# National Fenestration Rating Council Incorporated

**NFRC 200-2010[~~E1A3~~E1A4]**

Procedure for
Determining Fenestration Product Solar Heat Gain Coefficient
and Visible Transmittance at Normal Incidence



**PREPARED BY:**

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# *FOREWORD*

The National Fenestration Rating Council, Incorporated (NFRC) develops and operates a uniform rating system for energy and energy-related performance of fenestration and fenestration attachment products. The Rating System determines the U-factor, Solar Heat Gain Coefficient (SHGC), and Visible Transmittance (VT) of a product, which are mandatory ratings for labeling NFRC-certified products, and are mandatory ratings for inclusion on label certificates, and are supplemented by procedures for voluntary ratings of products for Air Leakage (AL) and Condensation Resistance. Together these rating procedures, as set forth in documents published by NFRC, are known as the NFRC Rating System.

The NFRC Rating System employs computer simulation and physical testing by NFRC-accredited laboratories to establish energy and related performance ratings for fenestration and fenestration attachment product types. The NFRC Rating System is reinforced by a certification program under which NFRC-licensed responsible parties claiming NFRC product certification shall label and certify fenestration and fenestration attachment products to indicate those energy and related performance ratings, provided the ratings are authorized for certification by an NFRC-licensed Certification and Inspection Agency (IA).

The requirements of the rating, certification, and labeling programs (Certification Programs) are set forth in the most recent versions of the following as amended, updated, or interpreted from time to time:

- NFRC 700 Product Certification Program (PCP)
- NFRC 705 Component Modeling Approach (CMA) Product Certification Program (CMA-PCP)

and through the Certification Programs and the most recent versions of its companion programs as amended, updated, or interpreted from time to time:

- The laboratory accreditation program (Accreditation Program), as set forth in the NFRC 701 Laboratory Accreditation Program (LAP)
- The IA licensing program (IA Program), as set forth in NFRC 702 Certification Agency Program (CAP)
- The CMA Approved Calculation Entity (ACE) licensing program (ACE Program) as set forth in the NFRC 708 Calculation Entity Approval Program (CEAP)

NFRC intends to ensure the integrity and uniformity of NFRC ratings, certification, and

labeling by ensuring that responsible parties, testing and simulation laboratories, and IAs adhere to strict NFRC requirements.

In order to participate in the Certification Programs, a Manufacturer/Responsible Party shall rate a product whose energy and energy-related performance characteristics are to be certified in accordance with mandatory NFRC rating procedures. At present, a Manufacturer/Responsible Party may elect to rate products for U-factor, SHGC, VT, AL, condensation resistance, or any other procedure adopted by NFRC, and to include those ratings on the NFRC temporary label affixed to its products or on the NFRC Label Certificate. U-factor, SHGC and VT, AL, and condensation resistance rating reports shall be obtained from a laboratory that has been accredited by NFRC in accordance with the requirements of the NFRC 701.

The rating shall then be reviewed by an IA that has been licensed by NFRC in accordance with the requirements of the NFRC 702. NFRC-licensed IAs review label format and content, conduct in-plant inspections for quality assurance in accordance with the requirements of the NFRC 702, and issue a product Certification Authorization Report (CAR) and may approve for issuance an NFRC Label Certificate for site-built or CMA products and attachment products. The IA is also responsible for the investigation of potential violations (prohibited activities) as set forth in the NFRC 707 Compliance and Monitoring Program (CAMP).

Products that are labeled with the NFRC Temporary and Permanent Label, or products that are listed on an NFRC Label Certificate in accordance with NFRC requirements, are considered to be NFRC-certified. NFRC maintains a Certified Products Directory (CPD), listing product lines and individual products selected by the Manufacturer/Responsible Party for which certification authorization has been granted.

NFRC manages the Rating System and regulates the PCP, LAP, and CAP in accordance with the NFRC 700 (PCP), the NFRC 701 (LAP), the NFRC 702 (CAP), the NFRC 705 (CMA-PCP), and the NFRC 708 (CEAP) procedures, and conducts compliance activities under all these programs as well as the NFRC 707 (CAMP). NFRC continues to develop the Rating System and each of the programs.

NFRC owns all rights in and to each of the NFRC 700, NFRC 701, NFRC 702, NFRC 705, NFRC 707, NFRC 708 and each procedure, which is a component of the Rating System, as well as each of its registration marks, trade names, and other intellectual property.

The structure of the NFRC programs and relationships among participants are shown in Figure 1, Figure 2, and Figure 3. For additional information on the roles of the IAs and laboratories and operation of the IA Program and Accreditation Program, see the NFRC 700 (PCP), NFRC 701 (LAP), and NFRC 702 (CAP) respectively..

**Figure 1**

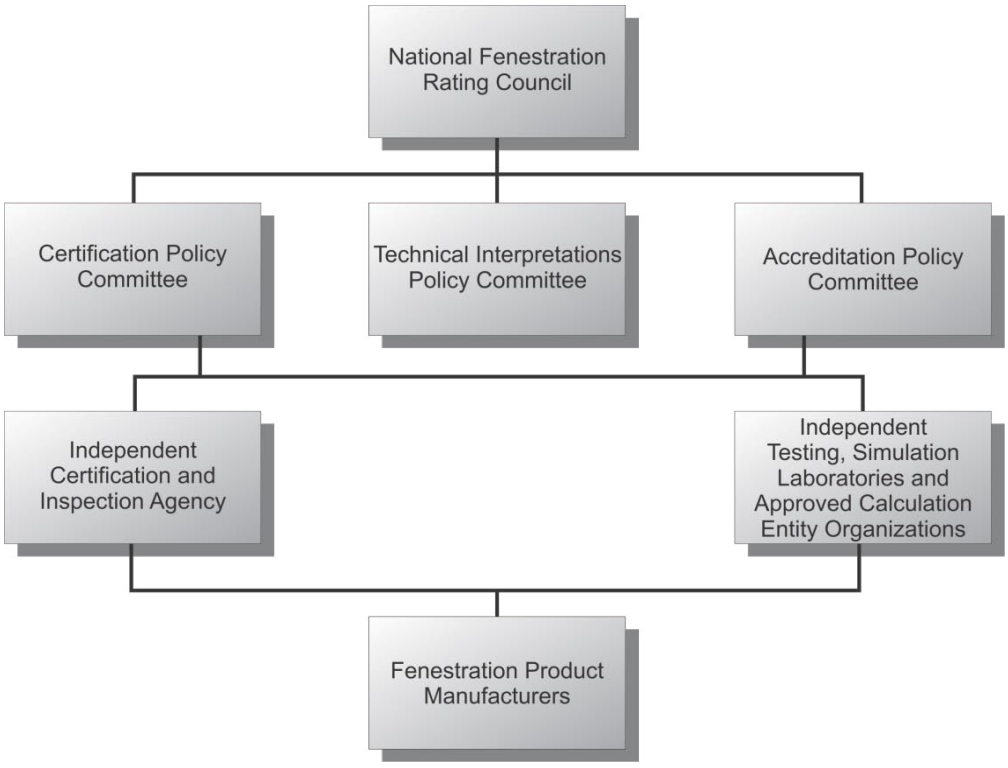

National Fenestration Rating Council
Certification Policy Committee
Technical Interpretations Policy Committee
Accreditation Policy Committee
Independent Certification and Inspection Agency
Independent Testing, Simulation Laboratories and Approved Calculation Entity Organizations
Fenestration Product Manufacturers

**Figure 2**

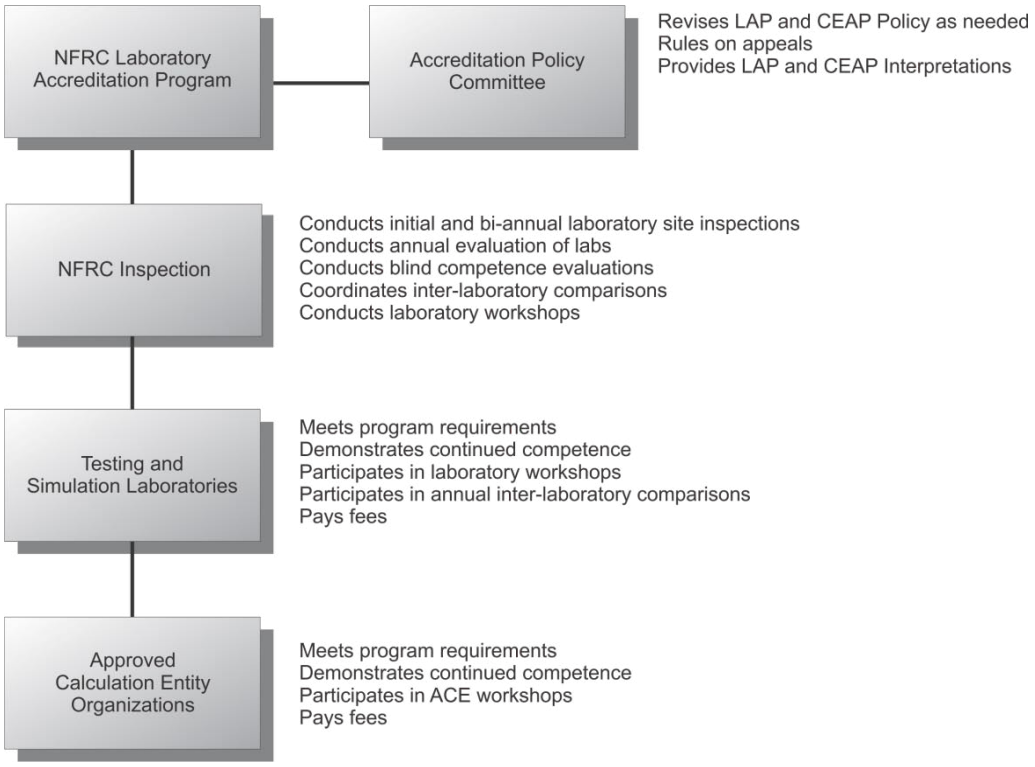
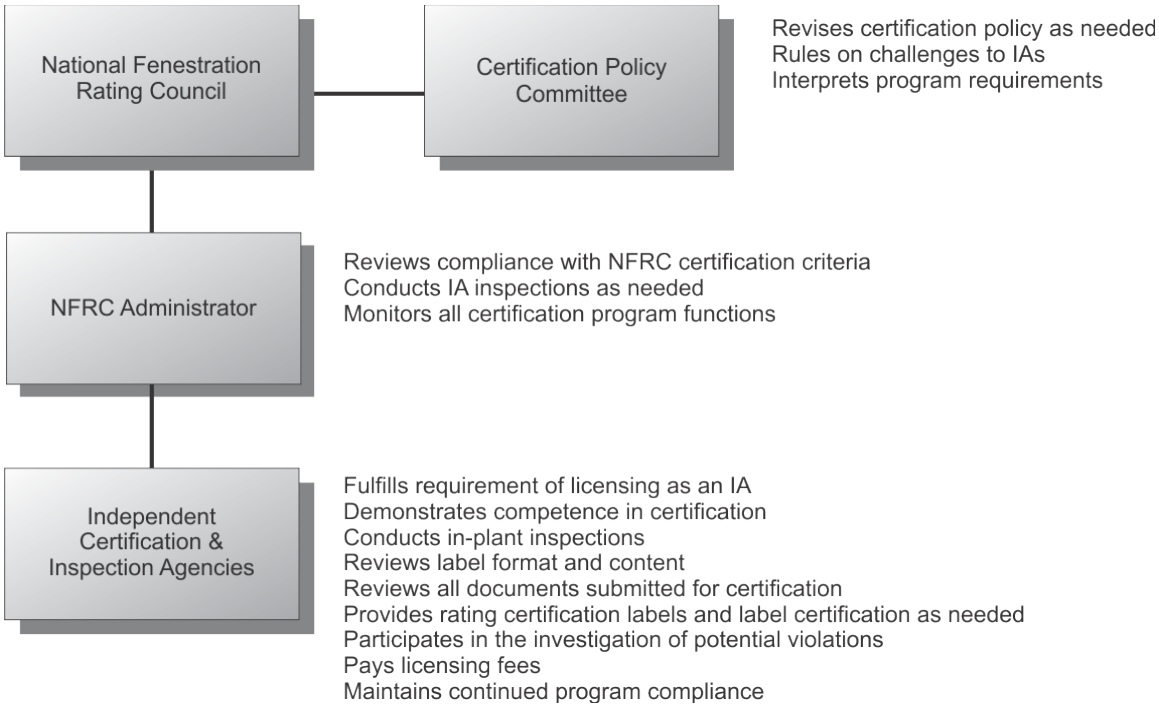

NFRC Laboratory Accreditation Program
Accreditation Policy Committee
Revises LAP and CEAP Policy as needed
Rules on appeals
Provides LAP and CEAP Interpretations
NFRC Inspection
Conducts initial and bi-annual laboratory site inspections
Conducts annual evaluation of labs
Conducts blind competence evaluations
Coordinates inter-laboratory comparisons
Conducts laboratory workshops
Testing and Simulation Laboratories
Meets program requirements
Demonstrates continued competence
Participates in laboratory workshops
Participates in annual inter-laboratory comparisons
Pays fees
Approved Calculation Entity Organizations
Meets program requirements
Demonstrates continued competence
Participates in ACE workshops
Pays fees

**Figure 3**




Questions on the use of this procedure should be addressed to:

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## *DISCLAIMER*

NFRC certification is the authorized act of a Manufacturer/Responsible Party in: (a) labeling a fenestration or related attachment product with an NFRC Permanent Label and NFRC Temporary Label, or (b) generating a site built or CMA label certificate, either of which bears one or more energy performance ratings reported by NFRC-accredited simulation and testing laboratories and authorized for certification by an NFRC-licensed IA. Each of these participants acts independently to report, authorize certification, and certify the energy-related ratings of fenestration and related attachment products.

NFRC does not certify a product and certification does not constitute a warranty of NFRC regarding any characteristic of a fenestration or fenestration-related attachment product. Certification is not an endorsement of or recommendation for any product or product line or any attribute of a product or product line. NFRC is not a merchant in the business of selling fenestration products or fenestration-related products, and therefore cannot warrant products as to their merchantability or fitness for a particular use.

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# 1. PURPOSE

To specify a method for calculating solar heat gain coefficient (SHGC) and visible transmittance (VT) at normal (perpendicular) incidence for fenestration products containing glazings or glazing with applied films, with specular optical properties calculated in accordance with ISO 15099 (except where noted) or tested in accordance with NFRC 201.

[***Note:*** This standard specifies a method for calculating the solar heat gain and visible transmittance from direct solar radiation through most fenestration products at normal incidence only. This procedure is limited to normal incidence calculations because solar optical data needed for such calculations is typically only available at normal incidence. While solar radiation rarely enters a fenestration product at normal incidence, SHGC and VT at near normal angles of incidence (less than $30^{o}$ off normal) are typically very similar to those at normal incidence; for other angles, the SHGC and VT at normal can be used, to first order, as an indicator of the relative magnitude of solar heat gain (SHG) and VT.]

# 2. SCOPE

## 2.1 Products and Effects Covered

A. Products of all frame materials including (but not limited to) aluminum, steel, thermally broken aluminum, wood, vinyl, reinforced vinyl, fiberglass, and plastic, used independently or in combination;

B. Products of all operator or unit types including (but not limited to) vertical sliding windows, horizontal sliding windows, casement windows, projecting windows, fixed windows, non-standard shaped windows, glazed wall systems, glazings for site built fenestration products, bay or bow windows, skylights, and vehicular (garage/rolling) access doors (with or without glazed areas);

C. Single or multiple assemblies of exterior doors;

D. Products of any size;

E. Products of all glazing materials, tints, and types, including (but not limited to) clear glass, tinted glass, laminated glass, dynamic glazing product, thin plastic films (internally suspended, internally applied, or externally applied), rigid plastics with or without any solar control, low-E, or any other partially transparent coating;

F. Products with any or no gap width between glazing layers;

G. Products with any gas-fill between glazing layers, including (but not limited to) air, argon, krypton, $CO_2$, or mixes of these gases;

H. Products with any spacer or spacer systems between glazings, including (but not limited to) metallic, non-metallic, or composite spacers;

I. Products utilizing any and all glazing dividers, including (but not limited to) interior, exterior, or between glazing grilles, muntin bars, caming, true divided lites, simulated divided lites, or simulated caming bars;

J. Products designed for installation at any tilt; and

K. "Film" attachment products that consist of a flexible adhesive-backed polymer film which may be applied to the interior or exterior surface of an existing glazing system in an installed fenestration product (i.e., as a retrofit, 'field-installed,' or 'daylight-installed').

[***Note:*** Films factory-applied to glazing prior to fenestration product fabrication and installation are already covered as glazing options by NFRC 200 and shall not be rated according to the procedure of Section 5.7]

Internal shading systems are included in 2.1.1A and shall be tested in accordance with NFRC 201.

### 2.1.1 Products Covered Using NFRC 201 Test Procedure for SHGC

Products not covered by NFRC 200 simulation techniques and that are covered by test-only procedures are as follows:

A. Products with shading systems between the glazing layers of the fenestration aperture;

B. Products with non-specular transmittance and reflectance properties, including (but not limited to) translucent fiberglass and glass blocks;

C. Fenestration systems whose glazing departs from being parallel, such as with curved glazing, complete bay windows, corrugated or patterned glazing, or glazing blocks (fenestration systems made up of combinations of complete windows or doors each of which individually meets the requirements in Section 2.1 can be included by treating each of the windows or doors separately);

D. Tubular daylighting devices;

E. Garden or greenhouse windows;

F. Adhesive-backed film products with non-specular transmittance and reflectance properties, including (but not limited to) opaque, textured, translucent, or 'frosted' films;

G. Adhesive-backed film products with non-uniform properties across their surface, including (but not limited to) patterned films; and

H. Dynamic attachment products for swinging doors.

## 2.2 Products and Effects Not Covered

### 2.2.1 Products and Effects Not Covered (SHGC)

It is the intent of this procedure to add the following products to the scope once a solar heat gain test procedure and/or advanced calculation methods have been developed (this may be accomplished through the issuance of a technical interpretation, addendum, and/or by a revision to this document).

A. Products with shading systems attached to the outside of the fenestration aperture;

B. Solar heat gain performance changes of a fenestration product over the course of time, i.e., long-term energy performance;

C. Fenestration systems with angular selectivity that is with optical properties, though specular on the small scale which produce emerging rays whose angle of transmittance is not equal to the angle of incidence, measured with respect to the normal to the plane of the fenestration aperture

D. Adhesive-backed film products with light-redirecting properties--that is with optical properties which produce one or more transmitted beams where the direction of the transmitted beam is not equal to the incident direction, including (but not limited to) holographic or micro-structured films; and

E. Adhesive-backed film products incorporating materials with optical properties that vary in response to ambient conditions (chromogenic), such as electrochromic, thermochromic, and photochromic materials.

### 2.2.2 Products and Effects Not Covered (VT)

It is the intent of this procedure to add the following products to the scope once a visible transmittance (VT) test procedure and/or advanced calculation methods have been developed This may be accomplished through the issuance of a technical interpretation, addendum, and/or by a revision to this document.

A. Products with shading systems, either between the glazing or attached to the inside or outside of the fenestration aperture;

B. Visible transmittance performance changes of a window over the course of time, i.e., long-term energy performance;

C. Products with non-specular transmittance and reflectance properties, such as translucent fiberglass and glass blocks;

D. Fenestration systems whose glazings depart from being parallel, such as with curved glass, complete bay windows, corrugated or patterned glass, glass blocks, etc. (fenestration systems made up of combinations of complete windows or doors, each of which individually meet the requirements in Section 2.1, can be included by treating each of the windows or doors separately);

E. Fenestration systems with angular selectivity, which is with optical properties, though specular on the small scale which produces emerging rays whose angle of transmittance is not equal to the angle of incidence, measured with respect to the normal to the plane of the fenestration aperture; and

F. Tubular daylighting devices.

# 3. DEFINITIONS

Definitions and terms are in accordance with definitions in NFRC 100; terms not specified in NFRC 100 have been selected to apply to the fenestration systems.

***Fenestration product with attachment:*** the total fenestration product resulting when a fenestration attachment is combined with (i.e., installed on) a reference fenestration product in the manner recommended by the manufacturer.

***Fenestration attachment***: a device designed to be physically attached to, incorporated with or covering a product that has been or may be rated according to NFRC procedures.

***Film:*** fenestration attachment products which consist of a flexible adhesive-backed polymer film which may be applied to the interior or exterior surface of an existing glazing system.

***Interlayer:*** a layer of material acting as an adhesive between plies of glass which adds additional performance to the finished product, for example, impact resistance, solar control, acoustical insulation.

***Laminated glass***: an assembly consisting of two or more lites of glass (conforming to ASTM Standard C 1036 or C 1048), that are bonded together by interlayer material.

***Lite:*** another term for a pane of glass used in a fenestration product. (Frequently spelled 'lite' in industry literature to avoid confusion with “light,” as in visible light.)

***Reference fenestration product:*** the fenestration product that an attachment is combined with for the purposes of rating. A reference fenestration product comprises a reference glazing system and a reference frame with a specified construction.

***Reference glazing system:*** the glazing system in the reference fenestration product.

***Reference frame***: the frame of the reference fenestration product. This may or may not correspond to an actual frame type available commercially. The reference frames used for this procedure are shown in Section 5.7.

***Solar Heat Gain Coefficient (SHGC):***

***Solar Heat Gain Coefficient*** (SHGC): the ratio of the solar heat gain entering the space through the fenestration product to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and that portion of the absorbed solar radiation which is then reradiated, conducted, or convected into the space.

***Frame Solar Heat Gain Coefficient*** ($SHGC_f$): the solar heat gain through all frame and sash members divided by the total incident solar radiation and the frame area, as defined in NFRC 100.

***Divider Solar Heat Gain Coefficient*** ($SHGC_d$): the SHGC representative of the divider area, as defined in NFRC 100.

***Edge-of-glazing Solar Heat Gain Coefficient*** ($SHGC_e$): the SHGC representative of the edge-of-glazing area, as defined in NFRC 100.

***Edge-of-divider Solar Heat Gain Coefficient*** ($SHGC_{de}$): the SHGC representative of the edge-of-divider area, as defined in NFRC 100.

***Center-of-glazing Solar Heat Gain Coefficient*** ($SHGC_c$): the SHGC representative of the center-of-glazing area, as defined in NFRC 100.

***Total fenestration product Solar Heat Gain Coefficient*** ($SHGC_t$): the SHGC representative of the total fenestration product, as defined in Equation 4-3 of Section 4.7.

***$SHGC_0$***: the total fenestration product SHGC for a center-of-glazing SHGC of 0.0.

***$SHGC_1$***: the total fenestration product SHGC for a center-of-glazing SHGC of 1.0.

***Frame absorptance***: the fraction of solar radiation absorbed by the exterior frame surface.

***Frame color***: the color of the exterior frame surface exposed to solar radiation (see frame absorptance).

***Visible Transmittance (VT):***

***Visible Transmittance (VT)***: the ratio of the visible light entering the space through the fenestration product to the incident visible light. The visible light entering a space is weighted by the photopic response of the eye (refer to NFRC 300).

***Frame Visible Transmittance*** ($VT_f$): the visible light through all frame and sash members divided by the total incident visible light and the frame area (as defined in NFRC 100).

***Divider Visible Transmittance*** ($VT_d$): the VT representative of the divider area, as defined in NFRC 100.

***Edge-of-glazing Visible Transmittance*** ($VT_e$): the VT representative of the edge-of-glazing area, as defined in Section 4.6 of NFRC 100; the value equals the center-of-glazing VT.

***Edge-of-divider Visible Transmittance*** ($VT_{de}$): the VT representative of the edge-of-divider area, as defined in NFRC 100; the value equals the center-of-glazing VT.

***Center-of-glazing Visible Transmittance*** ($VT_c$): the VT representative of the center-of-glazing area, as defined in NFRC 100.

***Total fenestration product Visible Transmittance*** ($VT_t$): the VT representative of the total fenestration product, as defined in Equation 4-4 of Section 4.7.

***$VT_o$***: the total fenestration product VT for a center-of-glazing VT of 0.0.

***$VT_1$***: the total fenestration product VT for a center-of-glazing VT of 1.0.

# 4. GENERAL

## 4.1 Compliance

Fenestration product ratings shall be determined following the procedure outlined in Section 4.1, in accordance with the criteria specified in Sections 4.2 through 4.7, as modified by applicable portions of Section 5. This section presents and references methods for determining specific fenestration product heat transfer properties or quantities used in the determination of these properties.

### 4.1.1 Product Line Simulation and Testing

The total fenestration product SHGC and VT shall be evaluated in the position specified in NFRC 100 and in accordance with ISO 15099, using the fenestration product sizes as given in Table 4-3 of NFRC 100. Fenestration products shall be evaluated without screens, removable grilles, or any other applied devices. The items listed below are exceptions to ISO 15099 that are to be implemented in NFRC-approved software/algorithms:

1) Section 7 (ISO 15099) on Shading Systems is currently excluded from NFRC procedures.

### 4.1.2 Testing Alternative

The component or total fenestration product SHGC shall be tested in accordance with NFRC 201.

The component or total fenestration product VT shall be tested once a test procedure has been approved.

## 4.2 Product Lines and Individual Products

### 4.2.1 Product Lines

Refer to Section 4.2.1 of NFRC 100 for the definition of a product line.

### 4.2.2 Individual Products

Refer to Section 4.2.2 of NFRC 100 for the definition of an individual product. For the purposes of this procedure only, variations in gap width, frame or sash color, and/or gas fill do not constitute different individual products.

### 4.2.3 Grouping of Products

A. Identify product groupings within a product line with respect to frame differences from the existing U-factor matrix. ~~Refer to Section 4.2.4 and Section 5.2.4 of NFRC 100, for simplifications to a product line.~~ To d~~D~~etermine representative frame U-factors for a group from the existing U-factor matrix~~.~~, ~~U~~use the frame option with the highest frame and edge U-factor for the lowest center-of-glazing U-factor in the matrix. Should the lowest

center-of-glazing option be included in a center-of-glazing grouping per NFRC 100, the group leader option shall be used. The frame SHGC is determined using this frame U-factor (refer to Section 4.7) and applies to all glazing options in the product grouping, regardless of the number of glazing layers, gap thicknesses, gas fills, and spacer type;

B. ~~Within the frame groupings, identify divider groupings, if any (refer to Section 4.2 and Section 5.2.4 of NFRC 100 for simplifications to a product line).~~ Assume a default divider U-factor of 2.27 W/m2·ºC (0.40 Btu/h·ft2·ºF) for all dividers, regardless of type of divider or size, including caming. The divider SHGC is determined using this divider U-factor (refer to Section 4.7) and applies to all glazing options in the product grouping, regardless of the number of glazing layers, gap thicknesses, gas fills, and spacer types~~. Separate dividers into two categories: those less than 25.4 mm (1.00 in) wide and those greater than or equal to 25.4 mm (1.00 in) wide. Dividers greater than or equal to 25.4 mm (1.00 in) are modeled at 38.0 mm (1.50 in) and dividers less than 25.4 mm (1.00 in) are modeled at 19.00 mm (0.75 in). Products with dividers in only a portion of the product are assumed to have dividers in the entire product. For caming, a default width of 8.0 mm (0.3 in) is used. For default divider and caming patterns refer to Section 4.2.4 and Section 5.2.4 of NFRC 100~~; and

C. When rating dynamic glazing products with shading systems between glazing layers, it shall be permitted to group combinations of shading systems and glazing layers. For purposes of determining SHGC, the shading system and glazing layers comprising each group leader shall be determined as follows.

i. Shading systems within a group shall vary only by color of the shading systems. The shading system used in the group leader shall be of the darkest color within the group. The darkest color shall be defined as that color with the lowest L* value in the CIE L*a*b* color space, as described in Section 8 of CIE 15.

If multiple shading systems within the group have the same, lowest, L* value, then any one of those shading systems shall be permitted to be used in the group leader.

ii. Glazing layers within a group, and the corresponding glazing layers used in the group leader, shall be determined in accordance with the representative glazing pane thicknesses rules of Table 4-1.

D. When rating dual skin translucent panels, with either air or an insulation infill between panels), it shall be permitted to group different thicknesses of panel skins. The grouping of panel thickness shall be in accordance with Table 4-1. Different tints

of the panel skins and different infills are not allowed to be grouped and will be different individual products within the same product line.

[**Note:** It is intended that these same rules shall apply to determining VT ratings as well, when procedures for obtaining VT ratings for such products are approved and implemented.]

E. Sightline groups shall consist only of individual products with sightline differences due to frame/sash base profile variations. These products shall be permitted to be grouped with each group represented by the sightline group leader. The group leader shall be the sightline option within the group such that all individual sightline frame/sash variations within the group have an SHGC of + or – 0.025 of that group leader when calculated using the glazing option with the highest center-of-glass SHGC or a center-of-glass SHGC equal to 0.71. If this approach is used, all sightline frame/sash variations within the group shall be assigned the same total fenestration product SHGC and VT as the sightline group leader. This procedure is only valid for glazing options with center-of-glass SHGCs lower than or equal to the option chosen to calculate the group leader.

i. Upon compliance of the conditions in Section 4.2.3.E.i, it is acceptable to create multiple group leaders to accommodate multiple steps in performance. The SHGC and VT Specialty Products Table of the sightline group leaders shall be determined in one of the following ways;

a. Model each product variation and determine the Specialty Products Table (SHGC0, SHGC1, VT0, and VT1) using the best U-factor glass option; or

b. Use the method outlined in Section 5.1.1.

## 4.3 Standard Conditions

This section presents procedures for determining total or component fenestration product SHGC and VT. For rating SHGC and VT of individual products at model sizes, follow Section 4.4.

### 4.3.1 Simulation

Approved solar optical data shall be used with the approved center-of-glazing software. NFRC approved solar optical data is listed in Reference 4.

The center-of-glazing SHGC ($SHGC_c$) shall be determined using the following conditions:

$T_{in}$ = 24ºC (75ºF)
$T_{out}$ = 32ºC (90ºF)

$V$ = 2.75 m/s (6.15 mph)
$T_{rm,out}$ = $T_{out}$
$T_{rm,in}$ = $T_{in}$
$I_s$ = 783 W/m$^2$ (248 Btu/h·ft$^2$)

### 4.3.2 Testing

Specified testing conditions in this section shall be used to determine the SHGC of the individual fenestration products. See Section 4.6.1 for both the center-of-glazing and the total fenestration product.

### 4.3.3 Environmental Conditions during NFRC 201 Testing

A. Average nominal inside air temperature shall be 24º C (75º F);

B. Inside surface coefficient (as measured on a vertical CTS per Section 5.5.1 of NFRC 201) shall be 7.7 W/m2K ± 5% (1.4 Btu/h·ft2·ºF ± 5%);

C. The solar irradiance shall never be less than 680 W/m2 (200 Btu/h·ft2);

D. The incident angle of the direct solar irradiance shall be maintained at less than or equal to 5$^o$ from normal to the plane of the solar calorimeter aperture (i.e., perpendicular to the outside surface of the surround panel); and

E. The aperture of the solar calorimeter (i.e., the plane of the outside surface of the surround panel) shall not be tilted more that 60$^o$ from vertical unless the laboratory can demonstrate that their calorimeter can meet the inside surface coefficient tolerance specified (Section 4.3.3.B) at the greater tilt angle.

#### 4.3.3.1 Center-of-Glazing Component Test Procedure

The center-of-glazing SHGC shall be calculated in accordance with NFRC 201, applying environmental conditions specified in Section 4.3.3. of this document.

Guidance for the appropriate use of NFRC's approved procedure for Testing for Center-of-Glazing Component Test Procedure for center-of-glazing ($VT_c$) will be published as an addendum to this procedure or as a Technical Interpretation.

## 4.4 Model Sizes and Configurations

Total fenestration product SHGC and VT shall be determined for the model size shown in Table 4-3 of NFRC 100.

## 4.5 Simulation Procedures

This section presents the method for determining individual product SHGC and VT for model sizes.

Determine the total fenestration product SHGC and VT values for center-of-glazing SHGC and VT values of 0.0 and 1.0 (per Section 4.7) for all applicable

cases: no dividers, dividers less than 25.4 mm (1.00 in) wide and greater than or equal to 25.4 mm (1.00 in) wide~~, and caming when applicable~~.

A. Nominal glass thickness may be used for determining the $SHGC_c$ and $VT_c$ of the glazing system;

B. For~~Identify~~ product groupings within a product line identified in Section 4.2.3.A with respect to frame differences~~.~~, ~~Refer to Section 4.2 and Section 5.2.4 of NFRC 100, for simplifications to a product line. Determine representative frame U-factors for a group from the existing Total Product U-factor matrix. Use the frame option with the highest frame and edge U-factor for the lowest center-of-glazing U-factor in the matrix. This includes situations when the total product U-Factor matrix includes the same glazing but different spacer assemblies or different frame/sash in the same product line. Should the lowest center-of-glazing option be included in a center-of-glass grouping per NFRC 100, then~~ the group leader ~~option~~ shall be used to determine the SHGC and VT of 0 and 1. The frame SHGC is determined using this frame U-factor (refer to Section 4.7) and applies to all glazing options in the product grouping~~, regardless of the number of glazing layers, gap thicknesses, gas fills, and spacer types~~;

C. ~~Within the frame groupings, identify~~For divider groupings, identified in Section 4.2.3.B, ~~if any (refer to Section 4.2 and Section 5.2.4 of NFRC 100 for simplifications to a product line). Assume a default divider U-factor of 2.27 W/(m2·ºC) (0.40 Btu/h·ft2·ºF) for all dividers, regardless of type of divider or size, including caming. T~~the divider SHGC is determined using this divider U-factor (refer to Section 4.7) and applies to all glazing options in the product grouping~~., regardless of the number of glazing layers, gap thicknesses, gas fills, and spacer types.~~ Separate dividers into two categories: those less than 25.4 mm (1.00 in) wide and those greater than or equal to 25.4 mm (1.00 in) wide. Dividers greater than or equal to 25.4 mm (1.00 in) are modeled at 38.0 mm (1.50 in) and dividers less than 25.4 mm (1.00 in) are modeled at 19.0 mm (0.75 in). Products with dividers in only a portion of the product are assumed to have dividers in the entire product. The overall window dimension shall be used to determine the number of horizontal and vertical dividers. For default divider ~~and caming~~ patterns, refer to NFRC 100;

Tapes that are transparent or translucent shall be deemed to be equivalent to the same glass without the tape;

D. Frame and divider SHGC shall be calculated with a default frame and divider absorptance of 0.3 for all products except glazed wall systems and sloped glazing systems (as defined in Table 4-3 of NFRC 100 and Section 5.6 in NFRC 100). For glazed wall systems and sloped glazing systems, use a default frame and divider absorptance of 0.5;

E. If using WINDOW to simulate each product group identified in Section 4.2.3 for U-factor, the frame representative SHGC0, SHGC1, VT0, and VT1 for no dividers, dividers less than 25.4 mm (1.00 in) wide, and dividers greater than or equal to 25.4 mm (1.00 in) wide used in Equations 4-1 and 4-2 shall be obtained from the group leader with no dividers.

F. For products that cannot use WINDOW, to obtain the frame representative SHGC0, SHGC1, VT0, and VT1 for no dividers, dividers less than 25.4 mm (1.00 in) wide, and dividers greater than or equal to 25.4 mm (1.00 in) wide, then the method in Section 4.7.B shall be used as appropriate;

~~E.~~G. A matrix of center-of-glazing SHGC and VT glazing options specific to the product line shall be created for use in Equation 4-1 and Equation 4-2. This center-of-glazing matrix may include variations in number of glazing layers, glazing types (tints, laminated glass, etc.), and glazing coatings.

For each product line, products may be rated using either:

i. The actual glazing infill assemblies pane thickness for determining SHGC and VT, or

ii. Applicable representative glazing infill pane thicknesses (in Table 4-1) for the range of glazing infill pane thicknesses for that product line. Table 4-1 is not applicable for laminated glass; the actual glass and interlayer assembly shall be used.

Laminates not found in the NFRC IGDB may be built in Optics, per NFRC 303, but the glass layers shall be NFRC # sign approved and the interlayer found in the approved interlayer list provided by LBNL.

Ratings for products with obscured, frit, wired, and/or stained glass shall be deemed to be equivalent to the ratings for clear glass; and

**Table 4-1 Representative Glazing Pane Thicknesses**

| Range of Glazing Infill Pane Thicknesses Used in Product Line | Represented by Size |
|---|---|
| mm (in) | mm (in) |
| x < 2.0 (x < 5/64) | Actual |
| 2.0 < x < 4.5 (5/64 < x < 11/64) | 3.0 (1/8) |
| 4.5 < x < 7.1 (11/64 < x < 9/32) | 6.0 (1/4) |
| 7.1 < x (9/32 < x) | Actual |

~~F.~~H. Products that meet the definition of a Dynamic Glazing Product shall be rated at their full ON and OFF or full OPEN and CLOSED positions. The manufacturer shall specify the appropriate procedure to use to achieve the stated positions. Rating procedures for the stated positions shall be the same as for non-Dynamic Glazing Products.

### 4.5.1 Component

#### 4.5.1.1 Approved Center-of-Glazing Simulation Program

Approved center-of-glazing software shall be used to determine $SHGC_c$ and $VT_c$. NFRC approved software is listed in Reference 4.

#### 4.5.1.2 Approved 2-D Heat Transfer Simulation Program

Approved 2-D heat-transfer software shall be used. NFRC approved software is listed in Reference 4. Determination of frame U-factors for calculating frame SHGC shall comply with the conditions of NFRC 100.

## 4.6 Test Procedures

If a product cannot be simulated in accordance with Section 4.5, the test procedures in this section shall be used to determine the SHGC of the individual fenestration products: Section 4.6.2 for the center-of-glazing and Section 4.6.1 for the total fenestration product. However, these test procedures shall only be used for the reporting of SHGC and VT if the size conditions in Section 4.4 of NFRC 100 are met. The only time a product line shall contain tested total fenestration product SHGC is when an accredited simulation laboratory states in writing that it cannot simulate an individual product(s) to a reasonable accuracy by either using the computational procedure or by using a combination of computational and center-of glazing component test procedures. In addition, the written permission of NFRC is required for products not specifically addressed in this document.

### 4.6.1 Total Fenestration Product

The total fenestration product SHGC shall be calculated in accordance with NFRC 201 at the conditions specified in Section 4.C.ii. Guidance for the appropriate use of NFRC's approved Total Fenestration Product Test Procedure for VT will be published as an addendum to this procedure or as a Technical Interpretation.

### 4.6.2 Component

The center-of-glazing SHGC shall be calculated in accordance with NFRC 201.

Guidance for the appropriate use of NFRC's approved procedure for Testing for Center-of-Glazing Component Test Procedure for Center-of-Glazing ($VT_c$) will be published as an addendum to this procedure or as a Technical Interpretation.

## 4.7 Total Fenestration Product Rating

The total fenestration product SHGC and VT shall be calculated as outlined below:

A. For fenestration products that will be using WINDOW and THERM for the total product calculations,determine all of the following, as applicable:

   i. Center-of-glazing SHGC and VT using the approved center-of-glazing computational program;

   ii. Edge-of-glazing SHGC and VT. This value shall be equal to the center-of-glazing SHGC and VT values, respectively;

iii. Obtain the frame representative $SHGC_0$, $SHGC_1$, $VT_0$, and $VT_1$ from WINDOW for no dividers, dividers less than 25.4 mm (1.00 in) wide, and dividers greater than or equal to 25.4 mm (1.00 in) wide, per Section 4.5.C of this document;

iv. Divider edge-of-glazing SHGC and VT. This value shall be equal to the center-of-glazing SHGC and VT values, respectively;

v. For any $SHGC_c$, the total fenestration product SHGC can be calculated using the following equation:

Equation 4-1

Where

$SHGC_0$ = The total fenestration product SHGC for the center-of glazing SHGC of 0.0

$SHGC_1$ = The total fenestration product SHGC for the center-of-glazing SHGC of 1.0

Perform the calculations with $SHGC_c$, $SHGC_0$, and $SHGC_1$ values to six significant figures (0.XXXXXX). Report the final SHGC value to two significant digits (0.XX);

vi. For any $VT_c$, the total fenestration product VT can be calculated using the following equation:

Equation 4-2

Where

$VT_0$ = The total fenestration product VT for the center-of-glazing VT of 0.0

$VT_1$ = The total fenestration product VT for the center-of-glazing VT of 1.0

Perform the calculation with $VT_c$, $VT_0$, and $VT_1$ values to six significant digits (0.XXXXXX). Report the final VT value to two significant digits (0.XX);

B. For products that cannot use WINDOW to obtain the frame representative $SHGC_0$, $SHGC_1$, $VT_0$, and $VT_1$ for no dividers, dividers less than 25.4 mm (1.00 in) wide, and dividers greater than or equal to 25.4 mm (1.00 in) wide, per Section 4.5.C of this document, then the following shall be determined, as applicable, to be able to calculate whole product SHGC/VT values (the exception is Vehicular Access (Garage) Doors shall refer to Section 5.5.5 of this document):

i. Center-of-glazing SHGC and VT using the approved center-of-glazing computational program;

ii. Edge-of-glazing SHGC and VT shall be, equal to the center-of-glazing SHGC and VT values, respectively;

iii. Frame and divider SHGCs shall be calculated in accordance with ISO 15099 (Section 4.2.2), and Equation 4-3 of this document. The frame and divider $SHGC_f$ shall be calculated separately;

$$SHGC_f = \alpha \cdot (U_f / (A_{surf} / A_f) \cdot h_{out}$$ Equation 4-3

Where

$\alpha$ = Frame or divider absorptance

$A_f$ = Sum of the projected dimensions of the opaque portion

$A_{surf}$ = Sum of the wetted areas of the opaque portion

$U_f$ = Area-weighted average winter nighttime U-factor of the opaque portion

$h_{out}$ = 30 W/m$^2$·K

The frame and divider U-factors shall be determined with the 2-D heat transfer computational program at the environmental conditions specified in NFRC 100, except as noted in Section 4.5 of this document,

iv. Opaque frame and divider VT are equal to 0.0,

v. Divider edge-of-glazing SHGC and VT, equal to the center-of-glazing SHGC and VT values respectively,

vi. The component areas:

a. Center-of-glazing area,
b. Divider area,
c. Edge-of-glazing area,
d. Edge-of-divider area,
e. Frame area,
f. Edge-of-Lite area,
g. Edge-of-Panel area,
h. Door-Lite Frame area,
i. Panel Core area,
j. Door Core area, and
k. Projected fenestration product area

vii. Perform the following calculations (as shown in Equation 4-4) to determine $SHGC_0$ and $SHGC_1$, where applicable:

a. Multiply all fenestration component SHGC: frame, door panel core, door panel edge, door core, door-lite frame, dividver, door-lite frame edge, the center-of-glazing, edge-of-glazing, and edge-of-divider by their corresponding areas. For $SHGC_0$; the $SHGC_c$, $SHGC_e$, $SHGC_{de}$, and SHGC edge-of-lite shall be equal to 0. For $SHGC_1$, the $SHGC_c$, $SHGC_e$, $SHGC_{de}$, and $SHGC_{le}$ shall be equal to 1.

b. Total these quantities, and

c. Divide this total by the projected fenestration product area to produce a table of computed representative frame fenestration product SHGCs at a center-of-glazing value of 0 and 1.;

Equation 4-4

Where

| | | |
|---|---|---|
| $SHGC_0$ | = | Representative SHGC of product with center-of-glazing SHGC = 0 |
| $SHGC_1$ | = | Representative SHGC of product with a center-of-glazing SHGC = 1. |
| $SHGC_x$ | = | Frame SHGC-values frame, door-lite frame, door core, door panel core, and door panel edge, as determined by Equation 4-3 |
| $A_x$ | = | Sum of the frame, door-lite frame, door core, door panel core, and door panel edge projected areas, $m^2$ ($ft^2$) |
| $SHGC_d$ | = | Divider SHGC, as determined by Equation 4-3 |
| $A_d$ | = | Divider area |
| $SHGC_e$ | = | Edge-of-glazing SHGC, set to zero for $SHGC_0$ and one for $SHGC_1$ |
| $A_e$ | = | Edge-of-glazing area |
| $SHGC_{de}$ | = | Edge-of-divider SHGC, set to zero for $SHGC_0$ and one for $SHGC_1$ |
| $A_{de}$ | = | Edge-of-divider area |
| $SHGC_{le}$ | = | Door-lite edge SHGC, set to zero for $SHGC_0$ and one for $SHGC_1$ |
| $A_{le}$ | | Door-lite edge area |
| $SHGC_c$ | = | Center-of-glazing SHGC, set to zero for $SHGC_0$ and one for $SHGC_1$ |
| $A_c$ | = | Center-of-glazing area |
| $A_{pf}$ | = | Projected fenestration product area |

viii. For any $SHGC_c$, the total fenestration product SHGC can be calculated using Equation 4-1 of this document.

ix. Perform the following calculations (as shown in Equation 4-5) to determine $VT_0$ and $VT_1$, where applicable::

a. Multiply all fenestration component VT; frame, door panel core, door panel edge, door core, door-lite frame, divider, door-lite frame edge, center-of-glazing, edge-of-glazing, edge-of-divider, and frame VT by their corresponding areas. For $VT_0$, the $VT_c$, $VT_e$, $VT_{de}$, and $VT_{le}$ shall be zero. For $VT_1$, the $VT_c$, $VT_e$, $VT_{de}$, and $VT_{le}$ shall be one.

b. Total these quantities, and

c. Divide this total by the projected fenestration product area to produce a table of computed representative fenestration product VTs at a center-of-glazing value of 0 and 1.

Equation 4-5

Where

$VT_0$ = Representative VT of product with a center-of-glazing VT = 0

$VT_1$ = Representative VT of product with a COG SHGC = 0.

$VT_x$ = Frame VT-values of frame, door-lite frame, door core, door panel core, and door panel edge

$A_x$ = Sum of the frame, door-lite frame, door core, door panel core, and door panel edge projected areas, $m^2$ ($ft^2$)

$VT_d$ = Divider VT

$A_d$ = Divider area

$VT_e$ = Edge-of-glazing VT, set to zero for $VT_0$ and one for $VT_1$

$A_e$ = Edge-of-glazing area

$VT_{de}$ = Edge-of-divider VT, set to zero for $VT_0$ and one for $VT_1$

$A_{de}$ = Edge-of-divider area

$VT_{le}$ Door-lite edge VT, set to zero for $VT_0$ and one for $VT_1$

$VT_{le}$ Door-lite edge area

$VT_c$ = Center-of-glazing VT, set to zero for $VT_0$ and one for $VT_1$

$A_c$ = Center-of-glazing area

$A_{pf}$ = Projected fenestration product area

x. For any $VT_c$, the total fenestration product VT can be calculated using Equation 4-2 of this document.

# 5. VARIATION FROM THE GENERAL REQUIREMENTS

## 5.1 Window and Sliding Glass Doors

### 5.1.1 Determining Specialty Products Tables for Sightline Variations

1. Determine the Table of SHGC and VT 0 and 1 values for two configurations:

   a. Product with the Greatest Daylight Opening; $SHGC0_{greatest}$, $SHGC1_{greatest}$, $VT0_{greatest}$, $VT1_{greatest}$

   b. Product with the Least Daylight Opening;

   $SHGC0_{least}$, $SHGC1_{least}$, $VT0_{least}$, $VT1_{least}$

2. Determine the $VT1_{option}$ for each variation by determining the Daylight Opening (Vision Area) and dividing by the Total Area as follows;

   $VT1_{option}$ = Daylight Opening Area / Total Area

3. Calculate the $SHGC0_{option}$ for each variation as follows;

   $SHGC0_{option} = SHGC0_{greatest} + (VT1_{greatest} - VT1_{option}) \cdot (SHGC0_{least} – SHGC0_{greatest}) / (VT1_{greatest} – VT1_{least})$

4. Calculate the $SHGC1_{option}$ for each variation as follows;

   $SHGC1_{option} = SHGC0_{option} + VT1_{option}$

## 5.2 Swinging Doors

### 5.2.1 Calculation of Total Product Rating

When simulating SHGC for continuous single pane decorative lite (decorative lite includes glass and caming), the decorative lite glass shall be assumed to have the same properties as clear glass of the same glass thickness~~; each decorative lite caming pattern shall be considered to be a different individual product or the optional caming pattern (as shown in Table 5-1 and Table 5-2) may be used to represent all decorative lite caming patterns. The default caming profile may be used to represent any caming profile~~.

When simulating SHGC where a single pane decorative lite (continuous or non-continuous) is used as the middle layer of a triple glazed glass unit, the decorative lite glass shall be assumed to have the same properties as clear glass of the same glass thickness~~; each decorative lite caming pattern shall be considered to be a different individual option or the optional caming pattern (as shown in Table 5-1 and Table 5-2) may be used to represent all decorative lite caming patterns. The default caming profile may be used to represent any caming profile~~.

#### 5.2.1.1 Simplification

For SHGC simulation~~U-factor simulation~~, if the minimum distances between the surrounding glass and the decorative lite (both glass and caming) are greater than 3 mm (0.118 in), ~~:~~

~~A. The caming pattern may be ignored and the option modeled as triple-glazed, or~~

~~B. The decorative lite layer may be ignored and the option modeled as double-glazed.~~

~~For SHGC simulation,~~ the ~~double-glazed~~ option shall be rated with the less than 25.4 mm (1.00 in) divider option. ~~For reporting purposes, this option shall not be grouped with any other option.~~

### 5.2.2 Determining Table of SHGC and VT 0 and 1 Values for Grouped Sightlines (See 5.1.1)

## 5.3 Skylights

### 5.3.1 Determining Table of SHGC and VT 0 and 1 Values for Grouped Sightlines (See 5.1.1)

## 5.4 Tubular Daylighting Devices

None

## 5.5 Garage (Vehicular Access) Doors

### 5.5.1 Scope

This section presents and references methods for determining specific garage door system solar heat gain properties or quantities used in the determination of these properties, where garage doors consist of both panel areas and glazed areas. At this time, the scope of these properties is limited to total garage door system SHGC.

### 5.5.2 Variations from Standard Product Lines

A given series of garage door systems defined by skin material and glazing material construction that differ only in:

A. Size;

B. Solid panel and panel cut-out configurations;

C. The replacement of core or a panel area with a glazing system;

D. Center-of-glazing characteristics, such as glazing types, gap widths, glazing areas, use of dividers, use of spacers, glazing coatings, and/or gas fills.

### 5.5.3 Variations from Standard Individual Products

An individual product, in a product line, shall be those products that comply with the requirements per Section 5.5.2.

### 5.5.4 Variations from Standard Simulation and Test Conditions

A. In accordance with U-factor validation testing to NFRC 100 for simulated garage door products, sectional garage doors shall have the SHGC determined based on a specimen filling a 2.13 m (7 ft) wide by 2.13 m (7 ft) tall opening (the aperture is smaller than the test specimen).

B. Glazing shall be per the manufacturer's design. If grids or dividers are normally used in garage door glazing, those grids and dividers shall be included for modeling purposes.

C. Door opening framing and sill shall be included in SHGC calculations. The framing (nominal 2 x 4) and the sill (nominal 2

x 6) shall consist of 38 mm (1 ½ in) wood surrounding the perimeter of the door.

### 5.5.5 Total Product Rating

The total garage door system SHGC shall be calculated as outlined below:

A. Determine all of the following, as applicable:

i. Top rail SHGC

ii. Bottom rail SHGC

iii. End stile SHGC

iv. Center-of-glazing SHGC

v. Glazing framing SHGC

vi. Divider SHGC

vii. Edge-of-divider SHGC

viii. Door panel core SHGC. This will only include portions of those top, intermediate, and bottom panels that are not glazed, and excludes glazing framing, top rail, bottom rail, and end stile areas

ix. The component areas in square feet, to the nearest 0.001 m2 (0.010 ft2) of:

a) Top rail area

b) Bottom rail area

c) End stile area

d) Center-of-glazing area

e) Glazing framing area

f) Divider area

g) Edge-of-divider area

h) Door panel core area

i) Projected total exterior door system area (framing and sill areas)

B. Perform the following calculations as shown in Equation 5-1:

i. Multiply the top rail, bottom rail, end stile, center-of-glazing, glazing framing, and door core SHGCs by their corresponding areas.

ii. Total these six quantities; and

iii. Divide this total by the projected total exterior garage door system area to produce computed total garage door system product SHGCs for all the door systems in the matrix of required SHGCs.

Where

| | | |
|---|---|---|
| $SHGC_t$ | = | *total door system SHGC* |
| $SHGC_{tr}$ | = | *top rail SHGC* |
| $A_{tr}$ | = | *top rail area* |
| $SHGC_{br}$ | = | *bottom rail SHGC* |
| $A_{br}$ | = | *bottom rail area* |
| $SHGC_{es}$ | = | *end stile SHGC* |
| $A_{es}$ | = | *end stile area* |
| $SHGC_{cg}$ | = | *center-of-glazing SHGC* |
| $A_{cg}$ | = | *center-of-glazing area* |
| $SHGC_{gf}$ | = | *glazing framing SHGC* |
| $A_{gf}$ | = | *glazing framing area* |
| $SHGC_d$ | = | *divider SHGC* |
| $A_d$ | = | *divider area* |
| $SHGC_{de}$ | = | *edge-of-divider SHGC* |
| $A_{de}$ | = | *edge-of-divider area* |
| $SHGC_{dc}$ | = | *door panel core SHGC* |
| $A_{dc}$ | = | *door panel core area* |
| $A_{pt}$ | = | *projected total door system area* |

## 5.6 Site Built

None

## 5.7 Applied Films

### 5.7.1 Scope

This section presents additional details specific to applied film products.

This section presents and references methods for determining specific applied film with reference fenestration products Solar Heat Gain Coefficient (SHGC) and Visible Transmittance (VT).

[***Note***: Films factory-applied to glazing prior to fenestration product fabrication and installation are already covered as glazing options by NFRC 200 and shall not be rated according to the procedure of Section 5.7.]

### 5.7.2 Variations from Standard Product Lines

None

### 5.7.3 Variations from Standard Individual Products

None

### 5.7.4 Variations from Standard Simulation and Test Conditions

#### 5.7.4.1 Approved Center-of-Glazing Computational Program

Approved center-of-glazing software (see Reference 4) shall be used to determine $SHGC_c$ and $VT_c$.

NFRC-approved solar optical data shall be used for the film installed on 3 mm (1/8 in) clear glass, 6 mm (1/4 in) clear glass, and 6 mm (1/4 in) grey glass. Any pane of 3 mm (1/8 in) clear glass may be used that has a center-of-glazing SHGCc of 0.86 $\pm$ 0.02 when modeled in configuration A (below) without the film installed. Any pane of 6 mm (1/4 in) clear glass may be used that has a center-of-glazing SHGCc of 0.82 $\pm$ 0.02 when modeled in configuration B (below) without the film installed. Any grey glass may be used that has a center-of-glazing SHGCc of 0.59 $\pm$ 0.02 when modeled in configuration C (below) without the film installed.

The following reference glazing systems shall be simulated with and without the film installed:

A. Single 3 mm (1/8 in) Clear;

B. Single 6 mm (1/4 in) Clear;

C. Single 6 mm (1/4 in) Grey;

D. Double 3 mm (1/8 in) Clear/3 mm (1/8 in) Clear: 7 mm (0.3 in) air gap;

E. Double 6mm (1/4 in) Clear/ 6 mm (1/4 in) Clear: 12.7 mm air gap; and

F. Double 6 mm (1/4 in) Grey/ 6mm (1/4 in) Clear: 12.7 mm air gap.

The position (surface number) of the film when installed on the glazing system shall be documented (i.e., #1 to #4).

This will yield the following matrix:

**Table 5-1 Center-of-Glazing Values -- $SHGC_c$ and $VT_c$**

| Reference Glazing System | Without Film | | With Film | | |
|---|---|---|---|---|---|
| | $SHGC_c$ | $VT_c$ | Film Position | $SHGC_c$ | $VT_c$ |
| 3 mm (1/8 in) clear | 0.859 | 0.899 | | | |
| 6 mm (1/4 in) clear | 0.816 | 0.884 | | | |
| 6 mm (1/4 in) grey | 0.576 | 0.444 | | | |
| 3 mm (1/8 in) clear<br>3 mm (1/8 in) clear | 0.761 | 0.814 | | | |
| 6 mm (1/4 in) clear<br>6 mm (1/4 in) clear | 0.702 | 0.786 | | | |
| 6 mm (1/4 in) grey<br>6 mm (1/4 in) clear | 0.454 | 0.395 | | | |

### 5.7.5 Calculation of Total Product Rating

The reference fenestration product and applied film product SHGC and VT shall be calculated as outlined below:

**Table 5-2 Values of $SHGC_0$ and $SHGC_1$ and $VT_0$ and $VT_1$ for Reference Products**

| Operator Type | Reference Frame | Reference Glazing | $SHGC_0$ | $SHGC_1$ | $VT_0$ | $VT_1$ |
|---|---|---|---|---|---|---|
| Residential Fixed | Aluminum | All 3 mm (1/8 in) options | 0.01969 | 0.83836 | 0.000000 | 0.81841 |
| Non-Residential Window wall | Aluminum | All 6 mm (1/4 in) options | 0.01640 | 0.89317 | 0.000000 | 0.87688 |

#### 5.7.5.1 Reference Fenestration Products

The construction of reference fenestration products that shall be used are listed in Table 5-3, along with their pre-calculated $SHGC_0/SHGC_1$ and $VT_0/VT_1$ values. Calculate the total fenestration product SHGC and VT for each reference fenestration product and the corresponding applied film product according to Section 5.7.5.2 and Section 5.7.5.3. This will result in the matrix in Table 5-3 for each film product, where SHGC and VT values for 'no film' refer to the reference fenestration product and values 'with film' refer to the applied film product.

**Table 5-3 Values of SHGC and VT for Reference Fenestration Products and Applied Film**

| Reference Product | | | SHGC | | VT | |
|---|---|---|---|---|---|---|
| Operator Type | Reference Frame | Reference Glazing | no film | with film | no film | with film |
| Residential Fixed | Aluminum | 3 mm (1/8 in) clear | 0.72 | | 0.74 | |
| Non-Residential Windowwall | Aluminum | 6 mm (1/4 in) clear | 0.73 | | 0.78 | |
| | | 6 mm (1/4 in) grey | 0.52 | | 0.39 | |
| Residential Fixed | Aluminum | 3 mm (1/8 in) clear<br>3 mm (1/8 in) clear | 0.64 | | 0.67 | |
| Non-Residential Windowwall | Aluminum | 6 mm (1/4 in) clear<br>6 mm (1/4 in) clear | 0.63 | | 0.69 | |
| | | 6 mm (1/4 in) grey<br>6 mm (1/4 in) clear | 0.41 | | 0.35 | |

#### 5.7.5.2 Total Fenestration Product SHGC

Calculate the total fenestration product SHGC for each reference fenestration product and the corresponding applied film product using the following equation:

Equation 5-2

Where

$SHGC_0$ = The total fenestration product SHGC for the center-of-glazing SHGC of 0.0 from column 4 of Table 5-2

$SHGC_1$ = The total fenestration product SHGC for the center-of-glazing SHGC of 1.0 from column 5 of Table 5-2

$SHGC_c$ = The center-of-glazing SHGC for the reference glazing or the reference glazing with the film applied, from columns 2 and 5 of Table 5-1, according to Section 5.7.4.1 above

Perform the calculations with $SHGC_c$, $SHGC_0$, and $SHGC_1$ values to six significant digits. Report the final SHGC value to two significant digits.

#### 5.7.5.3 Total Fenestration Product VT

Calculate the total fenestration product VT for each reference fenestration product and the corresponding applied film using the following equation:

Equation 5-3

Where

$VT_0$ = The total fenestration product VT for the center-of-glazing VT of 0.0 from column 6 of Table 5-2

$VT_1$ = The total fenestration product VT for the center-of-glazing VT of 1.0 from column 7 of Table 5-2

$VT_c$ = The center-of-glazing VT for the reference glazing or reference glazing with the film applied, from columns 3 and 6 of Table 5-1, according to Section 5.7.4.1

Perform the calculations with $VT_c$, $VT_0$, and $VT_1$ values to six significant digits. Report the final VT value to two significant digits.

### 5.7.6 Testing

If a fenestration product with applied film cannot be simulated in accordance with Section 5.7.4.1, the center-of-glazing test procedure in Section 5.7 shall be used to determine the SHGC and VT of the reference fenestration product glazing system with applied film. These values shall be used to calculate the total product SHGC and VT according to Section 5.7.5 above.

#### 5.7.6.1 Center-of-Glazing Component Test Procedure

The center-of-glazing component SHGC (SHGCc) shall be tested in accordance with NFRC 201 – see Section 7.2.2.1 of NFRC 201 for details on how to install a center-of-glazing specimen for testing.

Guidance for the appropriate use of NFRC's approved procedure for Center-of-Glazing Component Test Procedure ($VT_c$) will be published as an addendum to this procedure or as a Technical Interpretation.

#### 5.7.6.2 Total Fenestration Product Test Procedure

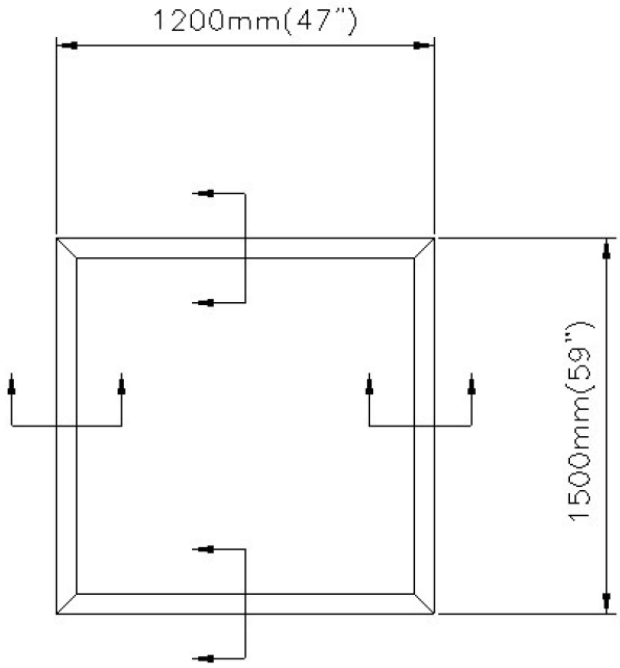
Not applicable – the frame and edge-of-glazing SHGC and VT values of reference fenestration products must be simulated.

#### 5.7.6.3 Total Fenestration Product SHGC for Non-Model Sizes

Not applicable – all reference fenestration products with applied films are to be at model sizes.

### 5.7.7 Figures

**Figure 5-1 Residential Fixed Aluminum Frame Reference Product**



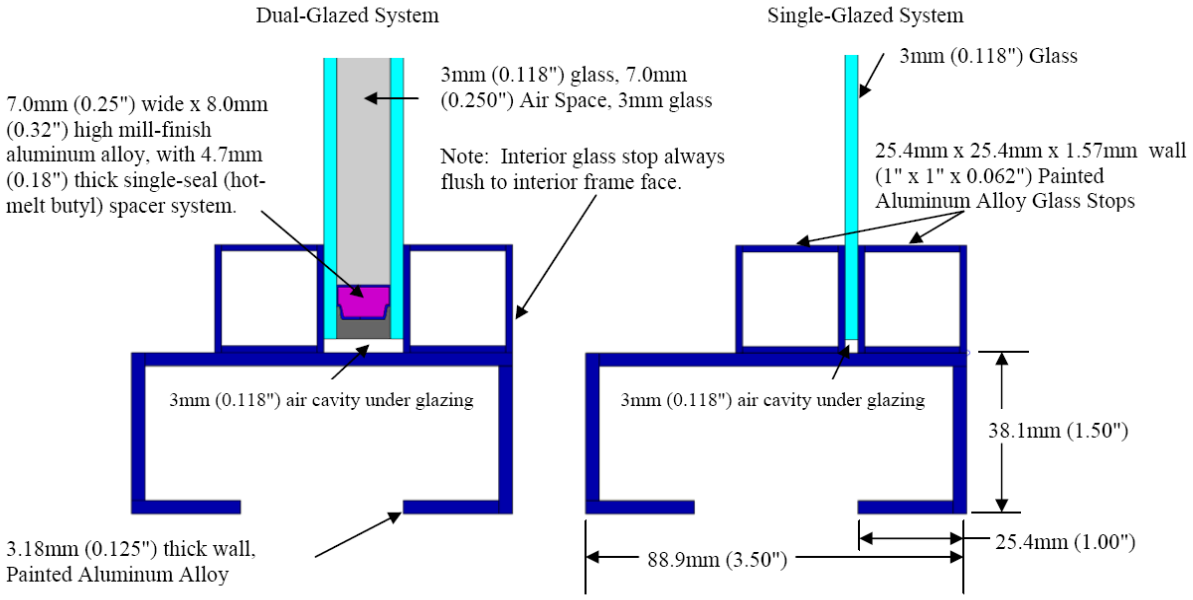
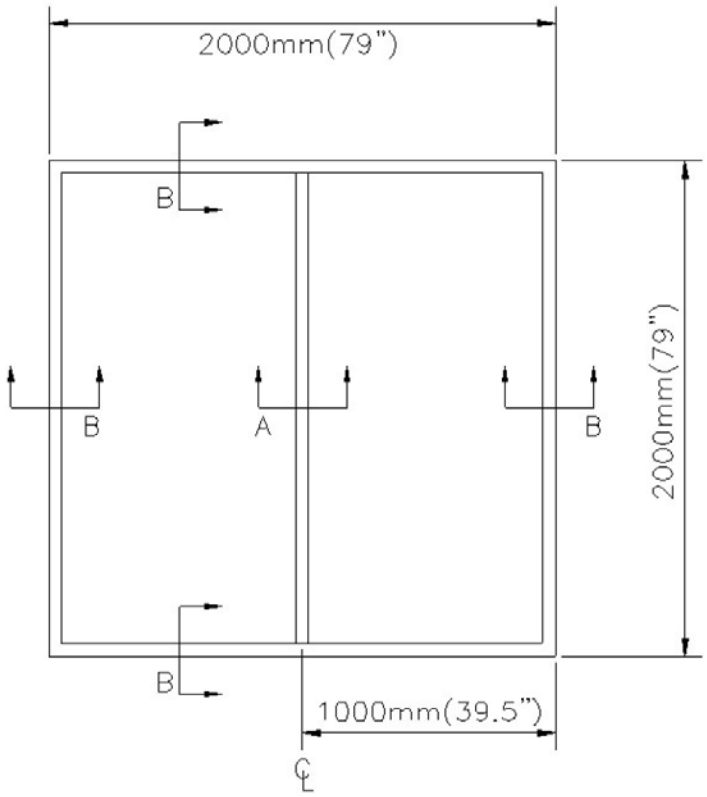



**Figure 5-2 Non-residential Windowwall Aluminum Frame Reference Product**



## Figure 5-3 Cross Section A

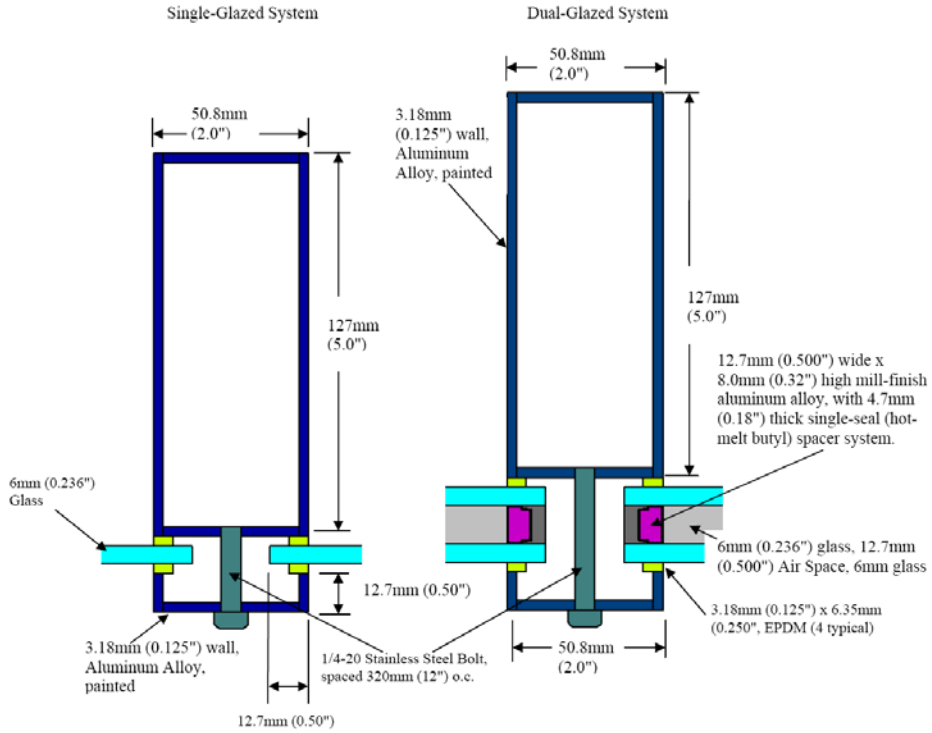
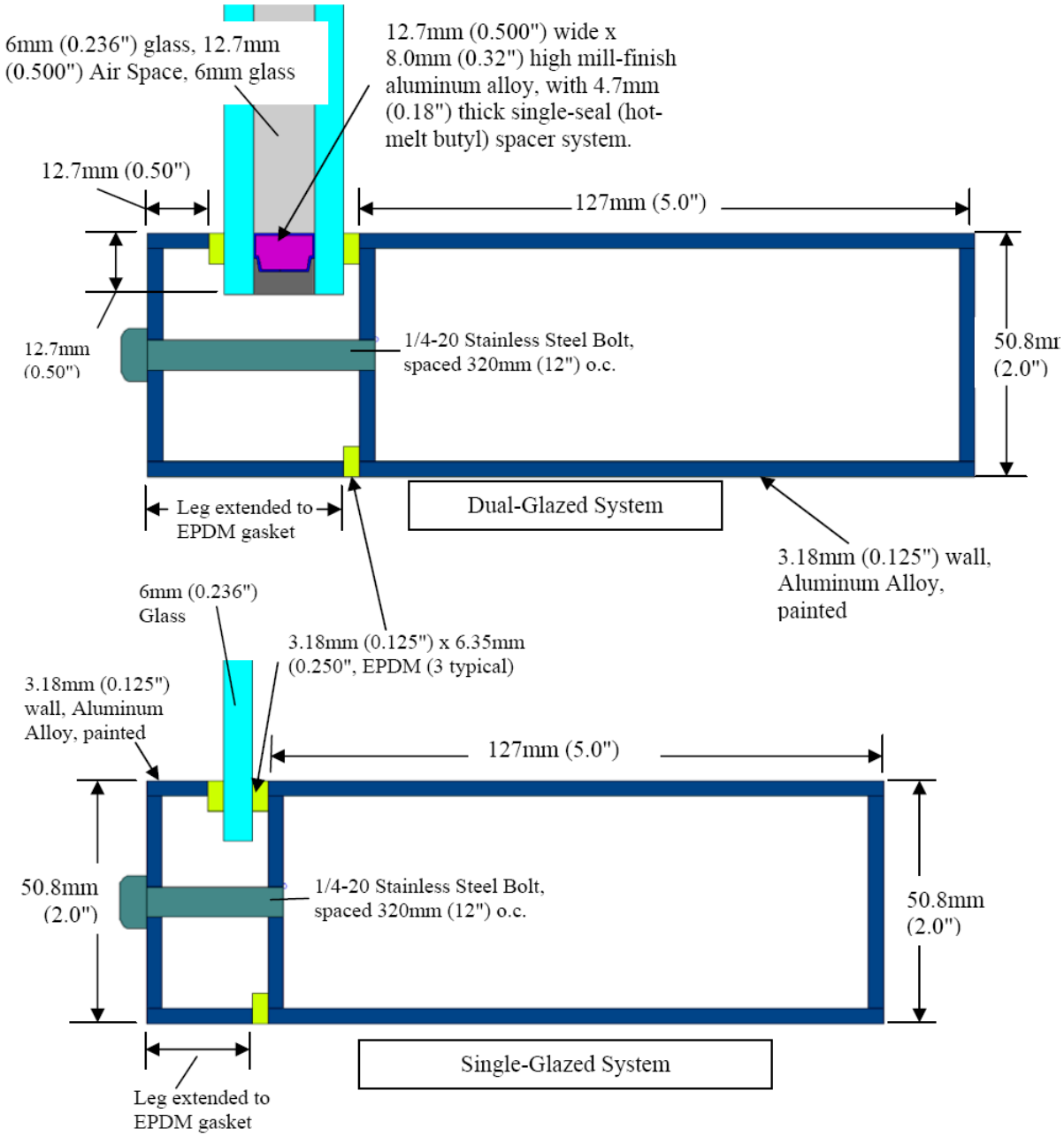


**Figure 5-4 Cross Section B**



## 5.8 Dynamic Attachment Products for Swinging Doors

Rating procedures for full and half glazed swinging doors shall be used with the dynamic attachment in the “fully open” and “fully closed” position.

### 5.8.1 Scope

This section presents additional details specific to Dynamic Attachments for Swinging Doors (DASD). This section presents and references methods for determining specific DASD SHGC and VT.

### 5.8.2 Methodology

Methodology for rating Full and Half Lite Swinging Doors can be found in Section 5.2. DASD products will be rated using reference Swinging Doors outlined in NFRC 100 Section 5.7.

### 5.8.3 Approved Computational Program

The DASD Product’s SHGC and VT shall be determined using approved glazed swinging door simulation. The DASD shall be modeled on the reference swinging doors indicated in NFRC 100 Section 5.7.3.

## 5.9 Component Modeling Approach (CMA) for Non-Residential Building Fenestration Products

This section covers methods for determining fenestration product SHGC and VT for fenestration products installed in non-residential buildings, including (but not limited to) fenestration products that are site assembled (built). This section also covers methods for determining fenestration product SHGC and VT for solarium/sunroom systems.

### 5.9.1 Scope

To specify a method for determining the SHGC and VT of non-residential fenestration systems, including site-built fenestration systems for non-residential buildings.

The ratings derived from this procedure may be used to compare thermal performance characteristics of non-residential fenestration systems and/or to provide architects, code specifiers, builders, etc., with a uniform and accurate means of determining and evaluating thermal performance characteristics of a specifically designed non-residential fenestration system. As an alternative, ratings determined in accordance with Section 4 are permitted.

### 5.9.2 Variations from Standard Product Lines

Non-residential fenestration systems covered by this method include products that are listed in NFRC 100, Table 4-3, including (but not limited to):

A. Transparent and translucent wall systems where the glazing material is glass, plastic, or other light transmitting panels (including opaque spandrel panels within the system), except those products where no testing or calculation procedure exists;

B. Glazed wall support and framing systems;

C. Changes made to a product type to address structural loads, e.g., changes made to frame components to build different size products, address wind-loads, and aesthetics.

D. Products with single or multiple glazing layers;

E. Products with spacer systems between glazings;

F. Horizontal, vertical, and sloped systems;

G. Products that, by design, may have multiple framing components and/or glazing combinations;

H. Fenestration systems using Unitized Construction, where a system is field assembled from factory assembled sub-units.

I. Spandrel panels; and

J. Non-residential products or systems not covered by NFRC 100 Section 4.4, Table 4-3.

**Combination assembly with common frame treatment:** A combination assembly that includes common frame members that wrap around the assembly and/or contain common mullion members that connect various individual products, so that the fenestration assembly is a single product and installed as such. A combination assembly with a common frame shall be treated as an assembly consisting of individual products and rated as such unless the heat flow through the common frame members differs by more than 20% from the heat flow through the frame assemblies of individual products. The heat flow shall be calculated using the best glazing option for individual cross-sections of common frame members, and their frame U-factors shall be compared to the respective frame U-factor of the individual cross-sections in the assembly.

### 5.9.3 Variations from Standard Individual Products

The following products and product configurations have special provisions:

A. Single glazed products; and

B. Double-sash products.

### 5.9.4 Variations from Standard Simulation and Test Conditions

A. For single glazed products, framing members shall be modeled using single glazing best and worst options, as detailed in Section 5.9.5.3.

B. For double-sash products, framing members shall be modeled using the same distribution of best/worst insulating and single glazing as in actual product. For example, if the actual product incorporates insulating glass (IG) and single glazing in a double-sash configuration, best/worst options should incorporate best/worst IG + single glazing. Reverse product configuration

(i.e., single + IG) shall also result in modeling frame members using the single + IG best/worst option. If double sash incorporates IG + IG configuration, that needs to be reflected in best/worst modeling.

C. Simplications to a Product Line – Frame Components

This section presents additional product line simplification rules specific to frame components.

A. Frame Grouping

All grouping rules contained in Section 4 shall be permitted to be utilized with the calculation procedures of Section 5.6. In addition, if the frames are grouped by U-factor in accordance with NFRC 100, Sections 4 and 5.9, the frame SHGC ($SHGC_f$) shall be calculated in accordance with Section 5.6.5 by using the frame U-factor group leader and the actual individual frame component projected frame depth (PFD) within that group.

### 5.9.5 Calculation of Total Product Rating

#### 5.9.5.1 Component Modeling Procedure

The SHGC and VT rating of a fenestration product may vary by size. In order to provide a uniform rating procedure, as well as size specific information, the component modeling procedure as described in this section shall be used as the primary method. For the comparison rating of non-residential systems, the SHGC and VT rating for model (standard) size per NFRC 100 Table 4-3 is calculated. SHGC and VT ratings for sizes other than standard size can be calculated for informational purposes when applicable.

#### 5.9.5.2 Basic Product Line Model and Component Information for Calculating and Reporting SHGC and VT

SHGC and VT shall be reported on a component basis for each frame assembly (i.e., sill, jambs, head, etc.), each spacer configuration, and each glazing system (center-of-glass). The SHGC and VT for frame components shall be reported as $SHGC_f$ and $VT_f$ (i.e. frame SHGC and VT) using the four representative options (Low and High), as defined in Table 5-4, and which gives a template for reporting SHGC and VT.

#### 5.9.5.3 Definition of Low and High Configurations

A total of four Low/High or L/H configurations are defined. The glazing and spacers used in the L/H configurations are defined in NFRC 100 with the best glazing system $SHGC_{cog} \leq 0.2$. In the case of single glazing systems, use the best glazing with $SHGC_{cog} \leq 0.3$ and clear glass for the worst glazing option.

These configurations are assembled from two different glazing options at the extreme ends of thermal performance and two spacer configurations at the extreme ends of thermal performance. The following are four Low and High configurations:

A. ~~b1 in Table 5-4: l~~Low glazing with low spacer ~~($SHGC_{b1}$ and $VT_{b1}$)~~;

B. ~~b2 in Table 5-4: l~~Low glazing with high spacer ~~($SHGC_{b2}$ and $VT_{b2}$)~~;

C. ~~w1 in Table 5-4: h~~High glazing with low spacer ~~($SHGC_{w1}$ and $VT_{w2}$)~~; and

D. ~~w2 in Table 5-4: h~~High glazing with high spacer ~~($SHGC_{ww}$ and $VT_{ww}$)~~.

~~**Table –5-4 Template for Reporting Component SHGC and VT**~~

| | ~~**Frame**~~ | | | |
|---|---|---|---|---|
| | ~~w1~~ | ~~w2~~ | ~~b1~~ | ~~b2~~ |
| ~~*SHGC*~~ | | | | |
| ~~*VT*~~ | | | | |
| ~~*PFD [mm](inch)*~~ | | | | |
| ~~*OWL [mm](inch)*~~ | | | | |

~~Center of Glass: $SHGC_c$ (dimensionless)~~

~~Spacer: $k_{eff}$ = W/m-K (Btu/hr-ft-F)~~

~~The quantities w1, w2, b1, and b2 are defined in Reference [10].~~

For each individual product, total fenestration product SHGC and VT shall be reported for the specified configuration at the model size, as shown in Table 4-3 of NFRC 100. The calculation of this total product SHGC and VT is done using procedure detailed in Reference [10].

### 5.9.5.4 Approved Total Fenestration Product SHGC Calculation Procedure

The total fenestration product SHGC and VT calculation procedure shall be calculated as per the procedure detailed in Reference [10].

Approved software shall be used for calculating the total fenestration product SHGC and VT. NFRC-approved software is listed in Reference 4.

Follow the NFRC-approved procedure for rounding the final result. The SHGC and VT rating shall be reported to X.XX decimals. All variables used in the formula shall be expressed to at least three significant decimal places.

#### 5.9.5.5 Determining SHGC and VT for Sloped Glazing Systems

All sloped glazing systems shall be rated for SHGC and VT at a slope of $90^{o}$ above the horizontal.

#### 5.9.5.6 Approved Total Fenestration Product SHGC and VT for Non-Model Sizes

The procedure in Reference [10] and NFRC-approved software as defined in Section 5.9.5.1 shall be used to determine size specific product indices.

## 6. REFERENCES


1) *NFRC 100-2010: Procedure for Determining Fenestration Product U-factors.* National Fenestration Rating Council: Greenbelt, MD; 2010. www.nfrc.org.

2) *NFRC 300-2010: Test Method for Determining the Solar Optical Properties of Glazing Materials and Systems*. National Fenestration Rating Council: Greenbelt, MD; 2010. www.nfrc.org.

3) *NFRC Simulation Manual*. National Fenestration Rating Council: Greenbelt, MD. www.nfrc.org.

4) *List of Approved Simulation Computer Programs.* National Fenestration Rating Council: Greenbelt, MD. www.nfrc.org.

*5)* *ISO/FDIS 15099. Thermal Performance of Windows, Doors and Shading Device-– Detailed Calculations.* International Organization for Standardization: Geneva, Switzerland. www.iso.org

6) ASTM Standard C 1172. "Standard Specification for Laminated Architectural Flat Glass." ASTM International, West Conshohocken, PA, 2009, DOI: 10.1520/C1172-09, www.astm.org.

7) ASTM Standard C 1036. "Standard Specification for Flat Glass," ASTM International, West Conshokocken, PA, 2006, DOI: 10.1520/C1036-06, www.astm.org.

8) ASTM Standard C 1048. "Standard Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass." ASTM International, West Conshohocken, PA, 2004, DOI: 10.1520/C1048-04, www.astm.org.

9) CIE "Colorimetry Technical Report." 15:2004 (3rd Edition). International Commission on Illumination (CIE), Vienna, Austria. www.cie.co.at.

10) Curcija DC, Bhandari MS, Manteghi M, Shah BV. "Component Modeling Methodology for Predicting Thermal Performance of Non-Residential Fenestration Systems," Thermal Performance of Building Envelopes IX, Clearwater, FL. December, 2004.

# APPENDIX A (NON-MANDATORY INFORMATION)

Determination of SHGC and VT at Non-Standard Sizes

The approved total fenestration product SHGC and VT calculation procedure may be used to evaluate the total fenestration product SHGC and VT for size configurations other than the Model Sizes for purposes other than certification.

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