AERC 1

Procedures for Determining Energy Performance Properties of Fenestration Attachments

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Foreword

The Attachments Energy Rating Council (AERC) is an independent, public interest, non-profit organization whose mission is to develop and maintain a program to allow participants to rate, label, and certify the performance of fenestration attachments.

This document, AERC 1, provides the main technical rating procedures to determine the energy performance properties (U-factor, SHGC, VT, and Air Leakage) of fenestration attachments installed in combination with standardized baseline windows and skylights under standardized conditions. AERC 2 provides the procedures to determine the corresponding annual energy performance ratings for fenestration attachments when used in a model residential home: Energy Performance Index for heating, EP_H, and Energy Performance Index for cooling, EP_C. AERC 1 and AERC 2 are supported by AERC 1.1 which provides the technical procedures for determining material property inputs (optical and thermophysical properties), and AERC 1.2 which provides physical testing procedures. The energy performance ratings determined by these technical procedures are designed to be used in conjunction with AERC's labeling and certification program, as detailed in *AERC 100 National Standard for Rating the Energy Performance of Fenestration Attachments*.

The attachment product types currently covered by this standard are listed in Section 2. Other product types such as louvered shutters, roman shades, drapes, and sheer shades may be added in future versions of the standard as technical procedures are developed.

1. Introduction

The purpose of this standard is to provide the technical rating procedures to determine the energy performance properties of fenestration attachments installed in combination with standardized baseline windows and skylights under standardized conditions. The energy performance properties include overall heat transfer coefficient (U-factor), solar heat gain coefficient (SHGC), visible transmittance (VT), and air leakage (AL). AERC 2 provides the procedures to determine the corresponding annual energy performance ratings for fenestration attachments when used in a model residential home: Energy Performance Index for heating, EP_H, and Energy Performance Index for cooling, EP_C.

2. Scope

This standard shall apply to interior and exterior fenestration attachments, defined as products attached to fenestration, or attached to or near the perimeter of the inner or outer wall surrounding fenestration.

The technical procedures of this standard apply to the following fenestration attachment product types:

- Cellular Shades
- Slat Shades
- Roller Shades

- Secondary Windows including Storm Windows, Window Panels, and Commercial Secondary Windows
- Pleated Shades
- Solar Screens
- Surface Applied Films
- Exterior Roller Shutters
- Awnings
- Window Quilts

This standard does not apply to or address:

- Primary fenestration inclusive of windows, doors, and skylights.
- Fenestration attachments over windows or doors in interior walls of buildings and not part of the thermal envelope of the building.
- Changes in performance properties over time of fenestration attachments or the windows, doors, and skylights over which they are installed.
- Changes in performance properties using conditions other than the standardized environmental, installation, and baseline window conditions specified in this document.

3. Referenced Documents and Standards

AERC 1.1 Revision 5 (2019) – *Procedures for Determining the Optical and Thermal Properties of Window Attachment Materials*, Attachments Energy Rating Council, New York NY, www.aercnet.org.

AERC 1.2 Revision 2 (2020), *Physical Test Methods for Measuring Energy Performance Properties of Fenestration Attachments*, Attachments Energy Rating Council, New York NY, www.aercnet.org.

AERC 2 Revision 2 (2020), *Procedures for Determining Heating and Cooling Annual Energy Performance Ratings of Fenestration Attachments*, Attachments Energy Rating Council, New York NY, www.aercnet.org.

AERC 400, *Policies and Procedures*, Attachments Energy Rating Council, New York NY, 2019, www.aercnet.org.

AERC 1.3-2020, *AERC Simulation Manual*, Lawrence Berkeley National Laboratory, Berkeley CA, 2017.

Complex Glazing Database (CGDB), Lawrence Berkeley National Laboratory, Berkeley CA, 2019. https://windows.lbl.gov/software/

Certified Product Database (CPD), Attachments Energy Rating Council, New York NY, 2019, www.aercnet.org.

IEEE/ASTM SI 10-2010, *American National Standard for Metric Practice*, ASTM International, West Conshohocken PA, 2010, www.astm.org.

International Glazing Database (IGDB), Lawrence Berkeley National Laboratory, Berkeley CA, 2019. https://windows.lbl.gov/software/

ISO 15099:2003, *Thermal Performance of Windows, Doors and Shading Devices — Detailed Calculations*, International Organization for Standardization, 2003.

THERM 7, Lawrence Berkeley National Laboratory, Berkeley CA, 2019. https://windows.lbl.gov/software/

WINDOW 7, Lawrence Berkeley National Laboratory, Berkeley CA, 2019. https://windows.lbl.gov/software/

"Modeling Procedure for Window Awnings", Lawrence Berkeley National Laboratory, Berkeley CA, 2020.

4. Terminology

4.1. Definitions

See AERC 400 Appendix A. Where there is a difference in definition between AERC 400 Appendix A and other reference documents, the definition from AERC 400 shall take precedence.

4.2. Acronyms

AERC	Attachments Energy Rating Council
AL	Air leakage
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASTM	American Society of Testing Materials
CPD	Certified product database
CGDB	Complex glazing database
EP_H	Energy Performance Index for heating
EP_C	Energy Performance Index for cooling
IGDB	International glazing database
ISO	International Standards Organization
NFRC	National Fenestration Rating Council
SHGC	Solar heat gain coefficient
$SHGC_{Annual}$	Modified solar heat gain coefficient for annualized, weighted-sky solar insolation model
VT	Visible transmittance
VT_{Annual}	Modified visible transmittance for annualized, weighted-sky solar insolation model

5. Technical Procedures

This section provides the procedures for determining U-factor, SHGC, VT, and AL ratings of fenestration attachment products used in combination with standardized baseline windows and skylights under standardized conditions.

Section 5.1 includes the general requirements that apply to all fenestration attachment products.

Section 5.2 includes variations and additions to these requirements that pertain to specific product types, including definitions of characteristics that distinguish individual products within each product type.

To standardize performance comparisons between products, determination of the U-factor, SHGC, and VT using one specific baseline window (Baseline Window B in Section 5.1.1.1, except as noted) is required for attachment products for use in labeling and listing in the AERC CPD. Additionally, the U-factor, SHGC (or $SHGC_{Annual}$ for awnings), and VT (or VT_{Annual} for awnings) of attachment products may optionally be determined using other standardized baseline windows, skylights, and doors as outlined in Section 5.1.1.1.

Test procedures are also provided for determining AL ratings of fenestration attachment products. AL ratings are only required for some attachment product types, as specified in Sections 5.1.5 and 5.2.

Exception: The determination of energy performance of awnings and other projecting shading products is different than for fenestration attachment products that are coplanar with the baseline window. When mounted above the baseline window opening, projecting products have negligible effect on U-factor and AL, and SHGC and VT calculated at normal incidence do not fully account for shading, which is sensitive to the actual solar angle and building geometry. Awnings shall comply with Section 5.1.1 and the product specific requirements in Section 5.2.9.

5.1. Procedures Applicable to All Attachment Products

5.1.1. Standardized Conditions

5.1.1.1. Baseline Windows and Skylights

Appendix A provides specifications (dimensions, materials, and standard sizes) for the following Baseline Windows that may be used for determining U-factor, SHGC, and VT ratings of fenestration attachments. AL ratings of fenestration attachments are not determined over a baseline window, but are instead tested over a calibration test panel as described in Section 5.1.5.

Baseline Windows:

A. Nonmetal-framed, single pane, clear *(optional)*
B. Nonmetal-framed, double pane, clear *(required for U, SHGC, VT except as noted)*
C. Nonmetal-framed, double pane, low-E *(optional)*

D. Metal-framed, single pane, clear *(optional, except as noted)*
E. Metal-framed, double pane, clear *(optional)*
F. Metal-framed, double pane, low-E *(optional)*

At a minimum, the U-factor, SHGC, and VT of all fenestration attachments shall be determined in accordance with Sections 5.1.2, 5.1.3, and 5.1.4 in combination with Baseline Window B (nonmetal-framed, double pane, clear glass).

In addition, the U-factor, SHGC, and VT of fenestration attachments may optionally be determined in accordance with Sections 5.1.2, 5.1.3, and 5.1.4 in combination with any of the Baseline Windows listed above and specified in Appendix A, so long as the performance properties are also determined for baseline window B.

> ***Exception**: For commercial secondary windows, determination of the U-factor, SHGC, and VT in combination with Baseline Window D is required, and optional in combination with Baseline Window B and the other Baseline Windows.*

Ratings for attachment products intended for use over vertical fenestration shall be determined with the baseline window in the vertical orientation.

Ratings for attachment products intended for use over skylights and other sloped fenestration shall be determined with the baseline window rotated at a slope of 20 degrees above horizontal.

Non-rectangular products shall be rated as rectangular products over these baseline windows using the same materials and at the size specified in Appendix A.

5.1.1.2. Attachment Installation

Ratings for attachment products shall be determined with the product installed over the baseline windows / skylights of Section 5.1.1.1 following the manufacturer's installation instructions and as specified in this section and Appendix A.

Ratings shall be determined with either the attachment product mounted within the window recess (inside mount) or outside the window recess (outside or overlap mount) as specified for each product type in Table 5-1.

Table 5-1: Mounting position for attachment product installation

Attachment Product Type (see Section 5.2)	**Mounting Position (see Appendix A)**
Cellular Shades	Inside mount
Slat Shades	Inside mount
Roller Shades - interior	Inside mount
Roller Shades - exterior	Outside / overlap mount

Secondary Windows (Storm Windows and Window Panels, Commercial Secondary Windows) - interior or exterior	Inside mount
Pleated Shades	Inside mount
Solar Screens	Inside mount
Surface Applied Films	On glass
Exterior Roller Shutters	Outside / overlap mount
Awnings	Outside / overlap mount

- For exterior products to be rated as installed within the window recess (inside mount), the attachment plane shall be as indicated in the baseline window drawings in Appendix A. Any reductions in product width/height inside the opening shall be 6 mm (3 mm on each side) except as noted for specific attachment product types in Section 5.2.
- For exterior products to be rated as installed outside the window recess (overlap mount), the attachment plane shall be as indicated in the baseline window drawings in Appendix A, and overlap the window frame by 38 mm (1.5 inches) on each side. Note: see Section 5.2.9.3 for additional mounting and geometry specifications for awnings.
- For interior products to be rated as installed within the window recess (inside mount), the attachment shall be modeled as installed with the closest surface of the attachment 37 mm (1.5 inch) inwards from the plane of glazing towards the interior of the building when fully deployed and any slats / vanes rotated perpendicular to the glazing plane (also see Appendix A). Any reductions in product width/height inside the opening shall be 6 mm (3 mm on each side) except as noted for specific attachment product types in Section 5.2.
- For interior products to be rated as installed outside the window recess (overlap mount), the attachment shall be modeled as installed on the head/jambs/sill as indicated in the baseline window drawings in Appendix A, and overlap the window frame by 38 mm (1.5 inches) on each side.
- Where installation according to these dimensions is precluded by physical constraints, the mounting distance between the attachment product and the glazing plane may be modified to accommodate the attachment product, extending the head / jambs / sills if necessary. Any variations in these dimensions shall be recorded.

Where ratings are determined with the attachment product mounted to the surrounding building materials (e.g. brickmold, interior trim) rather than directly to

the baseline window frame or glazing, these surrounding materials shall be modeled as coniferous wood (k = 0.081 Btu/hr-ft-F) as shown in Appendix A.

Any additional specifications regarding installation for specific attachment product types are included in Section 5.2.

5.1.1.3. Environmental and Boundary Conditions

The following standard environmental and boundary conditions shall be used:

For U-factor,

- T_{inside} = 21°C (69.8°F)
- ASHRAE / NFRC inside convection model in the currently approved Lawrence Berkeley National Laboratory WINDOW and THERM software tools
- Effective inside room temperature $T_{rm,inside} = T_{inside}$
- Effective room emissivity = 1.0
- $T_{outside}$ = -18°C (-0.4°F)
- ASHRAE / NFRC outside convection model with exterior wind speed = 5.5 m/s (convection coefficient h_c=26 W/m^{2}K)
- Effective sky temperature $T_{sky} = T_{outside}$
- Effective sky emissivity = 1.0
- Direct solar radiation I_s = 0 W/m^2

For SHGC,

- T_{inside} = 24°C (75.2°F)
- ASHRAE / NFRC inside convection model in the currently approved Lawrence Berkeley National Laboratory WINDOW and THERM software tools
- Effective inside room temperature $T_{rm,inside} = T_{inside}$
- Effective room emissivity = 1.0
- $T_{outside}$ = 32°C (89.6°F)
- ASHRAE / NFRC outside convection model with exterior wind speed = 2.75 m/s (convection coefficient h_c=15 W/m^{2}K)
- Effective sky temperature $T_{sky} = T_{outside}$
- Effective sky emissivity = 1.0
- Direct solar radiation I_s = 783 W/m^2

5.1.2. U-factor

5.1.2.1. Simulation procedures

The U-factor shall be calculated for each individual product (as determined for the appropriate product type in Section 5.2) installed in combination with the required Baseline Window and, optionally, other baseline windows as specified in Section 5.1.1.1.

The U-factor for operable attachment products shall be calculated in both the fully open/retracted and fully closed/deployed positions, except as noted for specific product types in Section 5.2.

The U-factor shall be calculated using the currently approved Lawrence Berkeley National Laboratory WINDOW and THERM software tools in accordance with:

- AERC 1.3, AERC Simulation Manual, currently adopted version.
- Default material and gas property libraries in the currently approved Lawrence Berkeley National Laboratory WINDOW and THERM software tools.
- Optical and thermophysical property data included in the latest published version of the IGDB and CGDB.
- Attachment installation details of Section 5.1.1.2.
- Environmental and boundary conditions of Section 5.1.1.3.
- Any additional requirements in Section 5.2 for the applicable product type.

Lift and control cords as well as discrete mounting hardware and operating components that do not extend along more than 50% of the full length or width of the attachment product may be ignored. This includes components such as but not limited to screws, bolts, brackets, latches, handles, clutches, cord locks, control rods, and end caps.

5.1.2.2. Test Option

For attachment products that cannot be simulated according to Section 5.1.2.1, the U-factor may be physically tested with the product installed in combination with the required Baseline Window as specified in AERC 1.2. The U-factor for operable attachment products shall be tested in both the fully open and fully closed positions, except as noted for specific product types in Section 5.2. If the U-factor is not or cannot be determined in accordance with AERC 1.2, the fenestration attachment shall be assigned a U-factor the same as the required Baseline Window without any attachment.

Exception: determination of U-factor in accordance with Section 5.1.2.1 or 5.1.2.2 is not required for awnings.

5.1.3. Solar Heat Gain Coefficient

5.1.3.1. Simulation procedures

The SHGC or $SHGC_{Annual}$ shall be calculated for each individual product (as determined for the appropriate product type in Section 5.2) installed in combination with the required Baseline Window and, optionally, other baseline windows as specified in Section 5.1.1.1.

The SHGC for operable attachment products (except Awning) shall be calculated in both the fully open and fully closed positions, except as noted for specific product types in Section 5.2. $SHGC_{Annual}$ shall be calculated in the fully deployed position only.

The SHGC or $SHGC_{Annual}$ shall be calculated using the currently approved Lawrence Berkeley National Laboratory WINDOW and THERM software tools in accordance with:

- AERC 1.3, AERC Simulation Manual, currently adopted version.
- Default material and gas property libraries in the currently approved Lawrence Berkeley National Laboratory WINDOW and THERM software tools.
- Optical and thermophysical property data included in the latest published version of the IGDB and CGDB.
- Attachment installation details of Section 5.1.1.2.
- Environmental and boundary conditions of Section 5.1.1.3.
- Any additional requirements in Section 5.2 for the applicable product type.

Lift and control cords as well as discrete mounting hardware and operating components that do not extend along more than 50% of the full length or width of the attachment product may be ignored. This includes components such as but not limited to screws, bolts, brackets, latches, handles, clutches, cord locks, control rods, and end caps.

5.1.3.2. Test Option

For attachment products that cannot be simulated according to Section 5.1.3.1, the SHGC may be physically tested with the product installed in combination with the required Baseline Window as specified in AERC 1.2. The SHGC for operable attachment products shall be tested in both the fully open and fully closed positions, except as noted for specific product types in Section 5.2. If the SHGC is not or cannot be determined in accordance with AERC 1.2, the fenestration attachment shall be assigned a SHGC of “ND” for “not determined”.

Exception: determination of SHGC at normal solar incidence in accordance with Section 5.1.3.1 or 5.1.3.2 is not required for awnings. $SHGC_{Annual}$ cannot be evaluated using the "Test Option" at this time.

5.1.4. Visible Transmittance

5.1.4.1. Simulation procedures

The VT or VT_{Annual} shall be calculated for each individual product (as determined for the appropriate product type in Section 5.2) installed in combination with the required Baseline Window and, optionally, other baseline windows as specified in Section 5.1.1.1.

The VT for operable attachment products (except Awnings) shall be calculated in both the fully open and fully closed positions, except as noted for specific product types in Section 5.2. VT_{Annual} shall be calculated in the fully deployed position only.

The VT or VT_{Annual} shall be calculated using the currently approved Lawrence Berkeley National Laboratory WINDOW and THERM software tools in accordance with:

- AERC 1.3, AERC Simulation Manual, currently adopted version.
- Default material and gas property libraries in the currently approved Lawrence Berkeley National Laboratory WINDOW and THERM software tools.
- Optical and thermophysical property data included in the latest published version of the IGDB and CGDB.
- Attachment installation details of Section 5.1.1.2.
- Environmental and boundary conditions of Section 5.1.1.3.
- Any additional requirements in Section 5.2 for the applicable product type.

Lift and control cords as well as discrete mounting hardware and operating components that do not extend along more than 50% of the full length or width of the attachment product may be ignored. This includes components such as but not limited to screws, bolts, brackets, latches, handles, clutches, cord locks, control rods, and end caps.

5.1.4.2. Test Option

For attachment products that cannot be simulated according to Section 5.1.4.1, the VT may be physically tested with the product installed in combination with the required Baseline Window as specified in AERC 1.2. The VT for operable attachment products shall be tested in both the fully open and fully closed positions, except as noted for specific product types in Section 5.2. If the VT is not or cannot be determined in accordance with AERC 1.2, the fenestration attachment shall be assigned a VT of "ND" for "not determined".

Exception: determination of VT at normal solar incidence in accordance with Section 5.1.4.1 or 5.1.4.2 is not required for awnings. VT_{Annual} cannot be evaluated using the "Test Option" at this time.

5.1.5. Air Leakage

The air leakage of secondary windows (storm windows and window panels, and commercial secondary windows) shall be tested in accordance with the procedures of AERC 1.2. Air leakage testing for other fenestration attachment product types is optional.

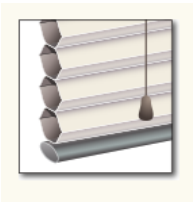
Operable attachment products shall be tested in the fully closed position.

5.2. Specific Product Types

This section contains additional details, variations, and requirements that apply to specific product types, including the definition of characteristics that distinguish individual products within each product type.

Performance properties shall be calculated in the “fully open” (or “fully retracted)” and “fully closed” (or “fully deployed)” positions in accordance with Section 5.1 as defined for each product type below. Informative Note: Determination of U, SHGC, and VT performance properties in other positions (states of deployment, slat angles, etc.) is not required by this standard, but may be required for certain product types for use in AERC 2 for calculation of EP_H and EP_C.

5.2.1. Cellular Shades



Cellular shade product lines include fenestration attachments incorporating a cellular construction made from fabric or other materials joined together to form cells that trap air.

5.2.1.1. Individual Products

Individual products for which distinct performance properties shall be determined are distinguished by differences in one or more of the following characteristics:

- Cell count (e.g. single cell, double cell, triple cell, full cell within a cell, split cell within a cell, etc.)
- Nominal cell size
- Nominal cell shape (e.g. square, hexagonal, asymmetric pentagonal, custom shape drawn in THERM, etc.)
- Cell fabric / material type, including multiple / different coatings or materials on any surface of the cell including front, back, or interior.
- Rail height and depth (head, mid, bottom, and side rails)
- Rail material (head, mid, bottom, and side rails)
- Products incorporating edge tracks or edge seals
- Cell orientation (e.g. vertical vs. horizontal)
- Interior vs. exterior use

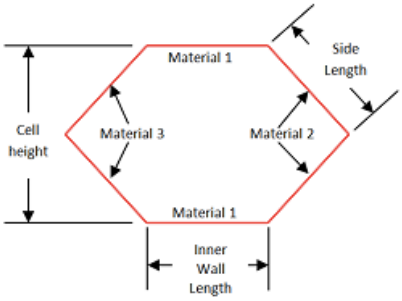
Products with different paints, colors, or finishes for head/bottom rails shall not be considered different individual products. For simulation of performance properties, a default solar absorptance of 0.3 shall be used for the head / bottom rails.

5.2.1.2. Product Grouping

Individual products may be grouped and simulations performed based on the group leader as designated below. Products are permitted to be grouped using multiple grouping rules at the same time. Individual products may be grouped that meet one or more of the following:

- Side lengths within the following ranges, provided all products within the group have the same cell fabric / material type: less than 14 mm (9/16 in), or greater than or equal to 14 mm (9/16 in).

Side length is determined as shown below:



For products combined in groups with side lengths < 14 mm (< 9/16 in), the product with the smallest side length shall be the group leader used to represent the group.

For products combined in groups with side lengths ≥ 14 mm (≥ 9/16 in), the product with the largest side length shall be the group leader used to represent the group.

- Cell materials shall be permitted to be grouped in accordance with AERC 1.1.

- Cellular shade products that meet the individual product classification rules with only a change to room-side fabric color shall be permitted to be grouped based on the emissivity and solar transmittance (Tsol) of the product's room-side fabric.

  Grouping cellular shade products in this manner shall require the following:
  - The standard CIELAB color space L*a*b* measurement for each room-side fabric shall be tested by the manufacturer.
  - The room-side fabric samples with the lightest color (highest L* value) and the darkest color (lowest L* value) shall be fully tested per AERC 1.1 to determine the emissivity and solar transmittance (Tsol) of both fabrics. Only the lightest and darkest fabric colors, based on L* values, will be fully tested and listed in the CGDB. If the street-side and room-side fabrics are the same light color, one additional test per AERC 1.1 of the darkest room-side color (lowest L* value) shall be analyzed and listed in the CGDB. If the street-side and room-side materials are the same dark color, one additional test per AERC 1.1 of the lightest room-side color (highest L* value) shall be analyzed and listed in the CGDB listed.
  - L* values for all room-side fabric colors shall be provided to the simulator to confirm proper testing was completed.

  Cellular product grouping shall be based on the emissivity of the room-side fabric. Grouping by room-side emissivity shall be categorized by an emissivity range as shown in Table 5-X below. Since the emissivities of room-side fabric

colors between the lightest and darkest fabrics will fall within the emissivities of the lightest and darkest colors, all fabric colors with L* values between the L* values of the lightest and darkest fabrics may be placed in the same group as the lightest and darkest fabrics. If the emissivities of the lightest and darkest fabrics fall within different emissivity ranges, full testing of additional fabric colors will be necessary to determine which colors may be placed into each group. Once the room-side fabrics have been placed into categories based on emissivity, the fabric with the highest emissivity in that category shall be designated as the group leader. If more than one fabric share the identical emissivity, then the group leader shall be determined by the room-side fabric with the highest Tsol.

Emissivity Category	Emissivity Range
I	$0.01 < e \leq 0.30$
II	$0.31 \leq e < 1.0$

Only the group leader based on emissivity or Tsol as outlined above will be used for simulation. Cellular products using other room-side fabric colors that satisfy the grouping rules may be listed in the CPD using the simulation results of the group leader.

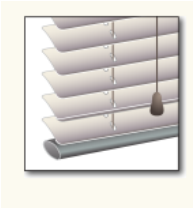
If new room-side fabric colors are added to a certified product, L* testing sshall be done on all new colors to determine whether they qualify for grouping. If they fall within the current range of L* for that certified product, products using the new room-side fabric colors may be listed in the CPD using the simulation results of the group leader. If the L* for a new color falls outside of the certified range, the manufacturer may choose to certify the new color as a single product or update the group to incorporate the new L* range and ratings, provided a new group leader is established

5.2.1.3. Product Positions and Other Rules

For cellular shades, when calculating performance properties in accordance with Section 5.1,

- “fully closed” shall mean deployed to cover the window opening to the fullest extent allowed by the attachment product design (as appropriate for the specific product: fully deployed until the attachment touches the surface of the base window, the maximum extent of the attachment hangs freely, or the attachment is in line with the base window's outermost bottom frame edge as shown in Appendix A), and
- “fully opened” shall mean retracted as far as possible to cover the window opening to the smallest extent allowed by the attachment product design.

5.2.2. Slat Shades



Slat shade product lines include fenestration attachments incorporating horizontal or vertical vanes or slats that can be both tilted and retracted. Other common terms include venetian blinds, mini-blinds, and vertical louvers. Horizontally-oriented products have vanes suspended above each other by cords, tapes, or other means. Vertically-oriented products have vanes hanging vertically adjacent to each other. Vanes may be overlapping or non-overlapping. These products are distinct from other window attachments as having two degrees of freedom in their operation (i.e., retraction and slat angle).

5.2.2.1. Individual Products

Individual products for which distinct performance properties shall be determined are distinguished by differences in one or more of the following characteristics:

- Slat width
- Slat thickness
- Slat curvature and shape (S-shape, crown shape, etc.)
- Overlapping vs. non-overlapping slats
- Slat material type, including different perforation patterns
- Multiple materials on slat front and back
- Horizontal vs. vertical vanes
- Interior vs. exterior use

Products with different paints, colors, or finishes for head/bottom rails shall not be considered different individual products. For simulation of performance properties, a default solar absorptance of 0.3 shall be used for the head / bottom rails.

5.2.2.2. Product Grouping

Individual products may be grouped and represented by a single set of performance properties determined for the group leader as designated below. Individual products may be grouped that meet one or more of the following:

- Slat width increments within 6 mm (0.25 in), provided all products within the group have the same fabric / material type, including color and perforation pattern. The product with the smallest slat width shall be the group leader used to represent the group.
- Slat thickness increments within 0.5 mm (0.02 in), provided all products within the group have the same fabric / material type, including color and perforation pattern. The product with the smallest slat thickness shall be the group leader used to represent the group.
- Slat materials that may be grouped in accordance with AERC 1.1.

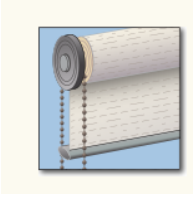
5.2.2.3. Product Positions and Other Rules

For slat shades, when calculating performance properties in accordance with Section 5.1,

- "fully closed" shall mean deployed over the window opening with the slats or vanes rotated to cover the window opening and minimize light transmittance to the fullest extent allowed by the attachment product design (as appropriate for the specific product: fully deployed until the attachment touches the surface of the base window, the maximum extent of the attachment hangs freely, or the attachment is in line with the base window's outermost bottom frame edge as shown in Appendix A), and
- "fully opened" shall mean retracted as far as possible and the slats or vanes rotated perpendicular to the plane of the window to cover the window opening to the smallest extent and maximize light transmittance to the largest extent allowed by the attachment product design.

Informative note: Determination of U, SHGC, and VT performance properties in other positions (states of deployment, slat angles, etc.) is not required by this standard, but *is* required for calculation of EP_H and EP_c in AERC 2.

5.2.3. Roller Shades



Roller shade product lines include fenestration attachments incorporating a material that may be retracted and rolled onto a cylindrical shaft.

Note: This includes exterior solar screen materials retracted and rolled onto a cylindrical shaft. Fixed solar screens are considered under section 5.2.6.

5.2.3.1. Individual Products

Individual products for which distinct performance properties shall be determined are distinguished by differences in one or more of the following characteristics:

- Shade material type
- Multiple materials on shade front and back, inclusive of low-e or metallized coatings
- Products incorporating fascia/cover boxes, edge tracks/side rails/edge seals/gaskets, and hem bars
- Interior vs. exterior use

Products with different paints, colors, or finishes for fascia/cover boxes, edge tracks/ side rails/ edge seals/ gaskets, and hem bars shall not be considered different individual products. For simulation of performance properties, a default solar absorptance of 0.3 shall be used for fascia/cover boxes, edge tracks/side rails/edge seals/gaskets, and hem bars. For insulating products, such as operable Insulating

Quilts, the default polymer thermal conductivity is used unless performance is measured, per AERC 1.1.

For exterior roller shades mounted outside the window recess and not overlapping the window glazing in the fully opened position, products fascia/cover boxes, edge tracks/side rails/edge seals/gaskets, and hem bars may be ignored, and shall not be considered different individual products.

5.2.3.2. Product Grouping

Individual products may be grouped and represented by a single set of performance properties determined for the group leader as designated below. Individual products may be grouped that meet one or more of the following:

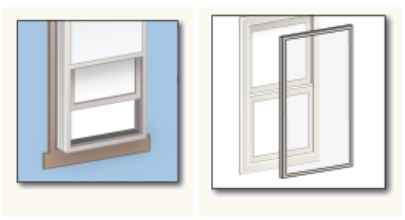
- Shade materials that may be grouped in accordance with AERC 1.1.
- For exterior roller shades only: different size fascia/cover boxes, edge tracks/side rails, and/or hem bars that are not permitted to be ignored in accordance with Section 5.2.3.1 may be grouped. A product configuration simulated with the smallest fascia/cover box size, smallest edge track/side rail/edge seal/gasket width, and smallest hem bar height shall be the group leader used to represent the group.
- For interior roller shades only: different size fascia/cover boxes, edge tracks/side rails, and/or hem bars may be grouped. Products within a range of 2.5 EP_c and 2.5 EP_H may be grouped, and the product with the lowest EP_H shall be the group leader.

5.2.3.3. Product Positions and Other Rules

For roller shades, when calculating performance properties in accordance with Section 5.1,

- “fully closed” shall mean deployed to cover the window opening to the fullest extent allowed by the attachment product design (as appropriate for the specific product: fully deployed until the attachment touches the surface of the base window, the maximum extent of the attachment hangs freely, or the attachment is in line with the base window's outermost bottom frame edge as shown in Appendix A), and
- “fully opened” shall mean retracted as far as possible to cover the window opening to the smallest extent allowed by the attachment product design.

5.2.4. Secondary Windows



Secondary window product lines include fenestration attachments incorporating a solid material that is mounted (usually in a frame) coplanar over existing fenestration. Products may be fixed or operable, and may be mounted to the interior or exterior of the existing window.

Secondary windows are divided into two product subcategories:

- **Storm Windows and Window Panels**
- **Commercial Secondary Windows**

Commercial secondary windows are differentiated from storm windows and window panels in that they are primarily intended for commercial versus low-rise residential applications.

The product subcategory shall be declared for each secondary window product line. A product line may also be rated and listed separately under both subcategories.

As specified in Section 5.1.1.1, each product subcategory uses a different required baseline window:

- For **Storm Windows and Window Panels,** the U-factor, SHGC, and VT are required to be determined in combination with Baseline Window B, and optional in combination with other baseline windows.
- For **Commercial Secondary Windows,** the U-factor, SHGC, and VT are required to be determined in combination with Baseline Window D, and optional in combination with Baseline Window B and other baseline windows. EP_H and EP_c ratings determined in accordance with AERC 2 are not applicable.

5.2.4.1. Individual Products

Individual products for which distinct performance properties shall be determined are distinguished by differences in one or more of the following characteristics:

- Glazing material type (glass, polymeric)
- Glazing coatings, films, tints
- Glazing thickness
- Number of glazing layers
- Fixed vs. operable configurations (single hung, double hung, other)
- Frame material types
- Frame profiles
- Spacer material or profile
- Interior vs. exterior use

Products with different paints, colors, or finishes for frames / sashes shall not be considered different individual products. For simulation of performance properties, a default solar absorptance of 0.3 shall be used for the frame / sash.

5.2.4.2. Product Grouping

Individual products may be grouped and represented by a single set of performance properties determined for the group leader as designated below. Individual products may be grouped that include:

- Non-tinted glazing thickness increments within the following ranges, provided all glazing for products within the group has the same surface applied coating or film (or none):
  ≤ 3.2 mm (≤ 1/8 in)
  > 3.2 to ≤ 13 mm (> 1/8– ≤ 1/2 in)
  > 13 mm (> 1/2 in)
  Within each range, the product with the largest thickness shall be the group leader used to represent the group.
- Translucent obscure glazing may be grouped with the same clear substrate glazing as long as the surface emissivity does not change. The product with the clear substrate glazing shall be the group leader used to represent the group.

5.2.4.3. Product Positions and Other Rules

For operable secondary windows, performance properties shall be calculated in the fully closed position.

As specified in Appendix A, for operable horizontal sliding products, the aspect ratio of the standardized baseline windows in Appendix A shall be reversed (1500 mm width x 1200 mm height, in place of 1200 mm width x 1500 mm height).

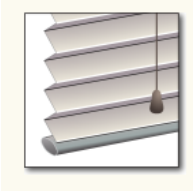
A horizontal sliding product may be grouped with the corresponding vertical sliding product provided each performance property (U, SHGC, VT, AL) does not vary more than 10%. The performance properties of the product with the higher U-factor shall be used to represent the group.

Insect screens may be omitted when determining performance properties for storm windows and window panels.

For exterior secondary windows to be rated as installed within the window recess (inside mount), any reductions in product width/height inside the opening shall be 3 mm (half on each side).

For interior secondary windows to be rated as installed within the window recess (inside mount), the secondary window and its associated seals shall fill the opening.

5.2.5. Pleated Shades



Pleated shade product lines include fenestration attachments incorporating a single layer of a pleated material.

5.2.5.1. Individual Products

Individual products for which distinct performance properties shall be determined are distinguished by differences in one or more of the following characteristics:

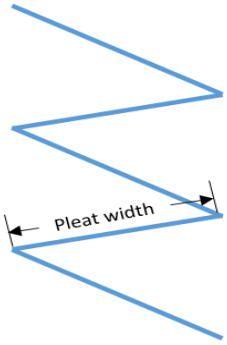
- Pleat width
- Shade material type
- With added liner
- Multiple materials on shade front and back
- Products incorporating edge tracks or edge seals
- Horizontal vs. vertical operation
- Interior vs. exterior use

Products with different paints, colors, or finishes for head/bottom rails shall not be considered different individual products. For simulation of performance properties, a default solar absorptance of 0.3 shall be used for the head / bottom rails.

5.2.5.2. Product Grouping

Individual products may be grouped and represented by a single set of performance properties determined for the group leader as designated below. Individual products may be grouped that meet one or more of the following:

- Pleat widths within 6 mm (0.25 in), provided all products within the group have the same fabric / material type, including color and perforation pattern. The product with the smallest pleat width shall be the group leader used to represent the group.
  Pleat width is defined as the distance between fold creases as shown below:



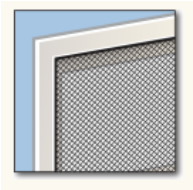
- Shade materials that may be grouped in accordance with AERC 1.1.

5.2.5.3. Product Positions and Other Rules

For pleated shades, when calculating performance properties in accordance with Section 5.1,

- “fully closed” shall mean deployed to cover the window opening to the fullest extent allowed by the attachment product design (as appropriate for the specific product: fully deployed until the attachment touches the surface of the base window, the maximum extent of the attachment hangs freely, or the attachment is in line with the base window's outermost bottom frame edge as shown in Appendix A), and
- “fully opened” shall mean retracted as far as possible to cover the window opening to the smallest extent allowed by the attachment product design.

5.2.6. Solar Screens



Solar screen product lines include fenestration attachments incorporating a screen material that is mounted (usually fixed in a frame) coplanar over existing fenestration.

Note: exterior solar screen materials retracted and rolled onto a cylindrical shaft shall be considered roller shade products. Exterior solar screen materials that are pleated to fold when the operating rail is moved shall be considered pleated shade products. See sections 5.2.3 and 5.2.5.

5.2.6.1. Individual Products

Individual products for which distinct performance properties shall be determined are distinguished by differences in one or more of the following characteristics:

- Screen material type
- Screen material opacity / openness
- Number of screen layers
- Frame material types
- Frame profiles

Products with different paints, colors, or finishes for frames / sashes shall not be considered different individual products. For simulation of performance properties, a default solar absorptance of 0.3 shall be used for the frame / sash. For insulating products, such as fixed Insulating Quilts, the default polymer thermal conductivity is used unless performance is measured, per AERC 1.1.

5.2.6.2. Product Grouping

Individual products may be grouped and represented by a single set of performance properties determined for the group leader as designated below. Individual products may be grouped that include:

- Screen materials that may be grouped in accordance with AERC 1.1.

5.2.6.3. Product Positions and Other Rules

For solar screens in sliding panels, performance properties shall be calculated in the fully closed position.

5.2.7. Surface Applied Films

Surface applied film product lines include fenestration attachments incorporating a polymeric film adhered directly to the glazing in existing fenestration.

5.2.7.1. Individual Products

Individual products for which distinct performance properties shall be determined are distinguished by differences in one or more of the following characteristics:

- Film material type (including different coatings, tints, multilayer compositions)
- Film thickness
- Interior vs. exterior use

5.2.7.2. Product Grouping

Individual products may be grouped and represented by a single set of performance properties determined for the group leader as designated below. Individual products may be grouped that include:

- Film materials that may be grouped in accordance with AERC 1.1.

5.2.7.3. Product Positions and Other Rules

For surface applied films, performance properties in Section 5.1 shall be calculated only in the as-applied position with the film covering the entire glazing area.

5.2.8. Exterior Roller Shutters

Exterior Roller shutter products are fenestration attachments mounted on the outdoor side of windows and incorporating individual hinged slats enabling the product to be retracted by rolling the slats onto a cylindrical shaft housed at the top.

5.2.8.1. Individual Products

Individual products for which distinct performance properties shall be determined are distinguished by differences in one or more of the following characteristics:

- Slat material type. Including different wall material, foam filling of slat cavities, color, and finish. Examples of wall materials are Aluminum Alloys, Steel, and PVC.

- Multiple materials on slats
- Perforation patterns
- Slat geometry/form

Products with different paints, colors, or finishes for shutter housing, bottom rails, and side rails shall not be considered different individual products. For simulation of performance properties, a default solar absorptance of 0.3 shall be used for these components only.

For exterior roller shutters not overlapping the window at normal incidence in the fully opened position, shutter housing, bottom rails, and side rails may be ignored for the purposes of modeling and simulation, and shall not be considered different individual products.

5.2.8.2. Product Grouping

Individual products may be grouped and represented by a single set of performance properties determined for the group leader as designated below. Individual products may be grouped that include:

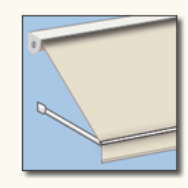
- Metal exterior roller shutters (i.e., Aluminum Alloys, Steel, etc.), regardless of the construction of slats (e.g., single wall, double wall, insulated, non-insulated, different geometry) and having same outdoor-facing color, may be represented by a single-wall product. If a single-wall product is not produced, then a double-wall product may be used.
- Roller shutters with different size perforations in the hinge joint may be grouped. The product with largest perforation shall be the group leader.
- Slat materials that may be grouped in accordance with AERC 1.1.

5.2.8.3. Product Positions and Other Rules

For roller shutters, when calculating performance properties in accordance with Section 5.1,

- “fully closed” shall mean deployed to cover the window opening to the fullest extent allowed by the attachment product design, and with any light slits in the closed position.
- “fully opened” shall mean retracted as far as possible to cover the window opening to the smallest extent allowed by the attachment product design, and with any light slits in the open position.

5.2.9. Awnings



Awning product lines include fenestration attachments mounted above existing fenestration and projecting out from the plane of the existing fenestration to provide shading. This section does not cover shading from overhangs, balconies, light shelves, or complex shape awnings where the main shading surface has more than one plane of fabric (e.g. dome, curved, or multipanel in different planes, not including side covers or valences).

Note: The determination of energy performance of awnings and other projecting shading products is different than for fenestration attachment products that are coplanar with the baseline window. When mounted above the baseline window opening, projecting products have negligible effect on U-factor and AL; additionally, SHGC and VT calculated at normal incidence do not fully account for shading from projections, which is sensitive to the actual solar angle and building geometry. The primary metrics related to energy performance for awnings are not U-factor, normal incidence SHGC, normal incidence VT, and AL, and therefore, Section 5.1 specifies that determination of these properties is not required for awnings. Instead, the relevant metrics for awnings include the equivalent $SHGC_{Annual}$ and VT_{Annual} for awnings accounting for shading geometry determined in accordance with Section 5.2.8.4, and the annual energy performance ratings determined in accordance with AERC 2 (e.g. EP_c).

This section provides additional details and requirements to standardize product geometry, as well as the definition of characteristics that distinguish individual products.

5.2.9.1. Individual Products

Individual products for which distinct performance properties shall be determined are distinguished by differences in one or more of the following characteristics:

- Shading fabric / material type, including different front and back surfaces
- Standard operating schedules (see Operating Schedule page in Appendix C)
- Awnings with different geometries (see Section 5.2.9.3)

Side covers and front valances shall not be included in simulation of performance properties, and variations in side covers and front valances shall not be considered different individual products.

Product fascia/cover boxes, edge tracks/side rails/edge seals/gaskets, hem bars, frames, hardware components, and side arms may be ignored, and shall not be considered when identifying different individual products.

5.2.9.2. Product Grouping

Individual products may be grouped and represented by a single set of performance properties determined for the group leader as designated below. Individual products may be grouped that include:

- Shading fabric / materials that may be grouped in accordance with AERC 1.1.

5.2.9.3. Product Positions and Other Rules

The geometry of awnings and projecting shading products shall be sized to Baseline Window B and standardized in accordance with geometries in Figure 5-2 and Table 5-2. Awnings shall be assigned the geometry or geometries with the deployment angle(s) closest to the product design and utilization of the operating schedule periods. This assignment must be verified during certification.

For fixed awnings:

- Performance properties for fixed awnings using a single geometry from Figure 5-2).

For operable awnings:

- $SHGC_{Annual}$ and VT_{Annual} for operable awnings shall be determined in accordance with Section 5.2.8.4 in the fully deployed position in a south-facing installation at a latitude of 40°.
- Calculation of EP will require multiple positions (fully retracted, midpoint deployed) to be modeled for use in AERC 2.

For awnings, when calculating performance properties,

- "fully deployed" shall mean deployed to cover the window opening to the fullest extent allowed by the attachment product design, as defined in Figure 5-2, and
- "fully retracted" shall mean retracted as far as possible to cover the window opening to the smallest extent allowed by the attachment product design.

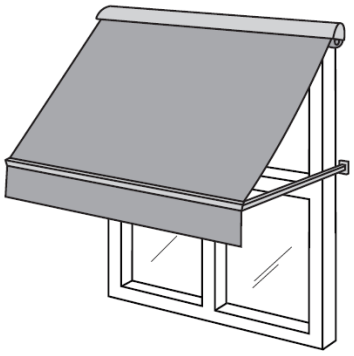
Figure 5-2: Awning Geometry and Positions

Note: Operable awnings may choose either Geometry Set 1 (1A+1B) or Geometry Set 2 (2A +2B) for simulation, while fixed awnings may choose 1A, 1B, 2A, or 2B, based on the construction of the awning. Geometries 1A and 2A represent the fully deployed position, and geometries 1B and 2B represent the mid-point deployed position. The length of the fabric will be different for the fully deployed and mid-point deployed positions.

	Geometry Set 1 (1A+1B)	Geometry Set 2 (2A+2B)

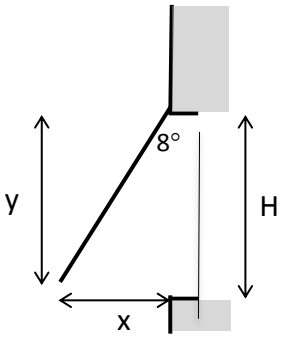
	Typical Operable Drop-arm Window Awnings Fully deployed (1A) and midpoint deployed (1B)		Typical Operable Folding-arm Window Awnings Fully deployed (2A) and midpoint deployed (2B)	
Fixed awnings might have any one of these four geometries.				
	Position 1A	Position 1B	Position 2A	Position 2B
Angle α	8°	45°	85°	85°
Cover length L	1500 mm	1060 mm	1506 mm	753 mm
Projection x-axis	0.14 x H	0.50 x H	1.00 x H	0.50 x H
Projection Drop y-axis	0.99 x H	0.50 x H	0.087 x H	0.043 x H
Fabric width	1.00 x W	1.00 x W	1.00 x W	1.00 x W
H = window recess height (1500 mm) W = window recess width (1200 mm)				

Operable Drop-arm Awning – Geometry Set 1 (1A+1B)



Geometry Set 1

Geometry 1A



Side view

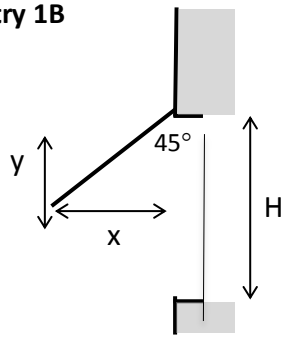
H = 1500 mm

W = 1200 mm

x = 0.14 H

y = 0.99 H

Geometry 1B



Side view

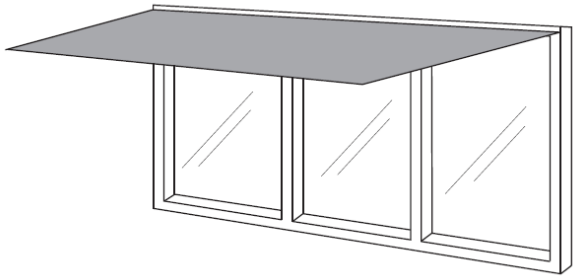
H = 1500 mm

W = 1200 mm

x = 0.5 H

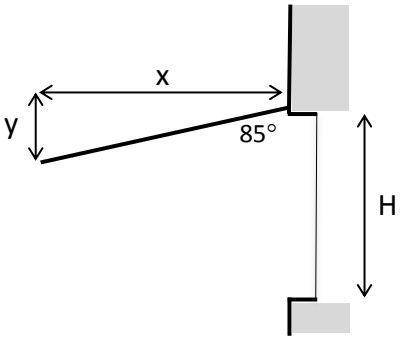
y = 0.5 H

Operable Folding-arm Awning – Geometry Set 2 (2A+2B)



Geometry Set 2

Geometry 2A



Side view

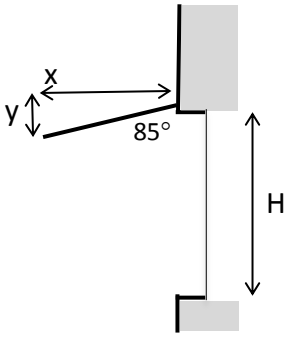
H = 1500 mm

W = 1200 mm

x = H

y = 0.087 H

Geometry 2B



Side view

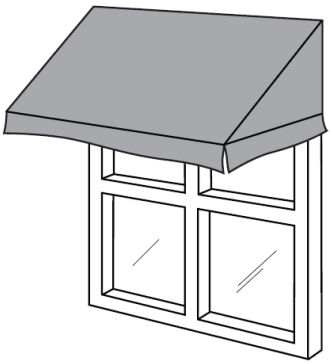
H = 1500 mm

W = 1200 mm

x = H/2

y = 0.043 H

Fixed Awning (Geometry A1, 1B, 2A, or 2B)



5.2.9.4. $SHGC_{Annual}$ and VT_{Annual} for Awnings

SHGC and VT shall not be calculated at normal incidence. Instead, the alternate metrics $SHGC_{Annual}$ and VT_{Annual} for awnings shall be calculated in accordance with Appendix C. $SHGC_{Annual}$ and VT_{Annual} are aggregated metrics that include the effects of shading across different times of day and year as a result of solar positions.

5.3. Dynamic Operation

For attachment products that can be operated such as raising, lowering, opening, or closing blinds and shades, Sections 5.1 and 5.2 determine the U-factor, SHGC, and VT under a specific set of environmental conditions and pre-specified positions: when the attachment is fully open/retracted and fully closed/deployed. These products may also be manually operated or automatically operated (automated) in different positions in a dynamic manner in response to environmental conditions, date and time, user commands, or other programming. This dynamic operation is not included in this standard – see AERC 2, which addresses annual energy performance ratings of fenestration attachment products.

6. Reporting

The following information shall be reported:

- Product manufacturer
- Product type, identification, drawings, and materials
- Simulation and/or testing laboratory
- Date of report
- For each applicable baseline window (required baseline window and any other optional baseline windows as specified in Section 5.1.1.1):
    - U-factor, SHGC, and VT with the attachment product in the fully closed position as defined in Section 5.2.

    - U-factor, SHGC, and VT with the attachment product in the fully open position as defined in Section 5.2. (Not required for secondary windows, awnings and solar screens.)
- Air leakage in the fully closed position, when tested in accordance with Section 5.1.5. (Not required for all product types.)
- Products grouped in accordance with Section 5.2, if applicable.
- Any other information required for inclusion in the certified product database in accordance with AERC 100 and AERC 400 Appendix G (Approved Software and Manuals).

Calculated U-factor, SHGC, and VT shall be determined with the full precision in the approved software prior to rounding and reporting of final results.

U-factor shall be rounded and reported to the nearest 0.05 W/m^2K (0.01 $Btu/hr \cdot ft^{2} \cdot °F$).

SHGC and VT shall be rounded and reported to two digits.

Tested air leakage shall be rounded and reported to the nearest 0.1 $L/s/m^2$ (0.02 cfm/ft^2).

All unit conversions and rounding shall be in accordance with IEEE/ASTM SI 10-2010.

Appendix A - Baseline Windows

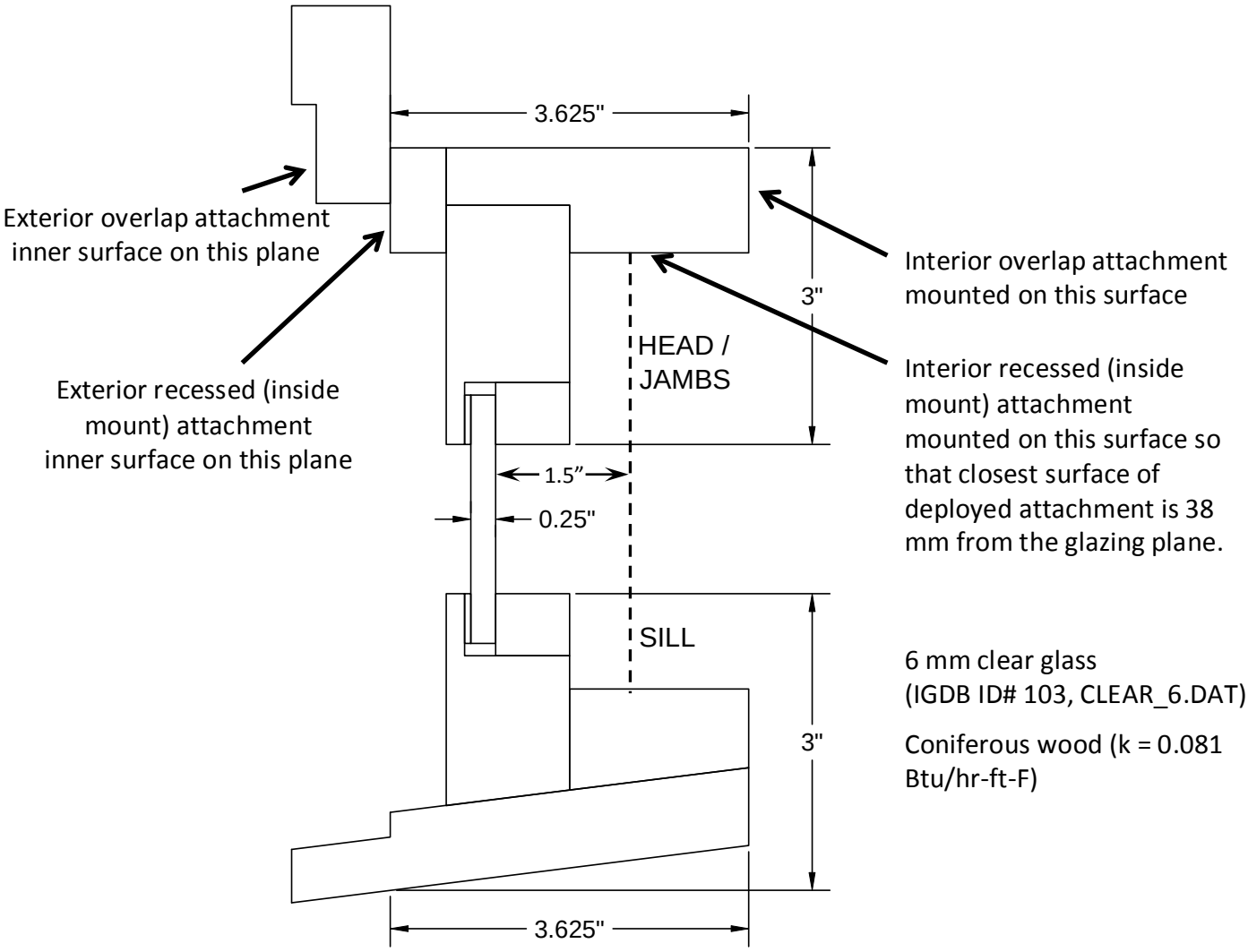
Note: Official THERM files of these windows may be downloaded from www.aercnet.org. Exact dimensions of the baseline windows are included in the THERM files.

See Section 5.1.1.2 for further details on attachment installation. Where installation according to these dimensions is precluded by physical constraints, the mounting distance between the attachment product and the glazing plane may be modified to accommodate the attachment product, extending the head / jambs / sills if necessary. Any variations in these dimensions shall be recorded.

Baseline Window A – Nonmetal-framed, single pane

The performance of attachments over all nonmetal-framed windows with single pane glazing shall be represented by the following generic wood fixed window.

Size: 1200 mm width x 1500 mm height (exception: 1500 mm width x 1200 mm height for use with horizontal sliding storm windows and window panels)



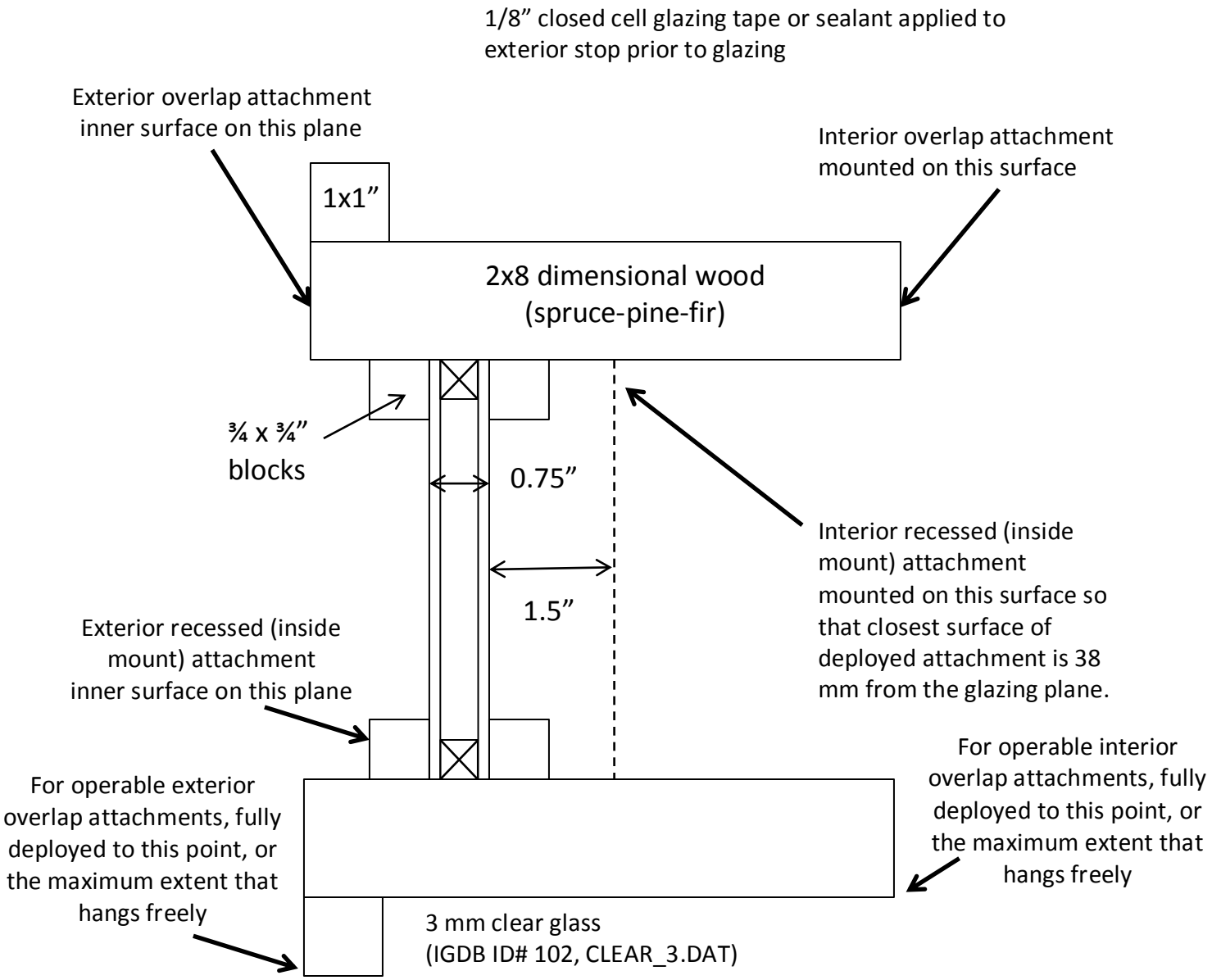
GENERIC WOOD FIXED WINDOW

Single Glazed

Baseline Window B – Nonmetal-framed, double pane

The performance of attachments over all nonmetal-framed windows with double pane glazing (without low-E glass) shall be represented by the following generic wood fixed window.

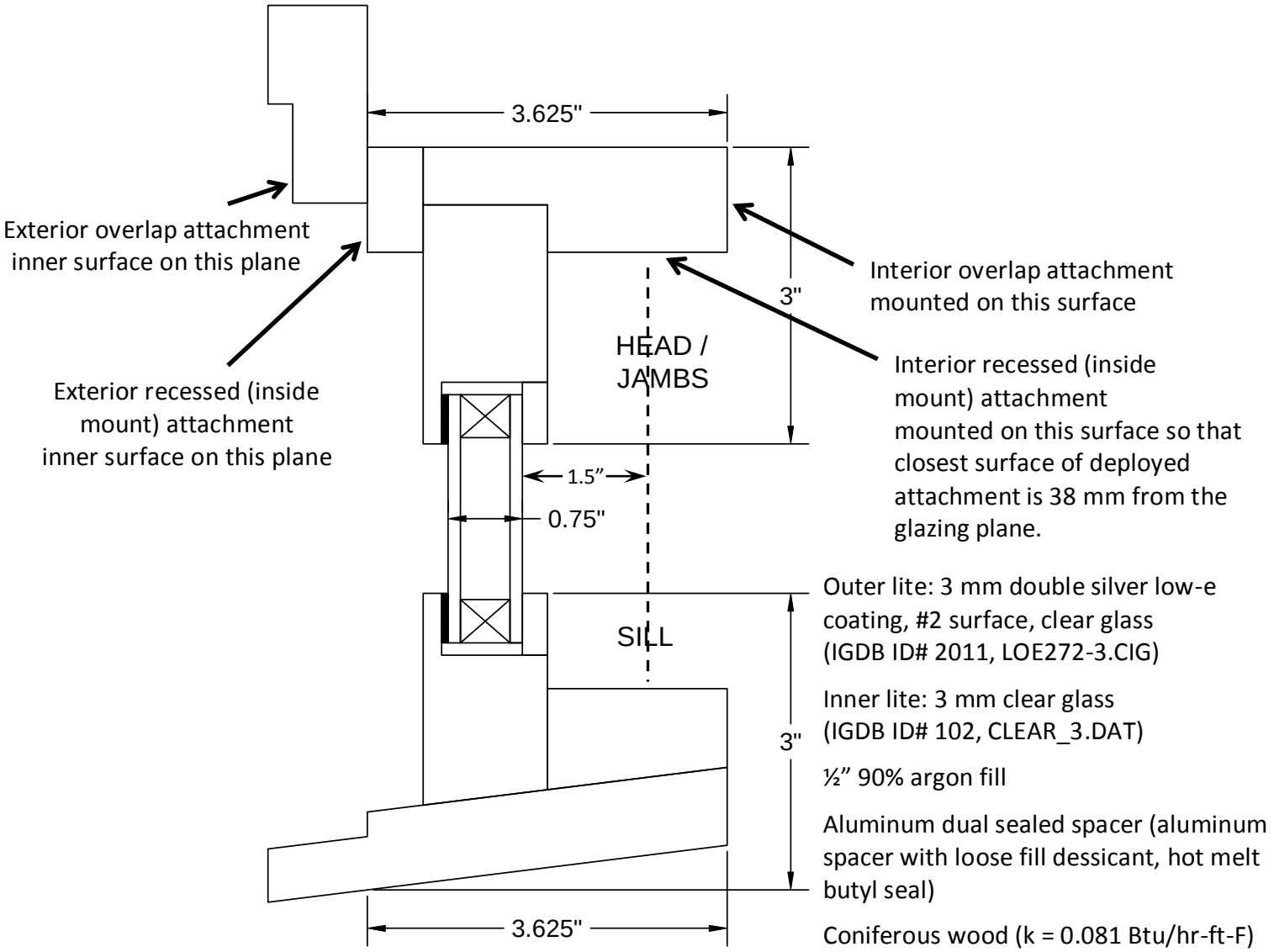
Size: 1200 mm width x 1500 mm height (exception: 1500 mm width x 1200 mm height for use with horizontal sliding storm windows and window panels)



Baseline Window C – Nonmetal-framed, double pane low-E

The performance of attachments over all nonmetal-framed windows with double pane low-E glazing shall be represented by the following generic wood fixed window.

Size: 1200 mm width x 1500 mm height (exception: 1500 mm width x 1200 mm height for use with horizontal sliding storm windows and window panels)



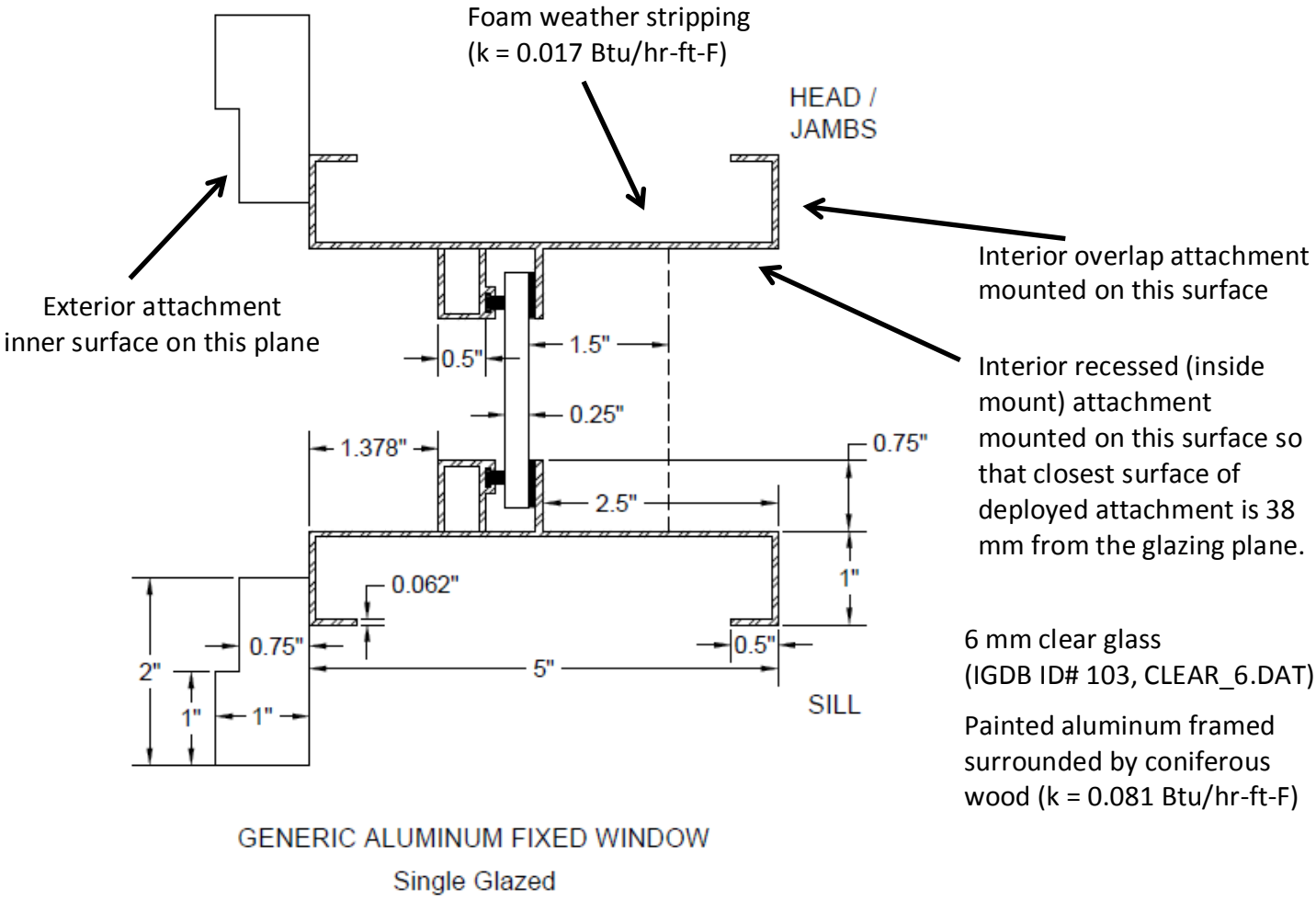
GENERIC WOOD FIXED WINDOW

Dual Glazed

Baseline Window D – Metal-framed, single pane

The performance of attachments over all metal-framed windows with single pane glazing shall be represented by the following generic aluminum fixed window.

Size: 1200 mm width x 1500 mm height (exception: 1500 mm width x 1200 mm height for use with horizontal sliding storm windows and window panels)



GENERIC ALUMINUM FIXED WINDOW

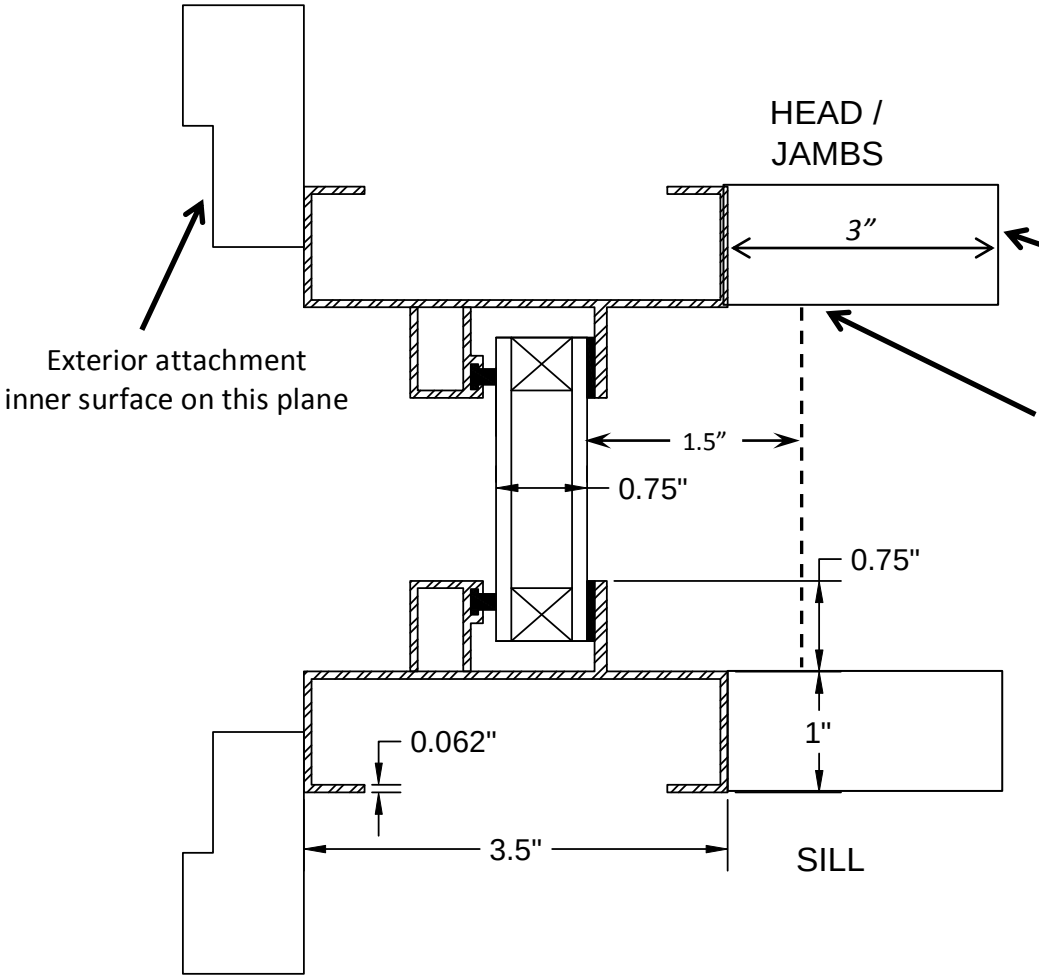
Single Glazed

Note: for attachment products with metal framing / rails, this assumes no direct contact between attachment and baseline window frame.

Baseline Window E – Metal-framed, double pane

The performance of attachments over all metal-framed windows with double pane glazing (without low-E glass) shall be represented by the following generic aluminum fixed window.

Size: 1200 mm width x 1500 mm height (exception: 1500 mm width x 1200 mm height for use with horizontal sliding storm windows and window panels)



3 mm clear glass
(IGDB ID# 102, CLEAR_3.DAT)

½” air fill

Aluminum dual sealed spacer
(aluminum spacer with loose fill dessicant, hot melt butyl seal)

Painted aluminum framed surrounded by coniferous wood
(k = 0.081 Btu/hr-ft-F)

GENERIC ALUMINUM FIXED WINDOW

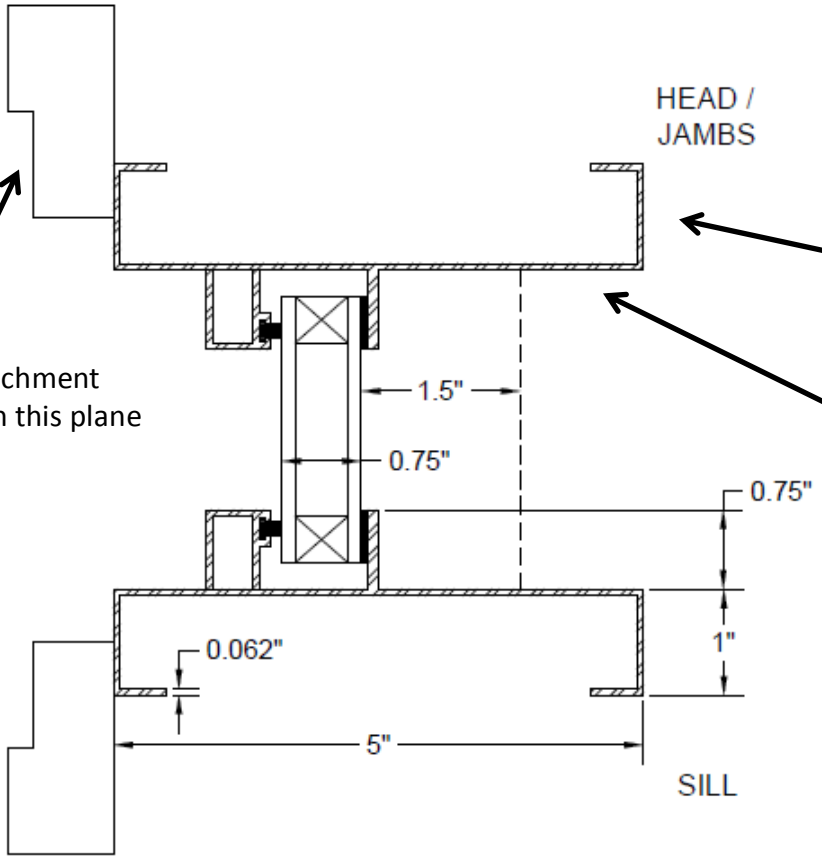
Dual Glazed

Note: for attachment products with metal framing / rails, this assumes no direct contact between attachment and baseline window frame.

Baseline Window F – Metal-framed, double pane low-E

The performance of attachments over all metal-framed windows with double pane low-E glazing shall be represented by the following generic aluminum fixed window.

Size: 1200 mm width x 1500 mm height (exception: 1500 mm width x 1200 mm height for use with horizontal sliding storm windows and window panels)



GENERIC ALUMINUM FIXED WINDOW

Dual Glazed

Outer lite: 3 mm double silver low-e coating, #2 surface, clear glass (IGDB ID# 2011, LOE272-3.CIG)

Inner lite: 3 mm clear glass (IGDB ID# 102, CLEAR_3.DAT)

½" 90% argon fill

Aluminum dual sealed spacer (aluminum spacer with loose fill dessicant, hot melt butyl seal)

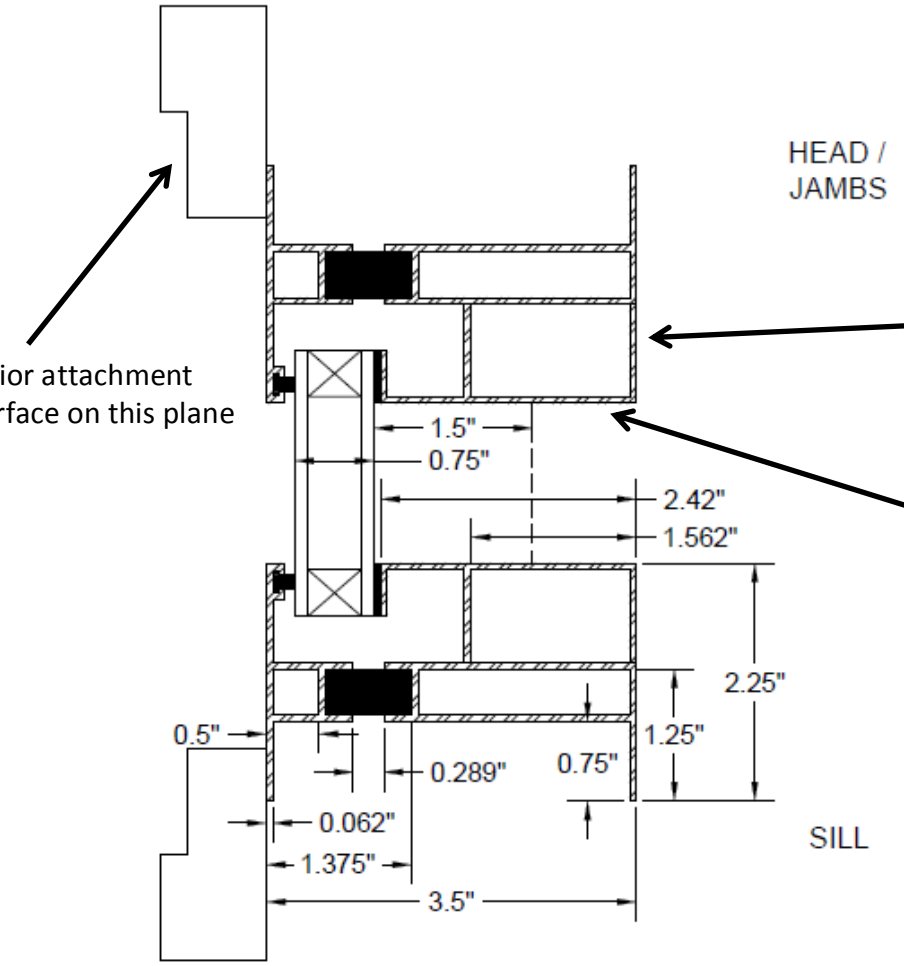
Painted aluminum framed surrounded by coniferous wood (k = 0.081 Btu/hr-ft-F)

Note: for attachment products with metal framing / rails, this assumes no direct contact between attachment and baseline window frame.

Baseline Window G – Metal-framed, double pane, thermally broken

The performance of attachments over all thermally broken metal-framed windows with double pane glazing (without low-E glass) shall be represented by the following generic aluminum fixed window.

Size: 1200 mm width x 1500 mm height (exception: 1500 mm width x 1200 mm height for use with horizontal sliding storm windows and window panels)



GENERIC ALUMINUM THERMALLY BROKEN FIXED WINDOW

Dual Glazed

3 mm clear glass (IGDB ID# 102, CLEAR_3.DAT)

½" air fill

Aluminum dual sealed spacer (aluminum spacer with loose fill dessicant, hot melt butyl seal)

Painted aluminum framed surrounded by coniferous wood (k = 0.081 Btu/hr-ft-F)

Note: for attachment products with metal framing / rails, this assumes no direct contact between attachment and baseline window frame.

Appendix B – Determination of Properties with Custom Baseline Windows (Non-Mandatory)

For fenestration attachments installed in combination with windows, skylights, or doors that differ from the baseline windows specified in Appendix A, the energy performance properties (U-factor, SHGC, VT, AL) may be determined in accordance with this Appendix. Custom baseline windows, skylights, and doors may differ in size, slope, configuration, and/or components from those in Appendix A.

Fenestration attachments over nonstandard baseline windows shall not be labeled for annual energy performance ratings in accordance with AERC 2 and AERC 100.

B.1 Simulation procedures

U-factor, SHGC, and VT shall be calculated in the fully open and fully closed positions, except as noted for specific product types in Section 5.2.

The U-factor, SHGC, and VT shall be calculated using the currently approved Lawrence Berkeley National Laboratory WINDOW and THERM software tools in accordance with:

- AERC 1.3, AERC Simulation Manual, 2017.
- Default material and gas property libraries in the currently approved Lawrence Berkeley National Laboratory WINDOW and THERM software tools.
- Optical and thermophysical property data included in the latest published version of the IGDB and CGDB.
- Environmental and boundary conditions of Section 5.1.1.3.
- Any additional requirements in Section 5.2 for the applicable product type.

Attachment installation shall be based on Section 5.1.1.2 except as required for installation over the custom baseline window, skylight, or door. Any variations from Section 5.1.1.2 shall be recorded.

Lift and control cords as well as discrete mounting hardware and operating components that do not extend along more than 50% of the full length or width of the attachment product may be ignored. This includes components such as but not limited to screws, bolts, brackets, latches, handles, clutches, cord locks, control rods, and end caps.

B.2 Test Option

For attachment products that cannot be simulated according to Section B.1, the U-factor, SHGC, and/or VT may be physically tested in accordance with AERC 1.2 using the custom baseline window in place of Baseline Window B. Air leakage (AL) is not simulated, and may optionally be physically tested in accordance with AERC 1.2.

B.3 Reporting

Reporting shall be in accordance with Section 6 except for the fenestration attachment installed in combination with the custom baseline window, skylight, or door.

All detailed dimensions, slope, glazing type, and component material listings shall be provided for the custom baseline window, skylight, or door. Any attachment installation details that vary from Section 5.1.1.2 shall be reported.

Any simulation or test report shall include the statement: “Performance properties are determined in accordance with AERC 1 Appendix B for the fenestration attachment installed in combination with the specified non-standard baseline window, skylight, or door. Performance properties installed in combination with other baseline windows, skylights, or doors will vary.”

Appendix C – Modeling Procedure for Window Awnings

(Reproduced from *"Modeling Procedure for Window Awnings",* Lawrence Berkeley National Laboratory, Berkeley CA, 2020.)

BERKELEY LAB
ENVIRONMENTAL ENERGY
TECHNOLOGIES DIVISION

Modeling Procedure for Window Awnings

Lawrence Berkeley National Laboratory
Environmental Energy and Technology Division
Windows and Daylighting Group
Berkeley, California

Charlie Curcija, Simon Vidanovic, Taoning Wang, Robin Mitchell with contributions from the AERC Technical Committee

September 22, 2020

ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY
ONE CYCLOTRON ROAD | BERKELEY, CALIFORNIA 94720 | TEL: 510.486.5001 | FAX: 510.486.7290

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INTRODUCTION

Awnings are special types of shading systems that are projecting from the window, rather than being co-planar with the glazing surface. This required different approach from other co-planar shading systems, so that calculated SHGC (Solar Heat Gain Coefficient) and VT (Visible Transmittance) are based on the blend of typical sun angles, rather than standard normal incidence and they will be labeled $SHGC_{ANNUAL}$ and VT_{ANNUAL}. The set of angles used for awnings is based on prior work for tubular daylighting devices, where normal incidence also do not represent good reference. $SHGC_{ANNUAL}$ and VT_{ANNUAL} are intended to be used as a indices of performance for awnings as a direct comparison to the normal incidence SHGC and VT, in the same manner that they are used for tubular daylighting devices. In this document, $SHGC_{ANNUAL}$ and VT_{ANNUAL} will be interchangeably used with SHGC and VT, representing the same quantity.

DETERMINATION OF $SHGC_{ANNUAL}$ AND VT_{ANNUAL}

$SHGC_{ANNUAL}$ and VT_{ANNUAL} in case of awnings will be calculated as an average over multiple angles of incidence, based on the set of solar angles, developed earlier for tubular daylighting devices (Goudey et al. 2012, McCluney and duPont 2010), shown in Table 1. Solar-Surface angle definitions are shown in Figure 1 (ASHRAE 2017).

Table 1. *Set of angles and time-constants for tubular daylighting devices (TDD)*

			Solar Azimuth (φ)		
Solar Altitude (β)	range applied		=0 to <15	=15 to <45	=45 to <75
	Angle	Middle point	0	30	60
	=15 to <25	20	0.000	0.106	0.084
	=25 to <35	30	0.074	0.097	0.072
	=35 to <45	40	0.034	0.064	0.068
	=45 to <55	50	0.026	0.053	0.078
	=55 to <65	60	0.023	0.051	0.074
	=65 to <75	70	0.029	0.055	0.012

Solar altitude angle is measured from the horizontal plane (ground) and is equal to 0° for Sun at the horizon (parallel to the ground) and is equal to 90° for the Sun directly above.

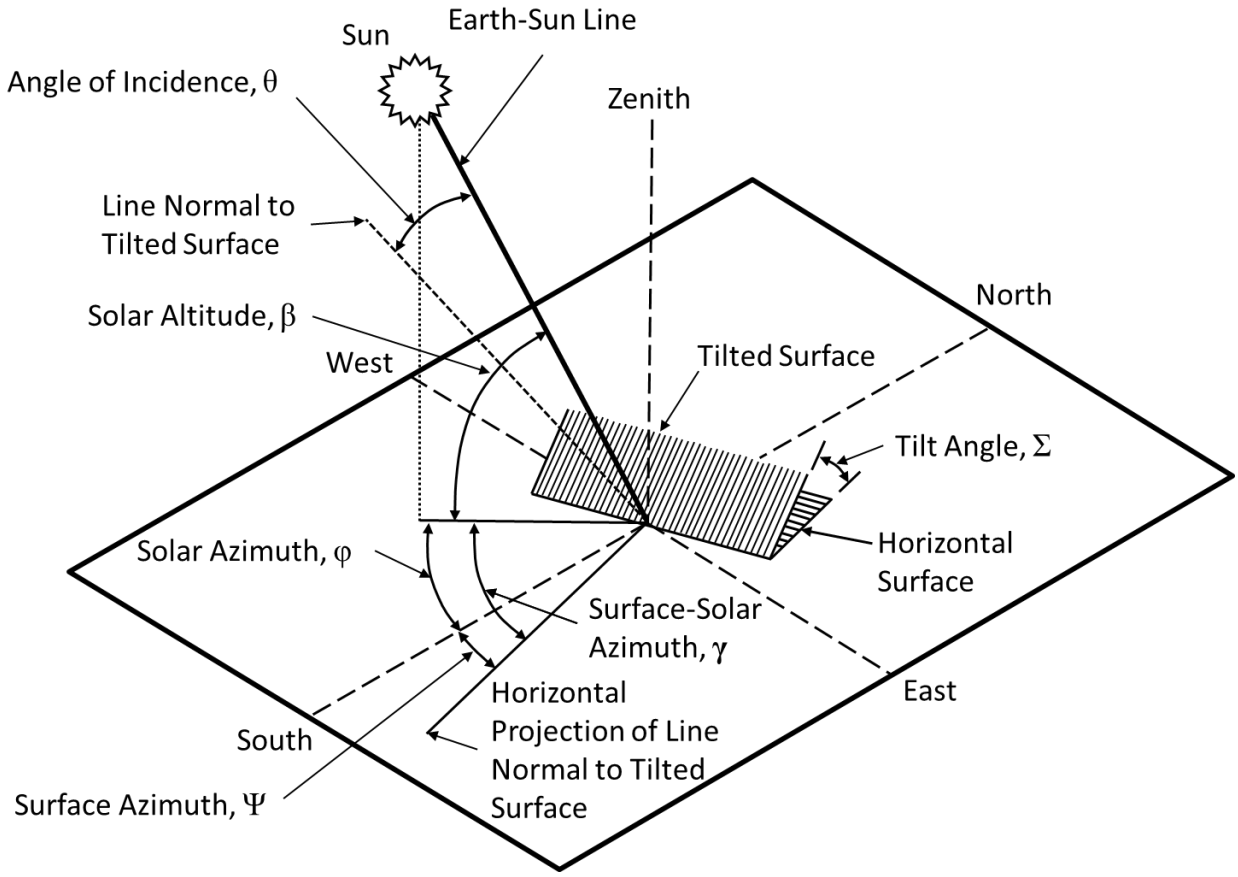


Figure 1: *Solar-Surface Angle Definitions*

Sum of all time-constants from the above table add to 1.000. Based on these and considering that there may not be symmetry in terms of Azimuth, the following table (Table 2) of sun angles and time constants is developed for awnings that includes both East and West Solar positions

Table 2. *Time-constants (W_i) for the set of angles for awnings*

			Azimuth (φ)				
Altitude (β)	range applied		75 > φ ≤ 45	45 > φ ≤ 15	15 > φ ≤ -15	-15 > φ ≤ -45	-45 > φ ≤ -75
	Angle	Middle point	60	30	0	-30	-60
	25 > β ≤ 15	20	0.042	0.053	0	0.053	0.042
	35 > β ≤ 25	30	0.036	0.0485	0.074	0.0485	0.036
	45 > β ≤ 35	40	0.034	0.032	0.034	0.032	0.034
	55 > β ≤ 45	50	0.039	0.0265	0.026	0.0265	0.039
	65 > β ≤ 55	60	0.037	0.0255	0.023	0.0255	0.037
	75 > β ≤ 65	70	0.006	0.0275	0.029	0.0275	0.006

The sum of all of time constants, W_i is still 1.000.

Optical calculations are done using BSDF (Bi-Directional Scattering Distribution Function) definition of incident and outgoing direction of radiation, where each layer is represented by the BSDF matrix. Figure 2 and Figure 3 shows BSDF representation of incident and outgoing hemisphere, where around the plane of a shading layer.

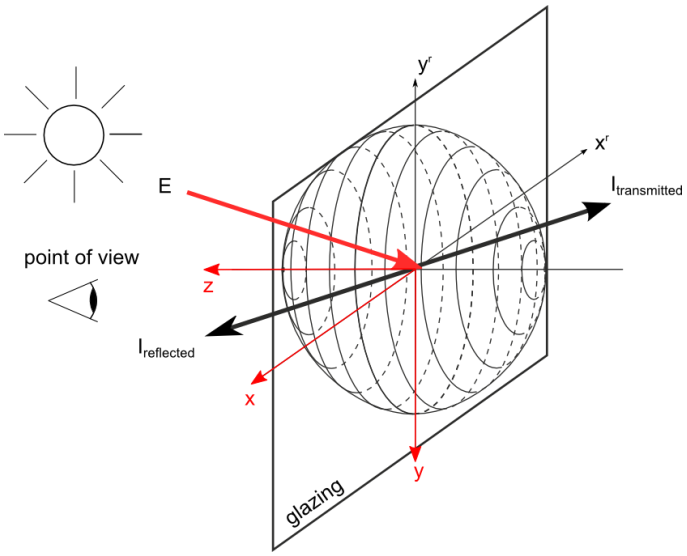


Figure 2: Incoming directions coordinate system

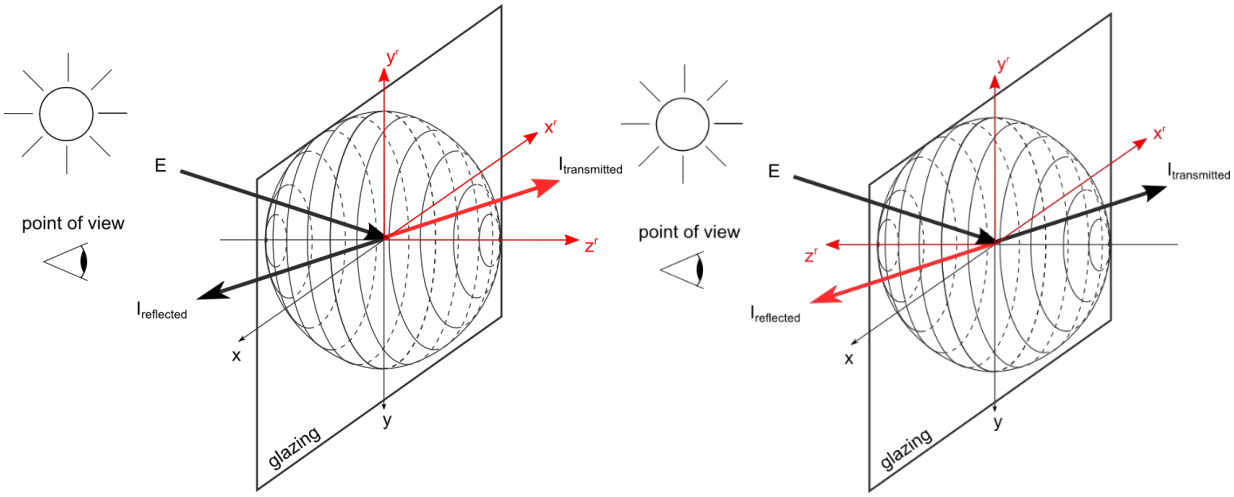
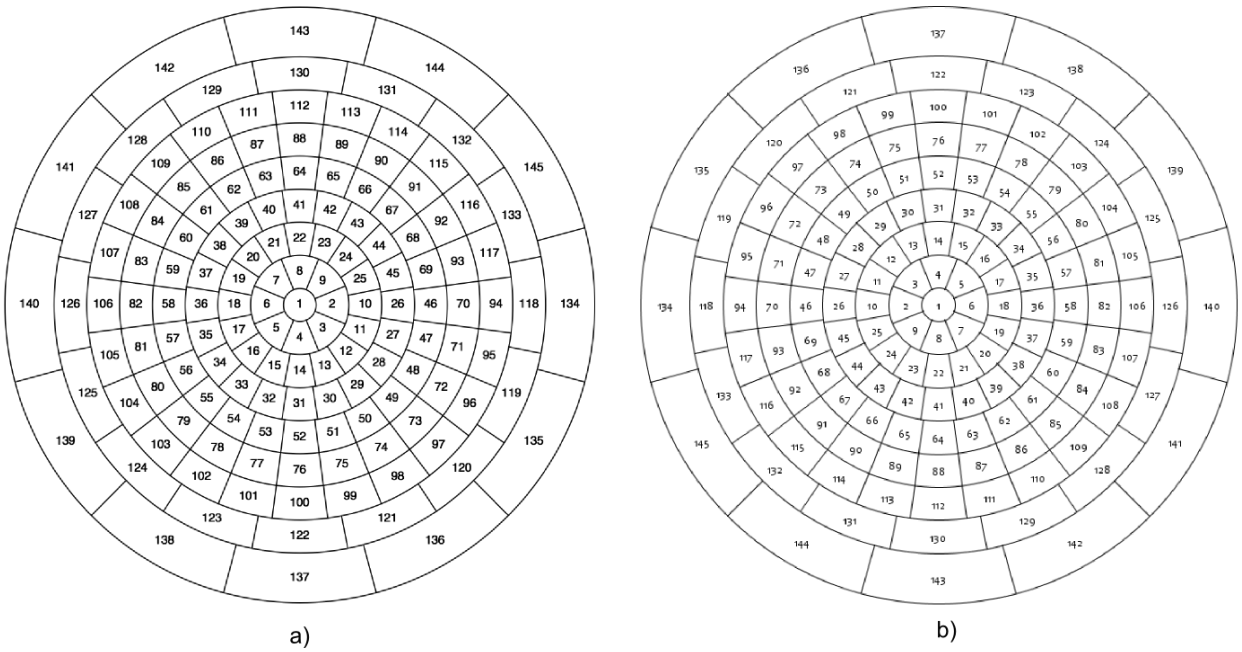


Figure 3: Outgoing directions coordinate system (transmittance and reflectance)

Each BSDF hemisphere is represented by so-called Klems basis, which has 149 incoming and outgoing patches. These patches are represented and numbered in the 2-D representation of each hemisphere, shown in Figure 4.



a) b)

Figure 4: BSDF patches for a) incoming and b) outgoing directions.

In order to apply set of angles shown in Table 2, conversion between BSDF patches and set of angles is done, resulting in the following set of patches.

Table 3. *BSDF Patch Number Mapping for the Set of Angles for Awnings*

			Azimuth (φ)				
Altitude (β)	range applied		75 > φ ≤ 45	45 > φ ≤ 15	15 > φ ≤ -15	-15 > φ ≤ -45	-45 > φ ≤ -75
	Angle	Middle point	60	30	0	-30	-60
	25 > β ≤ 15	20	107	60	22	68	117
	35 > β ≤ 25	30	108	61	41	67	116
	45 > β ≤ 35	40	128	86	64	90	132
	55 > β ≤ 45	50	128	86	88	90	132
	65 > β ≤ 55	60	129	111	112	113	131
	75 > β ≤ 65	70	129	111	130	113	131

Note that the center of each Klems patch corresponds to the closest altitude and azimuth angle set, as the Klems BSDF definition is fixed and cannot be adjusted to coincide with those angles. The combined system (combined glazing and shading system) properties are calculated using matrix multiplication (Klems 1994a and Klems 1994b) where each BSDF matrix represents individual layer (whether it is glass or shading layer) and the resulting BSDF matrix represents optical properties of the combined glazing and shading system.

For awnings, separate Radiance ray-tracing modeling is done to generate BSDF of the awning, in effect reducing all of the awnings geometry and optical properties of awnings material into the equivalent shading layer as if it was parallel to the glass. This allows the application of matrix multiplication for awnings. The resulting BSDF after matrix multiplication is used to calculate Tsol and Tvis of the window with the awning, as well as SHGC. Both standard VT and SHGC are calculated for normal incidence (patch 1 in the BSDF), as well as annual values of these quantities.

The $SHGC_{ANNUAL}$ and VT_{ANNUAL} *are* calculated from the set of angles in Table 2 (set of patches in Table 3). If we label time constants as W_i, the equations for $SHGC_{ANNUAL}$ and VT_{ANNAUL} become:

$$SHGC_{ANNUAL} = \sum_{i=1}^{29}\left(T_{sol,i} + \frac{q_{in,i(I_S=0)} - q_{in}}{I_{s,i}}\right)\cdot W_i$$

$$VT_{ANNUAL} = \sum_{i=1}^{29}\left(T_{vis,i}\right)\cdot W_i$$

Direct solar incidence radiation is set at the fixed number of 783 W/m^2, according to NFRC 100

AWNINGS GEOMETRY AND MODELING PARAMETERS

Awnings geometry is shown in Figure 5. Parameters indicated in the figure are user-entered values.

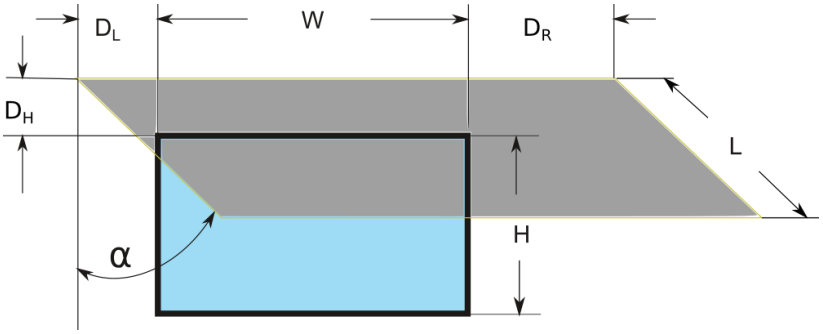


Figure 5: *Definition of Various Input Parameters*

W = Window width
H = Window height
L = Awning length
D_L = Left awning offset
D_R = Right awning offset
D_H = Top awning offset
α = Awnings angle from vertical (90° means horizontal awning)

Solar-optical modeling of awnings in WINDOW is done by Radiance ray-tracing software tool. Frads (LBNL 2019) module of Radiance (Ward and Shakespeare 1998.) performs forward ray-tracing calculation for non-coplanar surfaces to produce BSDF of the awning shade.

In Frads input, these parameters are translated into XYZ coordinates. Each corner of the baseline window and each corner of the awning rectangle are denoted by XYZ coordinates.

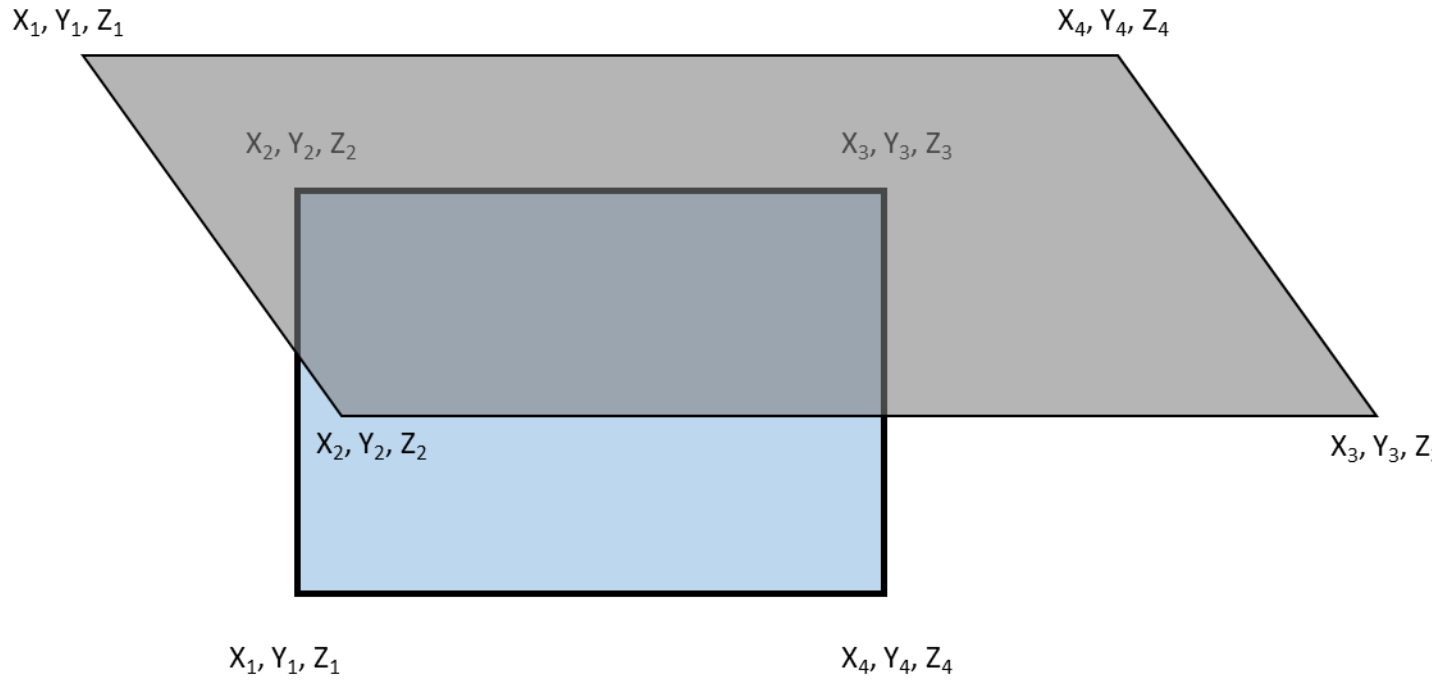


Figure 6: *Coordinate numbering for the window and awning polygons*

Frads inputs for the window and awning are provided in window.rad and awning.rad files:

Window.rad definition:

This file contains window polygon information. No material definition is needed, since it is only used for ray generation surface. Below is expected content of this file:

```
# geometry definition
void polygon window1 # modifier type identifier
# string argument, always zero in our case
# integer argument, always zero
# number of values that follows, 12 = number of vertices * 3
x1 y1 z1 # First vertex
x2 y2 z2 # Second vertex
x3 y3 z3 # Third vertex
x4 y4 z4 # Fourth vertex
```

window.rad example:

```
void polygon window1
0
0
12
0,0,0;
0,H,0;
W,H,0;
W,0,0
```

Awning.rad definition

This file contains awnings polygon information and material definition as a link to xml file. Below is expected content of this file:

```
# modifier type identifier # material definition, can be
substituted with other Radiance material
# thickness, BSDF.xml file, up vector (0 1 0, this vector can't
be the same as awning surface normal defined below
# always zero
# always zero
# geometry definition
#modifier type identifier
# string argument, always zero in our case
# integer argument, always zero
# number of values that follows, 12 = number of vertices * 3
# x1 y1 z1
# x2 y2 z2
# x3 y3 z3
# x4 y4 z4
```

awning.rad example:

```
6 0 C:\Users\Public\LBNL\WINDOW7.8\AwningBSDF\Material.xml 0 0 1
0
0
fabric polygon awning
  0
  0
  12
-DL,H+DH,0;
-DL,H+DH-L*Cos(α),L*sin(α);
W+DR,H+DH-L*Cos(α), L*sin(α);
W+DR,H+DH,0
```

Per AERC rules, the following data is used for input parameters:

W = 1.2 m
H = 1.5 m

$D_L = 0$
$D_R = 0$
$D_H = 0$
α and L are defined for four distinct cases shown in Figure 7 and Table 4.

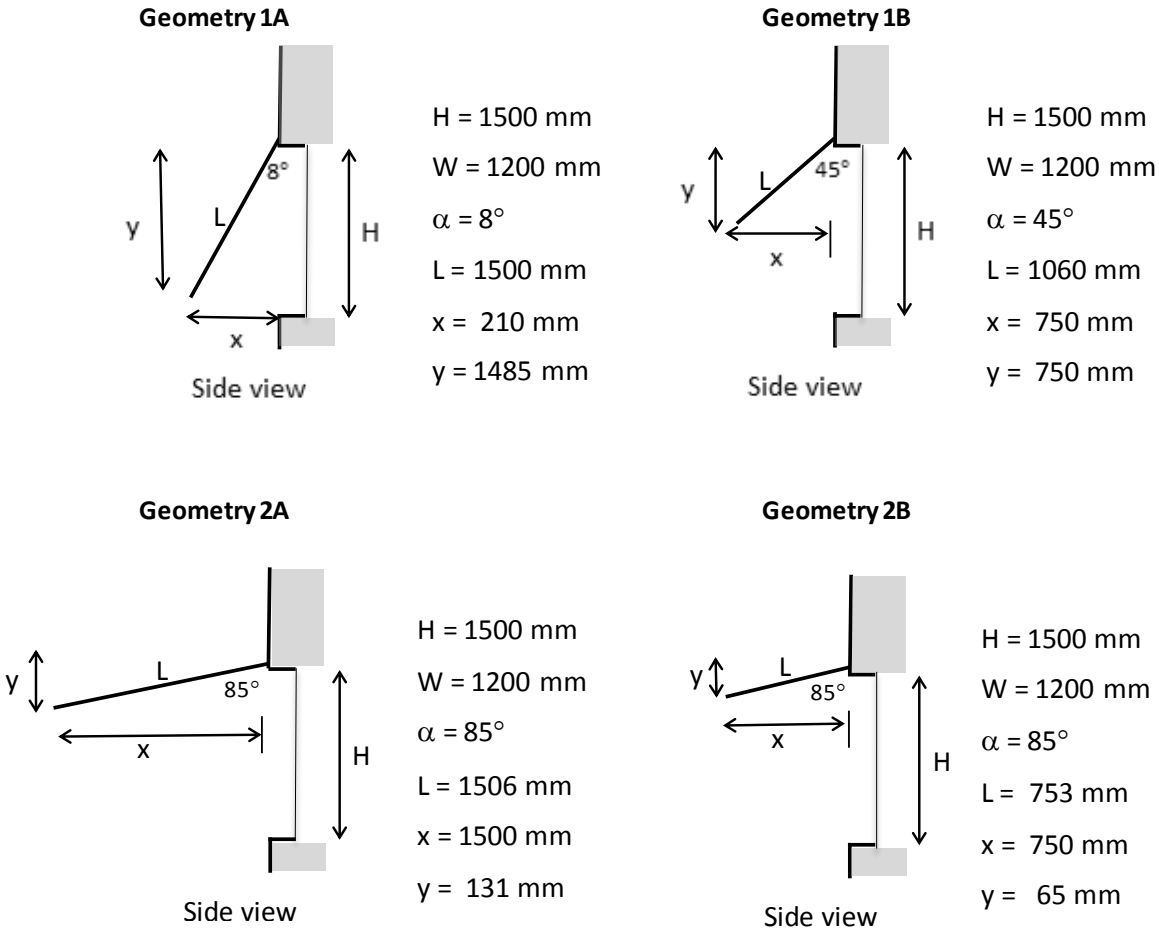


Figure 7: *Awnings Geometry and Positions*

Table 4. *Dimensions for Different Awning Geometries*

	Geometry Set 1 (1A+1B) Typical Operable Drop-arm Window Awnings Fully deployed (1A) and midpoint deployed (1B)		Geometry Set 2 (2A+2B) Typical Operable Folding-arm Window Awnings Fully deployed (2A) and midpoint deployed (2B)	
Fixed awnings might have any one of these four geometries.				
	Position 1A	Position 1B	Position 2A	Position 2B
Angle α	8°	45°	85°	85°
Cover length L	1500 mm	1060 mm	1506 mm	753 mm
Projection x-axis	0.14 x H	0.50 x H	1.00 x H	0.50 x H
Projection Drop y-axis	0.99 x H	0.50 x H	0.087 x H	0.043 x H

Fabric width	1.00 x W	1.00 x W	1.00 x W	1.00 x W
H = window recess height (1500 mm)		W = window recess width (1200 mm)		

EP CALCULATION

EP is calculated based on the new schedule for awnings. There are three distinct schedules, based on the awnings type:

In the tables below

- M = Morning
- A = Afternoon
- N = Night

Table 5. *permanently-installed, fixed awning*

Minneapolis	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Retracted - no shading												
Deployed – each of 1A, 1B, 2A, 2B	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Houston	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Retracted - no shading												
Deployed – each of 1A, 1B, 2A, 2B	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 6. *seasonally-installed fixed awning*

Minneapolis	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Retracted - no shading							1.00	1.00	1.00	1.00	1.00	1.00
Deployed – each of 1A, 1B, 2A, 2B	1.00	1.00	1.00	1.00	1.00	1.00						
Houston	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Retracted - no shading							1.00	1.00	1.00	1.00	1.00	1.00
Deployed – each of 1A, 1B, 2A, 2B	1.00	1.00	1.00	1.00	1.00	1.00						

Table 7. *operable awning:*

Minneapolis	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Retracted - no shading	0.30	0.20	0.30	0.40	0.30	0.40	0.75	0.65	0.75	0.75	0.65	0.75
Half-deployed – each of 1B, 2B	0.60	0.60	0.60	0.60	0.60	0.60	0.25	0.35	0.25	0.25	0.35	0.25
Deployed – each of 1A, 2A	0.10	0.20	0.10	0.00	0.10	0.00	0.0	0.0	0.0	0.0	0.0	0.0
Houston	Cooling Weekday			Cooling Weekend			Heating Weekday			Heating Weekend		
Deployment	M	A	N	M	A	N	M	A	N	M	A	N
Retracted - no shading	0.30	0.20	0.30	0.30	0.20	0.30	0.65	0.55	0.65	0.65	0.55	0.65
Half- deployed – each of 1B, 2B	0.60	0.60	0.60	0.60	0.60	0.60	0.35	0.45	0.35	0.35	0.40	0.35
Deployed – each of 1A, 2A	0.10	0.20	0.10	0.10	0.20	0.10	0.00	0.05	0.00	0.00	0.05	0.00

For permanently-installed fixed awnings, and seasonally-installed fixed awnings each of the four geometries, 1A, 1B, 2A, and 2B, shown in Figure 7, will be considered separately (separate product with individual rating, SHGC, VT). When calculating EP rating indices, for permanent and seasonal schedules each of the four positions is modeled using schedules in Table 5 for permanently-installed fixed awnings (always deployed) and Table 6 for seasonally-installed fixed awnings (no awning in the Winter and deployed in the Summer).

For operable awnings Table 7 lists 3 positions, retracted (no shading), half-deployed and deployed, resulting in two rated products; Geometry 1 and Geometry 2 with retracted (no awning), Half-deployed (1B for Geometry 1, and 2B for Geometry 2) and deployed (1A for Geometry 1, and 2A for Geometry 2). For each geometry parent-child relationship will be established, where parent record will show EP, while child records will show component properties (e.g., U, SHGC, VT, AL), similar to how results are shown for venetian blinds.

Naming Convention:

Naming of individual products, required for properly importing and calculating EP is listed in Table 8. Each of the fixed and seasonal products are calculated and shown individually. For operable awnings, Geometry 1 and Geometry 2 would be parent records with child records named as per Table 8.

Table 8. Naming of records

Geometry		**Fixed (AY)**	**Fixed Seasonal (AS)**	**Operable (AO)**
1	1A	AY1A	AS1A	AO1A, AO1B
	1B	AY1B	AS1B	
2	2A	AY2A	AS2A	AO2A, AO2B
	2B	AY2B	AS2B	

Example of the naming for permanently-installed fixed awning:

```
Awning 1A Permanent - Dark::AY1A::O::BW-B
```

Where, “O” means Outdoor position, and “BW-B” means Baseline Window B.

Example of the naming for Seasonally-installed fixed awning:

```
Awning 1A Seasonal - Dark::AS1A::O::BW-B
```

Example of the naming for Operable awning:

```
Awning 1A Operable - Dark::AO1A::O::BW-B
```

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