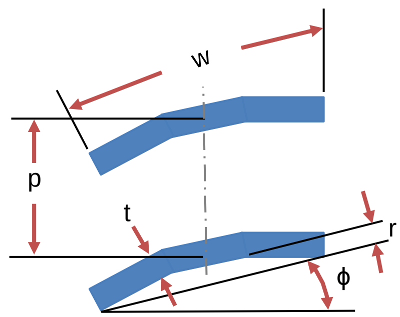



*Figure 5-7. Slat shade layer geometry. Slat width (w), slat spacing (p), tilt angle (ϕ), blind thickness (t), and rise (r) are defined according to the figure.*

A separate Shading Layer Library record must be created for each slat tilt angle defined by AERC. To obtain accurate Permeability Factor and optical performance results for a layer when slats are in the closed position, the maximum angles achieved when rotating slats fully tilted upward (maximum positive tilt angle) must be measured and entered with Tilt: Custom angle and the tilt angle achieved.

The Permeability Factor is calculated automatically by WINDOW based on the geometry of slats and tilt angle.

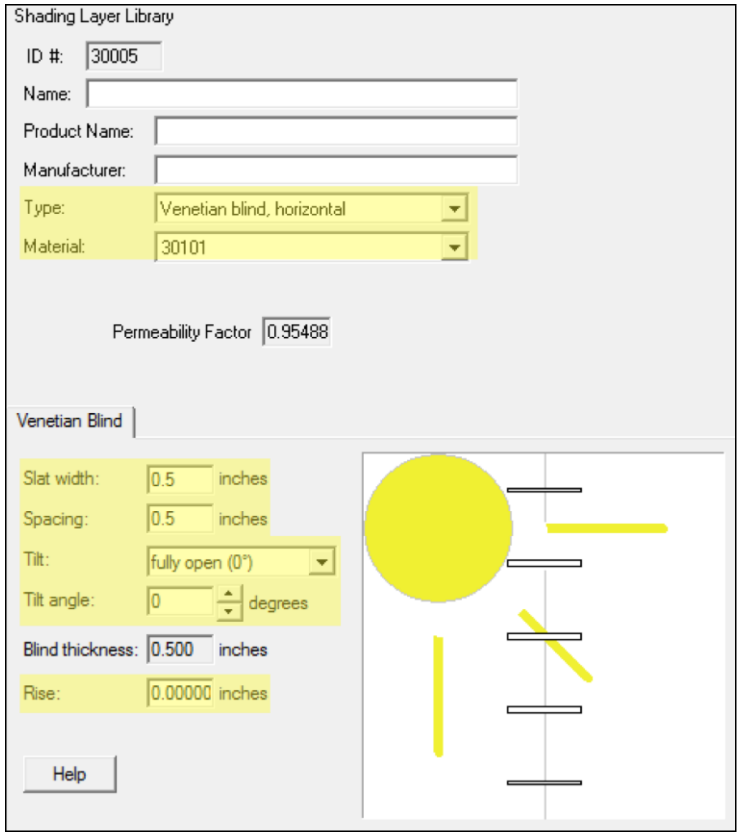



*Figure 5-8. Venetian blind, horizontal option from Shading Layer Library. Material is selected from the shade material library. Permeability Factor is calculated based on the entered geometry.*

### 5.3.6. Venetian blind, vertical

Used to define the following AERC products for submittal to the CGDB:

- Vertical Louver

For Shading Layer Type **Venetian blind, vertical**, the bulk material of the slat, without any perforations and which represents a perfectly Lambertian diffusing material, must be measured according to AERC 1.1 and imported into the Shade Layer Library. That material is then referenced in the Shading Layer Library, where the geometry of the layer is also defined. In the Shading Layer Library, the slat width (w), slat spacing (p), tilt angle (ϕ), blind thickness (t), and rise (r) are defined according to the Figure below. The blind thicknessis defined in the Shade Material Library.

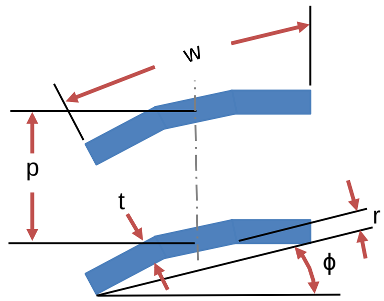



*Figure 5-9. Slat shade layer geometry. Slat width (w), slat spacing (p), tilt angle (ϕ), blind thickness (t), and rise (r) are defined according to the figure.*

A separate Shading Layer Library record must be created for each slat tilt angle defined by AERC. To obtain accurate Permeability Factor and optical performance results for a layer when slats are in the closed position, the maximum angles achieved when rotating slats fully tilted upward (maximum positive tilt angle) must be measured and entered with Tilt: Custom angle and the tilt angle achieved.

The Permeability Factor is calculated automatically by WINDOW based on the geometry of slats and tilt angle.

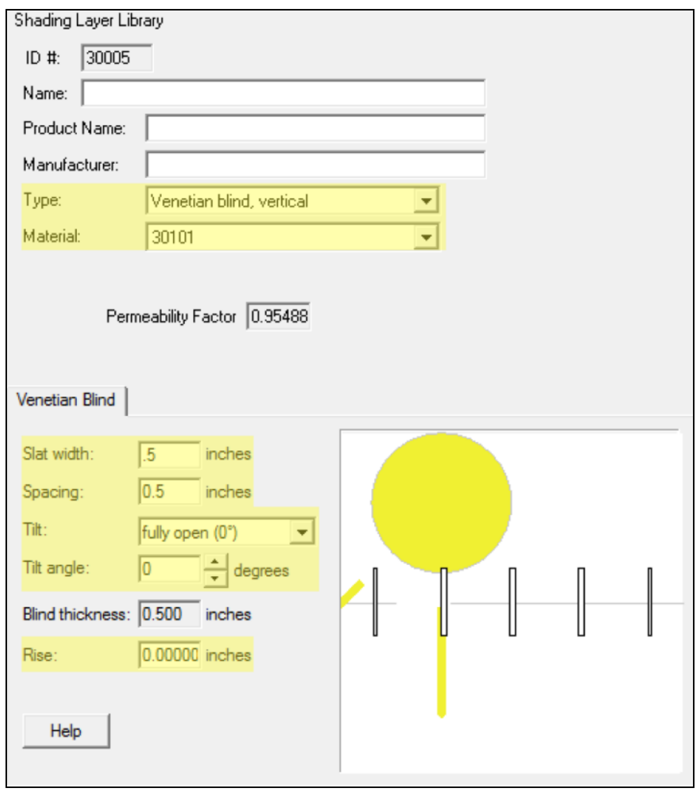



*Figure 5-10. Venetian blind, vertical option from Shading Layer Library. The Material is selected from the Shade Material Library. Permeability Factor is calculated based on the entered geometry.*

## 5.4. Defining AERC Product Types for submittal to CGDB

After all the appropriate materials have been measured and imported into WINDOW, depending on the AERC product type as described in the previous section, the AERC shading products are defined in the WINDOW Shading Layer Library. Details for these definitions are provided in this section. The following products are included in the AERC certification process:

- Cellular Shade
- Slat Shade
- Roller Shade
- Storm Window and Window Panel
- Pleated Shade
- Solar Screen

### 5.4.1. Cellular Shades

#### WINDOW Shade Material Library

- Import the measured materials that define the properties of cellular shade fabric(s).

#### WINDOW Shading Layer Library

- Shade layer geometry is drawn in THERM. Refer to the Cellular shade modeling section of *WINDOW User Manual* for modeling details.
- Shade materials selected from the Shade Material Library, are associated with each THERM polygon
- Select Type = **Therm File (*.thmx)**
- Reference the THERM thmx file with geometry and material assignments
- Assign Permeability Factor based on the airflow critical path as defined in Section 5.3.4.

### 5.4.2. Pleated Shades

#### WINDOW Shade Material Library

- Import the measured materials that define the properties of the pleated shade fabric

#### WINDOW Shading Layer Library

- Shade layer geometry drawn in THERM. Refer to the Cellular shade modeling section of WINDOW User Manual for modeling details.
- Shade materials, selected from the Shade Material library are associated with each polygon
- Select Type = **Therm File (*.thmx)**
- Reference THERM thmx file with geometry and material assignments
- Assign Permeability Factor of shade material based on the airflow critical path as defined in Section 5.3.4.

### 5.4.3. Slat Shades

#### WINDOW Shade Material Library

- Import the measured materials that defines the properties of the slat material

#### WINDOW Shading Layer Library

- Defined as one of the following types based on the orientation of the slats

- **Venetian blind, horizontal**
- **Venetian blind, vertical**

- Define shade geometry. Each slat tilt is a separate record in the Shading Layer Library. All geometry is defined for the shading layer except blind thickness, which is defined in the Shade Material Library. The following characteristics are used for calculating equivalent layer properties.
  - Slat width (w)
  - slat spacing (p)
  - blind thickness (t)
  - rise (r)
  - tilt angle (ϕ)
    - Four tilt angles are required for AERC and each is defined in a separate Shading Layer Library record.
      - 0 degrees (horizontal)
      - -45 degrees
      - 45 degrees
      - maximum positive tilt angle achievable by system in normal use.

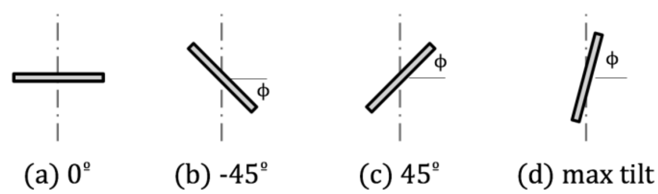



*Figure 5-11. Slat tilt angles for AERC shading layers*

### 5.4.4. Roller Shades

#### WINDOW Shade Material Library

- Import the measured materials that define the properties of the roller shade fabric if it is a homogeneous diffusing material. If not homogeneous diffusing then Shade with XML data is used in lieu of this method.

#### WINDOW Shading Layer Library

- Select Type = Perforated Screen
  - Select for non-specular shade materials with perforations.
  - Base material is selected from Shade Material Library
  - Geometry of the perforations is defined. Perforations must be in a regular repeating pattern of a single shape (circular, square, or rectangular).
- Select Type = Homogeneous Diffusing Shade
  - Select for non-specular shade materials without perforations
  - Base material is selected from Shade Material Library
  - Assign Permeability Factor of shade material based on AERC 1.1
- Select Type = Shade with XML data
  - Select for specular shade materials, non-woven materials, or materials with a non-uniform weave pattern
  - Reference XML data file with geometry and material assignments

### 5.4.5. Solar Screens

#### WINDOW Shade Material Library

- Import the measured materials that define the properties of the solar screen fabric if it is a homogeneous diffusing material. If not homogeneous diffusing then Shade with XML data is used in lieu of this method.

#### WINDOW Shading Layer Library

- Select Type = Perforated Screen
  - Select for non-specular shade materials with perforations.
  - Base material is selected from Shade Material Library
  - Geometry of the perforations is defined. Perforations must be in a regular repeating pattern of a single shape (circular, square, or rectangular).
- Select Type = Homogeneous Diffusing Shade
  - Select for non-specular shade materials without perforations
  - Base material is selected from Shade Material Library
  - Assign Permeability Factor of shade material based on AERC 1.1
- Select Type = Shade with XML data
  - Select for specular shade materials, non-woven materials, or materials with a non-uniform weave pattern
  - Reference XML data file with geometry and material assignments