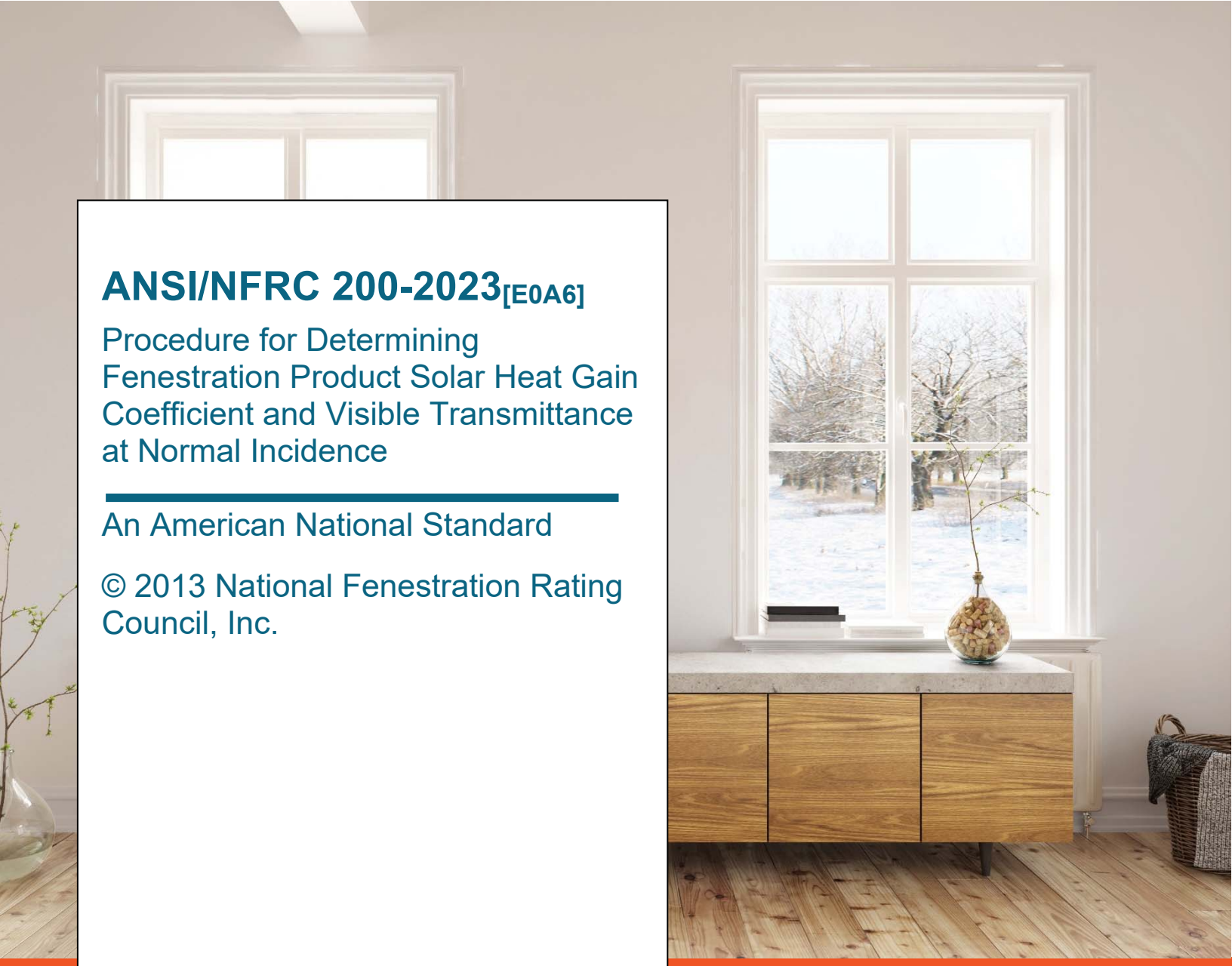

ANSI/NFRC 200-2023[E0A6]

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

An American National Standard

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National Fenestration Rating Council®

FOREWORD

The National Fenestration Rating Council, Incorporated (NFRC) has developed and operates a uniform rating system for energy and energy-related performance of fenestration 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, 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 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 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 program (Certification Program) 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).

Through the Certification Program 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 Program, 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 which has been licensed by NFRC in accordance with the requirements of the NFRC 702. NFRC-licensed IAs also 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), or 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).

Ratings for 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 Product Certification Program (PCP), Laboratory Accreditation Program (LAP) and Certification Agency Program (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 program 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

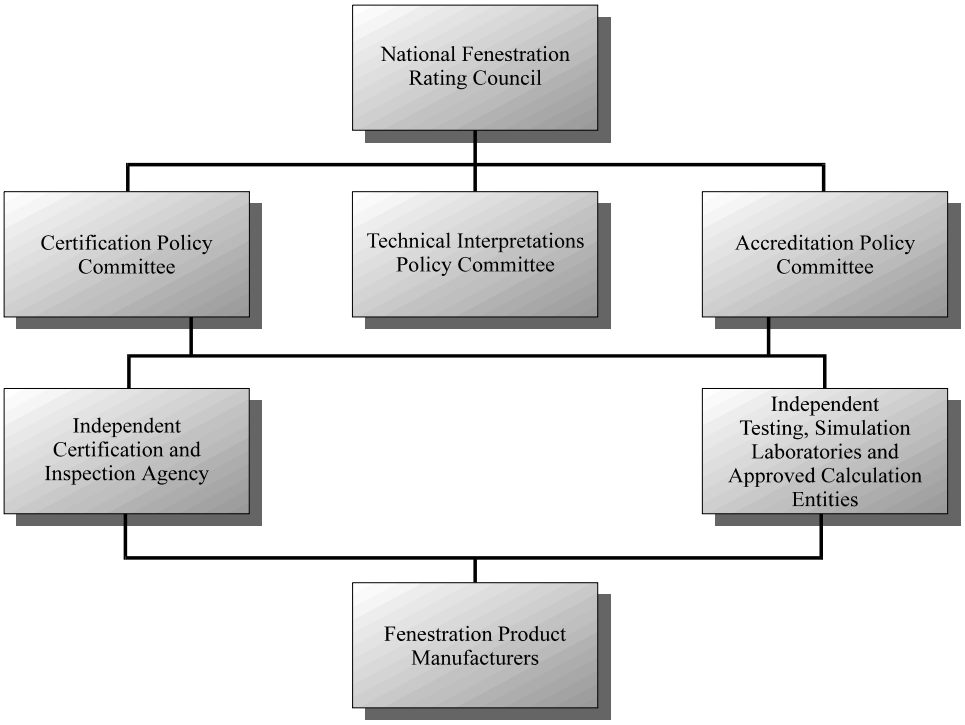


Figure 2

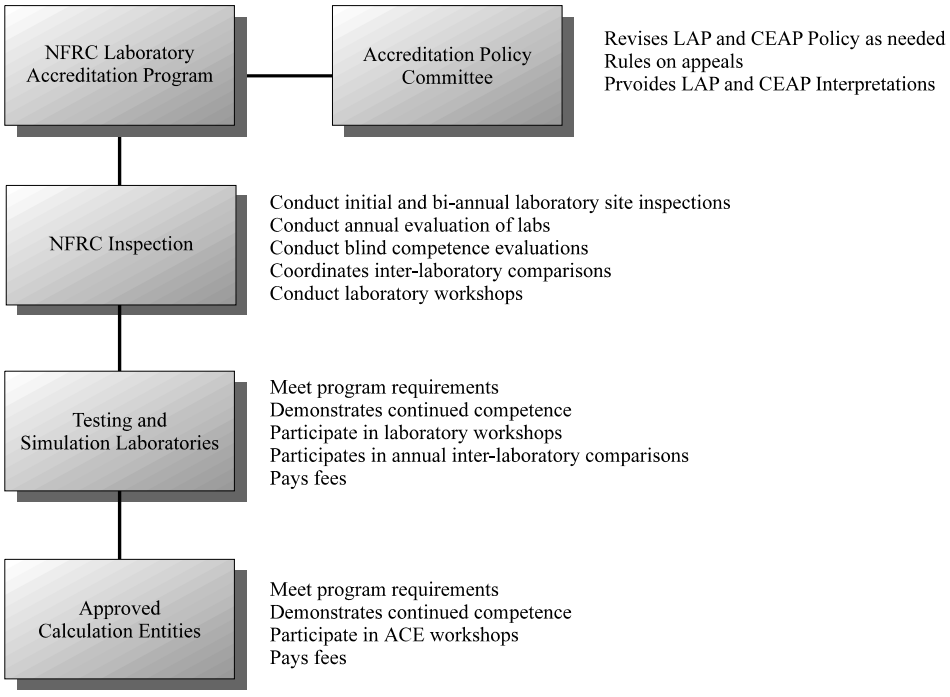
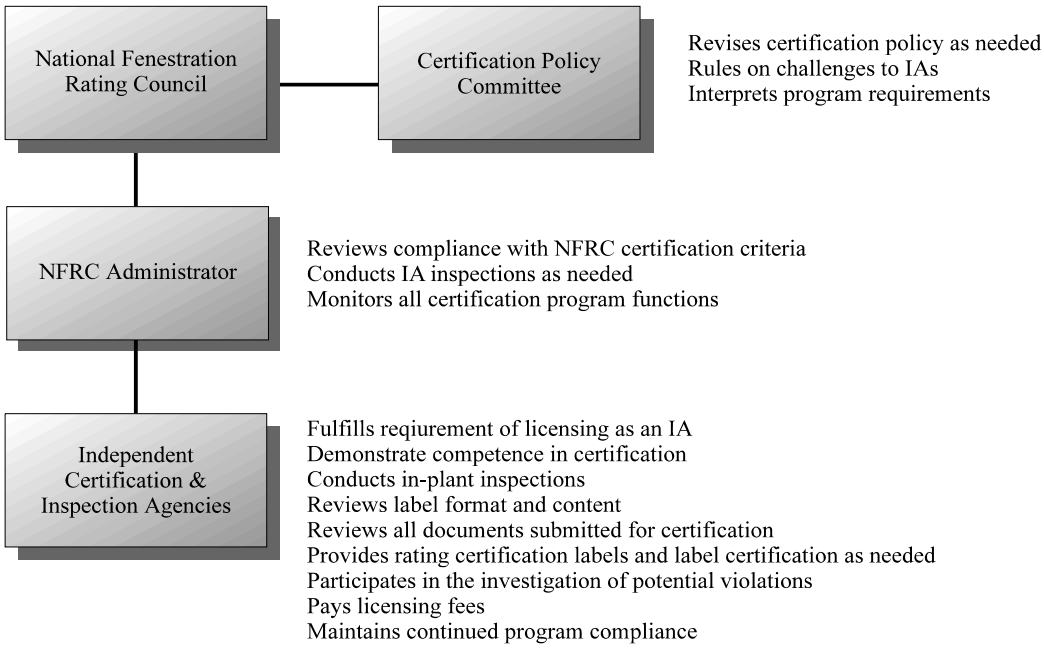


Figure 3



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.

NFRC THEREFORE DISCLAIMS ANY AND ALL LIABILITY THAT MAY ARISE FROM OR IN CONNECTION WITH SERVICES PROVIDED BY, DECISIONS MADE BY OR REPORTS OR CERTIFICATIONS ISSUED OR GRANTED BY ANY NFRC-ACCREDITED LABORATORY, NFRC-LICENSED IA OR ANY PRODUCT MANUFACTURER/ RESPONSIBLE PARTY; RELIANCE ON ANY NFRC PRODUCT DESCRIPTION, SPECIFICATION, RATING, TEST OR CERTIFICATION, WHETHER APPEARING IN A REPORT, A PRODUCT CERTIFICATION AUTHORIZATION OR A PRINTED OR ELECTRONIC DIRECTORY, OR ON A LABEL, OR ON A LABEL CERTIFICATE; OR THE SALE OR USE OF ANY NFRC-RATED OR CERTIFIED PRODUCT OR PRODUCT LINE; INCLUDING BUT NOT LIMITED TO DAMAGES FOR PERSONAL OR OTHER INJURY, LOST PROFITS, LOST SAVINGS OR OTHER CONSEQUENTIAL OR INCIDENTAL DAMAGES.

NFRC program participants are required to indemnify NFRC from and against such liability.

This standard is maintained by the Continuous Maintenance Process.

Approval of ANSI / NFRC 200 as an American National Standard is maintained using the continuous maintenance process. Comments or proposals for revisions on any part of this standard may be submitted to National Fenestration Rating Council at any time. Written comments or proposals must be in writing and be submitted to the NFRC Accredited Standards Developer at standards@nfrc.org.

Any written comments or proposals submitted to NFRC as provided above shall be submitted by NFRC to its consensus body for consideration within a reasonable timeframe not to exceed one year. The submitter will be notified by NFRC of the expected time frame for consideration of the proposal or comments. NFRC shall apply for reaffirmation of this standard regardless any comment or proposals every three years.

Table of Contents

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 [8] (except where noted) or tested in accordance with NFRC 201 [2], NFRC 202 [3], and NFRC 203 [4].

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

The following products and effects are within the scope of NFRC 200 and shall be permitted to be rated in accordance with this procedure.

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 (diffuse or specular), fritted glazing, etched glazing, sandblasted glazing, silicone coated glazing, thin plastic films (internally suspended,

internally applied, or externally applied, diffuse, or specular), rigid plastics (diffuse or specular) 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; Products with any gas-fill between glazing layers, including (but not limited to) air, argon, krypton, CO2, or mixes of these gases;

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

H. Products utilizing any 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;

I. Products designed for installation at any tilt;

J. 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

K. Products utilizing shading systems, diffusing systems, or dynamic glazing that are an integral part of the product as shipped from the manufacturer;

L. Dynamic Glazing Products, such as but not limited to electrochromic glazed products;

M. Vacuum insulating glass (VIG); and

N. Dynamic Attachments for Swinging Door.

2.1.1 Products Covered Using NFRC 201 Test Procedure for SHGC

Products not covered by NFRC 200 simulation procedures of Section 4.5 and that are covered by test-only procedures of Section 4.6 are as follows:

A. Fenestration products with shading systems other than venetian blinds between the glazing layers of the fenestration aperture;

B. Products with non-specular transmittance and reflectance properties, other than those listed in Section 2.1.E, 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, including hybrid 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. Laminated glass layers which incorporate embedded Building Integrated Photovoltaics (BIPV).

2.1.2 Products Covered Using NFRC 202 Test Procedure for VT

Products not covered by NFRC 200 simulation techniques and which are covered by test-only procedures are flat, diffusing products that cannot be measured in a spectrophotometer and cannot be simulated using computer tools due to complex internal structure or thickness. Examples of such products include, but are not limited to:

A. Translucent fiberglass or multicell plastic sandwich panels with or without internal grids;

B. Translucent multicell profile plastic panels with or without internal grids;

C. Translucent multicell plastic panels with or without internal grids;

D. Glass panels with translucent insulation insert material with or without internal grids between the glass; and

E. Translucent channel reinforcing profile glass with or without translucent insulation insert material between the glass; and

F. Laminated glass layers which incorporate embedded Building Integrated Photovoltaics (BIPV).

2.1.3 Products Covered Using NFRC 203 Test Procedure for VT

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

A. Tubular daylighting devices (TDD).

2.2 Products and Effects Not Covered

The following products and effects are beyond the scope of NFRC 200 and shall not be rated in accordance with this procedure.

2.2.1 Products and Effects Not Covered (SHGC)

A. Fenestration products with shading or diffusing systems other than those listed in Section 2.1;

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

C. Fenestration systems, other than those listed in Section 2.1, 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)

A. Fenestration products with shading or diffusing systems, other than those listed in Section 2.1;

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

C. 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); and

D. Fenestration systems, other than those listed in Section 2.1, with strong angular selectivity, that is, products being substantially specular in one or more directions while still being generally diffuse.

3. DEFINITIONS

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

Fenestration Attachment:
A device (such as, but not limited to, shades, films, or blinds) designed to be physically attached to, incorporated with, or covering a fenestration product.

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.

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

Fully CLOSED Position:
The orientation or condition of a Dynamic Glazing Product with a shading system, or a shade/blind fenestration attachment product, that allows the minimum Visible Transmittance (VT) within the design limitations of the product.

Fully OFF Position:
The orientation or condition of a Dynamic Glazing Product, such as chromogenic glazing, where the glazing is de-energized, de-activated, or otherwise “OFF.”

Fully ON Position:
The orientation or condition of a Dynamic Glazing Product, such as chromogenic glazing, where the glazing is energized, activated, or otherwise “ON.”

Fully OPEN Position:

The orientation or condition of a Dynamic Glazing Product with a shading system, or a shade/blind fenestration attachment product, that allows the maximum Visible Transmittance (VT) within the design limitations of the product.

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:

Two or more sheets of glass bonded together with one or more interlayers of transparent plastic to which the glass adheres if broken, conforming to ASTM C1172.

Lite:

Another term for glazing used in a fenestration product. Frequently spelled “lite” in industry literature to avoid confusion with “light,” as in “visible light.”

Obscure Glazing:

Glazing layer that fully or partially obscures or distorts the image through the layer. Including but not limited to acid-etched, imaged, fritted, silicone coated, embossed, patterned, textured, wired, and stained glass. Also included are products with privacy applied films and light-scattering interlayers.

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):

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 ANSI/NFRC 100.

Divider Solar Heat Gain Coefficient ($SHGC_d$):

The SHGC representative of the divider area, as defined in ANSI/NFRC 100.

Edge-of-glazing Solar Heat Gain Coefficient ($SHGC_e$):

The SHGC representative of the edge of glazing area, as defined in ANSI/NFRC 100.

Edge-of-divider Solar Heat Gain Coefficient ($SHGC_{de}$):

The SHGC representative of the edge-of-divider area, as defined in ANSI/NFRC 100.

Center-of-glazing Solar Heat Gain Coefficient ($SHGC_c$)

The SHGC representative of the center of glazing area, as defined in ANSI/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):

The ratio of visible radiation entering the space through the fenestration product to the incident visible radiation, determined as the spectral transmittance of the total fenestration system, weighted by the photopic response of the eye and integrated into a single dimensionless value. Weighted by a standard solar spectrum.

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 ANSI/NFRC 100).

Divider Visible Transmittance (VT_d):
The VT representative of the divider area, as defined in ANSI/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 ANSI/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 ANSI/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 ANSI/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 ANSI/NFRC 100 and in accordance with ISO 15099, using the fenestration product sizes as given in Table 4-3 of ANSI/NFRC 100. Fenestration products shall be evaluated without screens or removable grilles. The items listed below are exceptions to ISO 15099 that are to be implemented in NFRC-approved software/algorithms:

A. Include models for venetian blind slats (See References 14 and 15):

B. Thermal radiation from venetian blinds shall be calculated using directional diffuse radiation (See References 14 and 15);

C. Include models for fritted, etched, or sandblasted glazing (See References 15 and 16); and

D. Diffuse solar radiation propagation through the glazing system shall be calculated using matrix methodology (See References 15, 17 and 18).

E. For opaque spandrel panel systems, the center-of-glass SHGC shall be determined using Berkeley Lab WINDOW. (See Reference 6)

F. Include models for vacuum insulating glass (VIG) (See Reference 19 and 20)

4.1.2 Testing Alternative

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

For translucent panels, center-of-glazing VT shall be tested in accordance with NFRC 202.

For TDD products, the VT shall be tested in accordance with NFRC 203.

For products not covered under NFRC 202 or NFRC 203, the component or 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 ANSI/NFRC 100 for the definition of a product line.

4.2.2 Individual Products

Refer to Section 4.2.2 of ANSI/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. To determine representative frame U-factors for a group from the existing 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. Should the lowest center-of-glazing option be included in a center-of-glazing grouping per ANSI/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. Assume a default divider U-factor of 2.27 $W/m^{2}\cdot ºC$ (0.40 $Btu/h\cdot ft^{2}\cdot ºF$) 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; 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 the purposes of determining SHGC, the shading system and glazing layers comprising each group leader shall be determined using one of the following methods:

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.

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.

ii. If a shading manufacturer chooses to group products based on color, the products shall be modeled using default reflectance values (R_{sol} and R_{vis}) of 0.050, an emissivity value of 0.9, and a transmittance value (T_{ir}) of 0.00.

NOTE: If grouping by material, refer to Section 4.2.4.2 in ANSI/NFRC 100 for material properties.

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 ± 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. Exception to this is the modeling of an opaque spandrel panel system which shall create metal and insulation materials in the Glass Library for thickness, Tsol, Rsol1, Tvis, Rvis1, Rvis2, Tir, emissivity (front and back), and conductivity (See Reference 6 for simulation setup in Berkeley Lab WINDOW).The center-of-glazing SHGC (SHGCc) shall be determined using the following conditions:

Tin = 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 and VT of the individual fenestration products. See Section 4.6.1 for both the center-of-glazing and the total fenestration product.

4.3.2.1 SHGC Testing

A. Environmental Conditions during NFRC 201 Testing

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

ii. Inside surface coefficient (as measured on a vertical CTS per Section 5.5.1 of NFRC 201) shall be 7.7 W/m^{2}K ± 5% (1.4 Btu/h•ft^2•ºF ± 5%);

iii. The solar irradiance shall never be less than 680 W/m^2 (200 Btu/h•ft^2);

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

v. The aperture of the solar calorimeter (i.e., the plane of the outside surface of the

surround panel) shall not be tilted more than 60° 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.

B. Center-of-Glazing Component Test Procedure

i. The center-of-glazing SHGC shall be calculated in accordance with NFRC 201, applying environmental conditions specified in Section 4.3.2.1.A of this document;

ii. For a product that consists of a glazing panel only (without frame), the tested SHGC per NFRC 201 shall be the SHGC of the product.

4.3.2.2 VT Testing

A. Environmental Conditions during TDD NFRC 203 Testing (See NFRC 203).

B. Center-of-Glazing Component Test Procedure

i. The center-of-glazing VT shall be calculated in accordance with NFRC 202;

ii. For a product that consists of a glazing panel only (without frame), the tested VT per NFRC 202 shall be the VT of the product.

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 ANSI/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.

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

B. For product groupings within a product line identified in Section 4.2.3.A with respect to frame differences, the group leader 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;

C. For divider groupings, identified in Section 4.2.3.B, 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. 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 38.1 mm (1.50 in) and dividers less than 25.4 mm (1.00 in) are modeled at 19.05 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 patterns, refer to ANSI/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 ANSI/NFRC 100 and Section 5.6 in ANSI/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 $SHGC_0$, $SHGC_1$, 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 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 $SHGC_0$, $SHGC_1$, 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, then the method in Section 4.7.B shall be used as appropriate;

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 assembly's 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 obscure glazing shall be permitted to be assumed to be equivalent to the ratings when using a same-thickness glazing configuration without the obscuring features as long as this change is not associated with a change in coating properties or thermal conductivity. This option can be used as an alternative to obtaining product properties using the measurement procedure defined in NFRC 300 and 301 for diffuse products.

Glazing layers that are partially covered with a light-scattering element shall be simulated using the properties of the fully covered layer and properties of the non-scattering layer, and the final result is the area-weighted mix of the different areas 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

H. Products that meet the definition of a Dynamic Glazing Product shall be rated at their Fully ON/CLOSED and Fully OFF/OPEN 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, as outlined in this section or Section 4.6 as appropriate.

When rating Dynamic Glazing Products with slatted blinds between glass in the Fully OFF/OPEN position, the standardized slat stack heights of Table 4-2 of ANSI/NFRC 100 shall be used.

I. Product lines using the Trendline approach per Section 5.11 of ANSI/NFRC 100 shall use lowest center-of-glass endpoint to calculate the SHGC0, SHGC1, VT0, and VT1 for each Trendline.

J. Product lines using the Commercial Trendline approach (CTA) per Section 5.12 of ANSI/NFRC 100 shall use the SHGC and VT trendlines in 5.10.2.

4.5.1 Component

4.5.1.1 Approved Center-of-Glazing Simulation Program

Approved center-of-glazing software shall be used to determine SHGCc and VTc. 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 ANSI/NFRC 100.

4.6 Test Procedures

If a product listed in Section 2.1 cannot be simulated in accordance with Section 4.5, the test procedures in this section shall be used to determine the SHGC and VT of the individual fenestration product: 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 ANSI/NFRC 100 are met. The only time a product line shall contain tested total fenestration product SHGC and/or VT 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, written permission of NFRC is required for products not specifically addressed in this document.

Currently complex glazed products other than the following cannot be simulated:

A. Products with between-glass venetian blinds,

B. Products with outdoor woven shades,

C. Products with indoor woven shades,

D. Products with indoor venetian blinds, and

E. Products with fritted glazing.

4.6.1 Total Fenestration Product

A. The total fenestration product SHGC shall be calculated in accordance with NFRC 201 at the conditions specified in Section 4.3.2.1.A.

B. For TDD products, the determination of the whole product VT is per NFRC 203.

Guidance for the appropriate use of any future 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

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

B. The center-of-glazing VT shall be measured in accordance with NFRC 202.

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 SHGC0, SHGC1, VT0, and VT1 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:

$$SHGC = SHGC_0 + SHGC_c(SHGC_1 - SHGC_0)$$ 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 $SHGC_c$, SHGC0, and SHGC1 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:

$$VT = VT_0 + VT_c(VT_1 - VT_0)$$ 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 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, 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. See exceptions below for Vehicular Access (Garage) Doors and Side-Hinged Exterior

Exceptions:

Opaque spandrel panel fenestration products do not require VT ratings and therefore any combined references in the sections below for VT shall be ignored. For whole product SHGC of spandrel panel system fenestration products, equation 4-3 shall be used to area-weight the framing SHGC with the opaque spandrel $SHGC_c$.

i. Vehicular Access (Garage) Doors do not require VT ratings. Therefore, any combined references in the sections below for VT shall be ignored. Additionally, frame representative

SHGC0 and SHGC1 values are not required and therefore a whole product SHGC rating shall be obtained by following steps i. through v. below, and then referring to Section 5.5.5;

ii. Side-hinged exterior doors using the Simplified Door Rating (SDR) method shall use a default glazing in the doorglass assembly (DGAA) for determining the product line's SHGC0, SHGC1, VT0, and VT1 values. Therefore, only iii of this section applies. Refer to Section 5.2.2 for the modified SHGC0, SHGC1, VT0, and VT1 calculations that shall be used in Equations 4-1 and 4-2 for whole product SHGC/VT ratings.

(a) Center-of-glazing SHGC and VT using the approved center-of-glazing computational program;

(b) Edge-of-glazing SHGC and VT shall be equal to the center-of-glazing SHGC and VT values, respectively. This includes the glass edge for side-hinged exterior doors and vehicular access (garage) doors.

(c) 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;

Equation 4-3

$$SHGC_f = \alpha \cdot \frac{U_f}{\frac{Asurf}{Af} h_{out}}$$

Where

α = 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} = 20.6 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 ANSI/NFRC 100, except as noted in Section 4.5 of this document,

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

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

c. The component areas:

(i) Center-of-glazing area,

(ii) Divider area,

(iii) Edge-of-glazing area,

(iv) Edge-of-divider area,

(v) Frame area,

(vi) Edge-of-Lite area,

(vii) Edge-of-Panel area,

(viii) Door-Lite Frame area,

(ix) Panel Core area,

(x) Door Core area, and

(xi) Projected fenestration product area

d. Perform the following calculations (as shown in Equation 4-4) to determine SHGC0 and SHGC1, where applicable:

(i) Multiply all fenestration component SHGC: frame, door panel core, door panel edge, door core, door-lite frame, divider, 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.

(ii) Total these quantities and 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

$$SHGC_0 = \frac{[(SHGC_x A_x) + (SHGC_d A_d) + (SHGC_e A_e) + (SHGC_{de} A_{de}) + (SHGC_{le} A_{le}) + (SHGC_c A_c)]}{A_{pf}}$$

$$SHGC_1 = \frac{[(SHGC_x A_x) + (SHGC_d A_d) + (SHGC_e A_e) + (SHGC_{de} A_{de}) + (SHGC_{le} A_{le}) + (SHGC_c A_c)]}{A_{pf}}$$

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

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

iv. Perform the following calculations (as shown in Equation 4-5) to determine VT0 and VT1, 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

$$VT_0 = \frac{[(VT_x A_x) + (VT_d A_d) + (VT_e A_e) + (VT_{de} A_{de}) + (VT_{le} A_{le}) + (VT_c A_c)]}{A_{pf}}$$

$$VT_1 = \frac{[(VT_x A_x) + (VT_d A_d) + (VT_e A_e) + (VT_{de} A_{de}) + (VT_{le} A_{le}) + (VT_c A_c)]}{A_{pf}}$$

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

v. 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

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

i. Product with the Greatest Daylight Opening;

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

ii. Product with the Least Daylight Opening;

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

B. 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

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

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

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

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

5.2 Side-Hinged Exterior 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.

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.

5.2.1.1 Simplification

For SHGC 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), the option shall be rated with the less than 25.4 mm (1.00 in) divider option.

5.2.2 Simplified Door Rating (SDR) Method

This method shall refer to Section 4.5.B through 4.5.D to obtain the DGAA and door slab 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.

5.2.2.1 Determining $SHGC_0$ and $SHGC_1$

The opaque door area (that is, the area outside the DGAA, including door frame and sill) shall be simulated in five configurations, calculated per Equation 5-1, for the opaque, ¼ lite, ½ lite, ¾ lite, and full-lite opaque areas;

The SHGC of the DGAA of the door shall be simulated using 4 configurations, calculated per Equations 5-2 and 5-3, at the ¼ lite, ½ lite, ¾ lite and full-lite sizes (See Figure 5-10 of ANSI/NFRC 100 for door slab with various panel sizes);

Equation 5-1:

$$SHGC_{sd}A_{sd} = \left[\left(SHGC_f A_f\right) + \left(SHGC_{dc}A_{dc}\right) + \left(SHGC_p A_p\right) + \left(SHGC_{ep}A_{ep}\right)\right]$$

Equation 5-2: For $SHGC_0$ of DGAA

$$SHGC0_{DGAA}A_{DGAA} = \left[\left(SHGC_{lf}A_{lf}\right) + \left(SHGC_d A_d\right) + \left(SHGC_{de}A_{de}\right) + \left(SHGC_{eg}A_{eg}\right)\right]$$

Equation 5-3: For $SHGC_1$ of DGAA

$$SHGC1_{DGAA}A_{DGAA} = \left[\left(SHGC_{lf}A_{lf}\right) + \left(SHGC_d A_d\right) + \left(SHGC_{de}A_{de}\right) + \left(SHGC_{eg}A_{eg}\right) + \left(A_c\right)\right]$$

Equation 5-4*:*

$$SHGC_0 = \frac{\left[\left(SHGC_{sd}A_{sd}\right) + \left(SHGC0_{DGAA}A_{DGAA}\right)\right]}{A_t}$$

Equation 5-5:

$$SHGC_1 = \frac{\left[\left(SHGC_{sd}A_{sd}\right) + \left(SHGC1_{DGAA}A_{DGAA}\right)\right]}{A_t}$$

Where:

$SHGC_f$	=	Frame SHGC
A_f	=	Frame area
$SHGC_{lf}$	=	Lite frame SHGC
A_{lf}	=	Lite frame area
$SHGC_d$	=	Divider SHGC
A_d	=	Divider area
$SHGC_{de}$	=	Edge-of-divider SHGC
A_{de}	=	Divider area
$SHGC_{eg}$	=	Edge-of-lite SHGC
A_{eg}	=	Edge-of-lite area
$SHGC_c$	=	Center-of-lite SHGC
A_c	=	Center-of-lite Area

$SHGC_{dc}$	=	Door or Sidelite core SHGC
A_{dc}	=	Door or Sidelite core area
$SHGC_p$	=	Panel SHGC
A_p	=	Panel area
$SHGC_{ep}$	=	Edge-of-panel SHGC
A_{ep}	=	Edge-of-panel area
$SHGC0_{DGAA}$	=	Doorglass Assembly Area SHGC with a center-of-glass SHGCc of 0.00
$SHGC1_{DGAA}$	=	Doorglass Assembly Area SHGC with a center-of-glass SHGCc of 1.00
A_{DGAA}	=	Doorglass Assembly Area at ¼ Lite, ½ Lite, ¾ Lite, Full-Lite
$SHGC_{sd}$	=	SGHC of Door Slab & Frame/Sill Opaque area
A_{sd}	=	Opaque Area of NFRC Model Size Swinging Door, or Sidelite, for 1/4 lite, 1/2 lite, 3/4 lite, full-lite and complete opaque configurations
A_t	=	Total Area
$SHGC_0$	=	Representative SHGC of product with a COG SHGC = 0.00
$SHGC_1$	=	Representative SHGC of product with a COG SHGC = 1.00

5.2.2.2 Determining Whole Product SHGC

For any $SHGC_c$, the total SHGC can be calculated using $SHGC_0$ and $SHGC_1$ determined from 5.2.2.1 and input into Equation 4-1.

5.2.2.3 Determining VT_0 and VT_1

The opaque door area (that is, the area outside the DGAA, including door frame and sill) shall be simulated in five configurations, calculated per Equation 5-4, for the opaque, ¼ lite, ½ lite, ¾ lite, and full-lite opaque areas;

The DGAA of the door shall be simulated using 4 configurations, calculated per Equation 5-5, at the ¼ lite, ½ lite, ¾ lite and full-lite sizes (See Figure 5-10 in ANSI/NFRC 100 for door slab with various panel sizes);

Equation 5-6:

$$VT_{sd}A_{sd} = \left[\left(VT_fA_f\right) + \left(VT_{dc}A_{dc}\right) + \left(VT_pA_p\right) + \left(VT_{ep}A_{ep}\right)\right]$$

Equation 5-7: For VT_0 of DGAA

$$VT0_{DGAA}A_{DGAA} = \left[\left(VT_{lf}A_{lf}\right) + \left(VT_dA_d\right) + \left(VT_{de}A_{de}\right) + \left(VT_{eg}A_{eg}\right)\right]$$

Equation 5-8: For VT_1 of DGAA

$$VT1_{DGAA}A_{DGAA} = \left[\left(VT_{lf}A_{lf}\right) + \left(VT_dA_d\right) + \left(VT_{de}A_{de}\right) + \left(VT_{eg}A_{eg}\right) + \left(A_c\right)\right]$$

Equation 5-9:

$$VT_0 = \frac{\left[\left(VT_{sd}A_{sd}\right) + \left(VT_{0DGAA}A_{DGAA}\right)\right]}{A_t}$$

Equation 5-10:

$$VT_1 = \frac{\left[\left(VT_{sd}A_{sd}\right) + \left(VT_{1DGAA}A_{DGAA}\right)\right]}{A_t}$$

Where:

VT_f	=	Frame VT
A_f	=	Frame area
VT_{lf}	=	Lite frame VT
A_{lf}	=	Lite frame area
VT_d	=	Divider VT
A_d	=	Divider area
VT_{de}	=	Edge-of-divider VT
A_{de}	=	Divider area
VT_{eg}	=	Edge-of-lite VT
A_{eg}	=	Edge-of-lite area
VT_c	=	Center-of-lite VT
A_c	=	Center-of-lite Area
VT_{dc}	=	Door or Sidelite core VT
A_{dc}	=	Door or Sidelite core area
VT_p	=	Panel VT
A_p	=	Panel area
VT_{ep}	=	Edge-of-panel VT
A_{ep}	=	Edge-of-panel area
$VT0_{DGAA}$	=	Doorglass Assembly Area SHGC with a center-of-glass VTc of 0.00
$VT1_{DGAA}$	=	Doorglass Assembly Area SHGC with a center-of-glass VTc of 1.00
A_{DGAA}	=	Doorglass Assembly Area at ¼ Lite, ½ Lite, ¾ Lite, Full-Lite
VT_{sd}	=	VT of Door Slab & Frame/Sill Opaque area

A_{sd}	=	Opaque Area of NFRC Model Size Swinging Door, or Sidelite, for 1/4 lite, 1/2 lite, 3/4 lite, full-lite and complete opaque configurations
A_t	=	Total Area
VT_0	=	Representative VT of product with a COG VT = 0.00
VT_1	=	Representative VT of product with a COG VT = 1.00

5.2.2.4 Determining Whole Product VT

For any VT_c, the total VT can be calculated using VT_0 and VT_1 determined from 5.2.2.3 and input into Equation 4-2.

5.2.3 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 the 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 ANSI/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 (1.5 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 m^2 (0.010 ft^2) 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.

Equation 5-1

$$SHGC_t = \frac{\left[\begin{array}{c}(SHGC_{tr}A_{tr}) + (SHGC_{br}A_{br}) + (SHGC_{es}A_{es}) + \left(SHGC_{cg}A_{cg}\right) + \left(SHGC_{gf}A_{gf}\right) + \\ (SHGC_dA_d) + (SHGC_{de}A_{de}) + (SHGC_{dc}A_{dc})\end{array}\right]}{A_{pt}}$$

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 $SHGC_c$ of 0.86 ± 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 $SHGC_c$ of 0.82 ± 0.02 when modeled in configuration B (below) without the film installed. Any grey glass may be used that has a center-of-glazing $SHGC_c$ of 0.59 ± 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 3 mm (1/8 in) clear	0.761	0.814			
6 mm (1/4 in) clear 6 mm (1/4 in) clear	0.702	0.786			
6 mm (1/4 in) grey 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	0.011858	0.830317	0.000000	0.818459
Non-Residential Window wall	Aluminum	All 6 mm (1/4 in) options	0.015962	0.892832	0.000000	0.87687

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 SHGC0/SHGC1 and VT0/VT1 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 3 mm (1/8 in) clear	0.64		0.67	
Non-Residential Windowwall	Aluminum	6 mm (1/4 in) clear 6 mm (1/4 in) clear	0.63		0.69	
		6 mm (1/4 in) grey 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:

$$SHGC = SHGC_0 + SHGC_c(SHGC_1 - SHGC_0) \qquad \text{Equation 5-2}$$

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:

$$VT = VT_0 + VT_c(VT_1 - VT_0) \qquad \text{Equation 5-3}$$

$$VT = VT_0 + VT_c(VT_1 - VT_0)$$

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 Specified 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

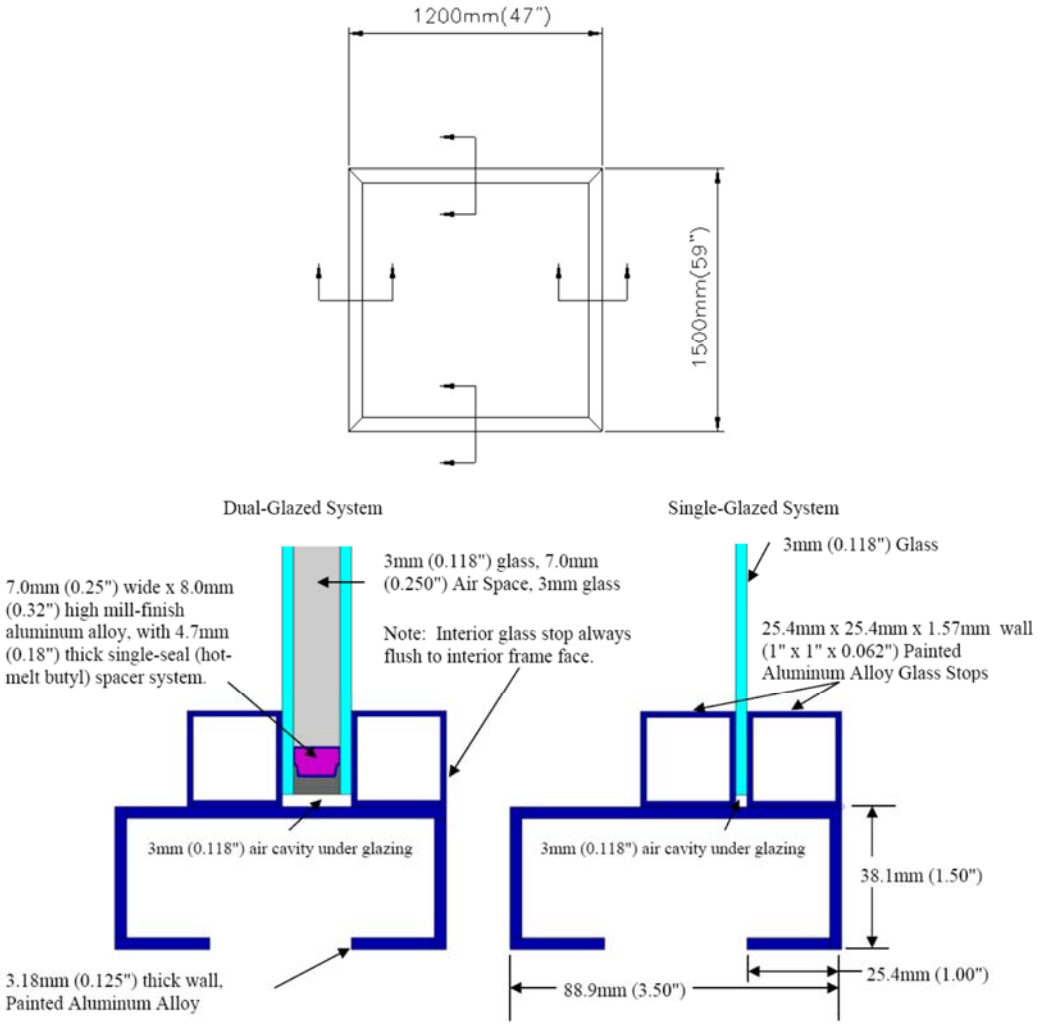


Figure 5-2 Non-residential Windowwall Aluminum Frame Reference Product

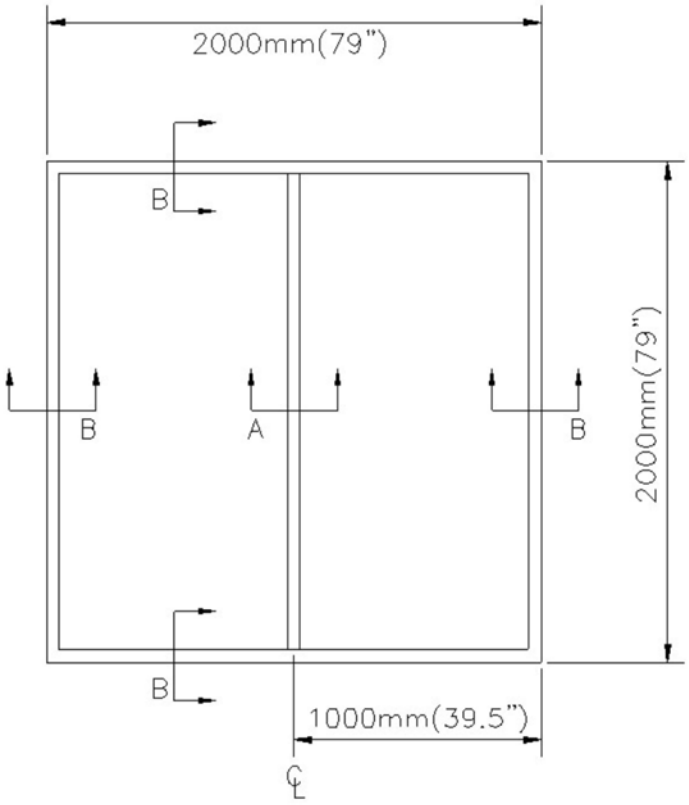


Figure 5-3 Cross Section A

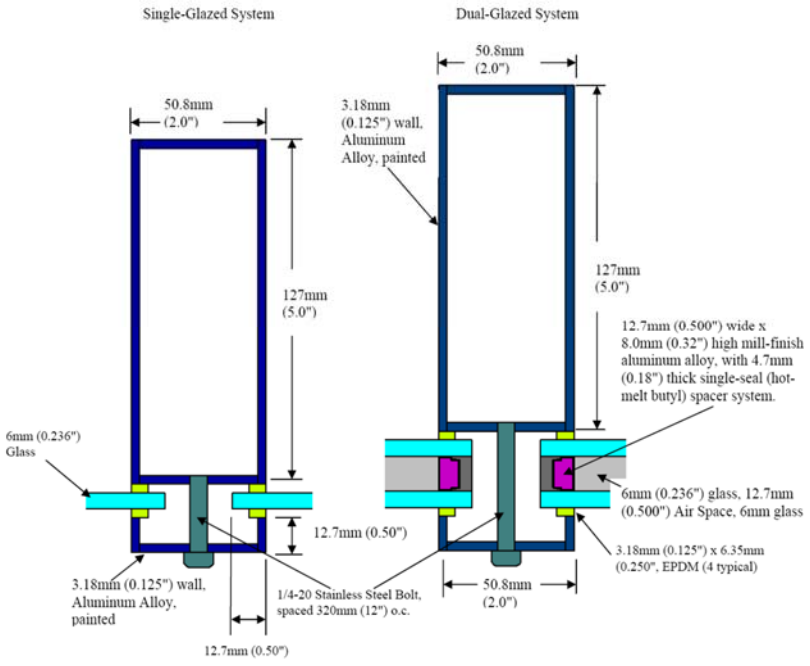
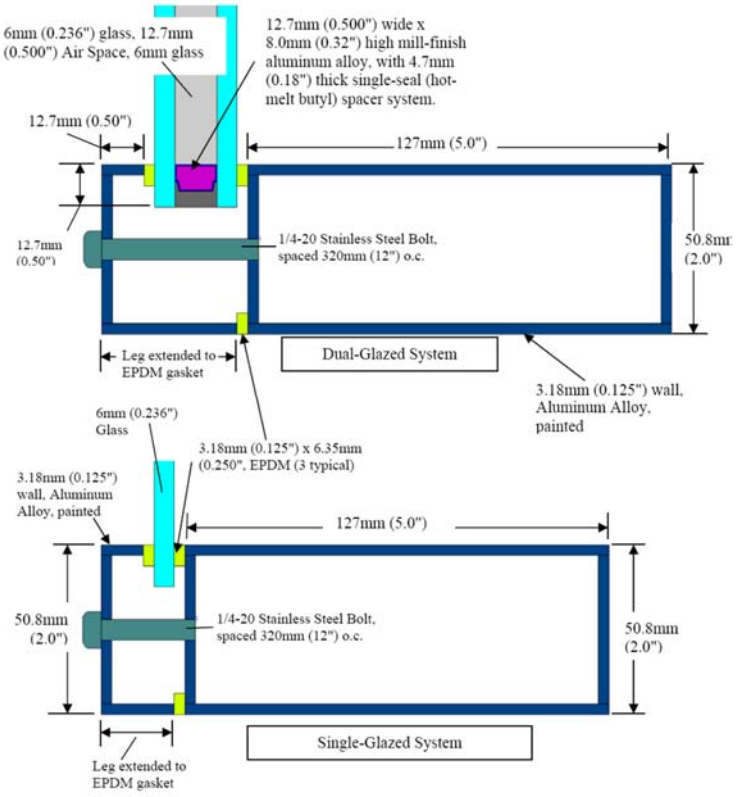


Figure 5-4 Cross Section B



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” positions.

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 ANSI/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 ANSI/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 ANSI/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 panel systems only with NFRC approved glazing layers in the IGDB. That is, panels without opaque metal skin insulation and/or fire safing; and

J. Non-residential products or systems not covered by ANSI/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. Simplifications to a Product Line – Frame Components

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

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 ANSI/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 product size. In order to provide a uniform rating procedure, as well as specified size 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 the model size per ANSI/NFRC 100 Table 4-3 is calculated. SHGC and VT ratings for sizes other than the model size can be calculated for informational purposes when applicable.

When a framing system used for curtain wall, window wall or sloped glazing is also used in other product types, the frame absorptance shall be 0.5 in the CMAST program.

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 ANSI/NFRC 100 with the best glazing system $SHGC_{cog} < 0.2$. In the case of single glazing systems, use the best glazing with $SHGC_{cog} < 0.3$ 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. Low glazing with low spacer;

B. Low glazing with high spacer;

C. High glazing with low spacer; and

D. High glazing with high spacer.

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 ANSI/NFRC 100. The calculation of this total product SHGC and VT is done using procedure detailed in Reference [13].

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 [13].

Approved software shall be used for calculating the total fenestration product SHGC and VT. NFRC-approved software is listed in Reference 7.

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 90º above the horizontal.

5.9.5.6 Approved Total Fenestration Product SHGC and VT for Specified Sizes

The procedure in Reference [13] and NFRC-approved software as defined in Section 5.9.5.1 shall be used to determine specified size product indices.

5.10 Commercial Trendline Approach (CTA)

This section provides procedures for determining commercial fenestration product SHGC and VT using the CTA, including (but not limited to) fenestration products that are site assembled (built).

5.10.1 Variations from Standard Product Lines

Commercial fenestration systems covered by the CTA method include products that are listed in ANSI/NFRC 100, Table 4-3, including (but not limited to):

Mulled Products: Mulled combination and composite products shall be simulated as individual products at the model size shown in Table 4-3 of ANSI/NFRC 100.

5.10.2 Development of a Trendline

SHGC and VT trendlines shall follow ANSI/NFRC 100, section 5.12.5.3 and use the same U_c point glazing configurations but use the corresponding $SHGC_c$ and VT_c values to generate trendlines.

A. Trendline $SHGC_b$ = whole product SHGC trendline using the default low spacer system

B. Trendline $SHGC_w$ = whole product SHGC trendline using the default high spacer system

C. Trendline VT_b = whole product VT trendline using the default low spacer system

D. Trendline VT_w = whole product VT trendline using the default high spacer system

The R^2 coefficient of determination is a measure of the linearity of the trendline points. Its value shall be greater than 0.980.

If the trendline's R2 evaluation does not meet linearity standards, the results shall require the re-simulation of the existing points or the re-categorization of the trendline per ANSI/NFRC 100, section 5.12.5.1.

5.10.3 Total Product Rating

Equation 5-15 and Equation 5-16 in Section 5.10.3.2 are used to determine the whole product $SHGC_{tot}$ and VT_{tot} rating of each individual product option categorized per ANSI/NFRC 100, Section 5.12.5.1.

Equation 5-15 and Equation 5-16 uses an interpolation procedure between Trendline $SHGC_w$ and Trendline $SHGC_b$ and between Trendline VT_w and Trendline VT_b and requires spacer system k_{eff} in ANSI/NFRC 100, Section 5.12.6.

5.10.3.1 SHGC and VT Range Determination

The SHGC and VT for the default low ($SHGC_b$ and VT_b) and default high ($SHGC_w$ and VT_w) spacer systems with the categorized glazing option's center-of-glass SHGC (SHGCc) and VT (VTc) shall be determined using the SHGC and VT trendlines, determined in 5.10.2.

Equation 5-11:

$$SHGC_w = Intercept_w + Slope_w \, x \, SHGC_c$$

Equation 5-12:

$$SHGC_b = Intercept_b + Slope_b \, x \, SHGC_c$$

Equation 5-13:

$$VT_w = Intercept_w + Slope_w \, x \, VT_c$$

Equation 5-14:

$$VT_b = Intercept_b + Slope_b \, x \, VT_c$$

Where:

$SHGC_w$ = SHGC trendline using the default high spacer system

$SHGC_b$ = SHGC trendline using the default low spacer system

$SHGC_c$ = SHGC between 0 and 1

VT_w = VT trendline using the default high spacer system

VT_b = VT trendline using the default low spacer system

VT_c = VT between 0 and 1

5.10.3.2 Total SHGC and VT ($SHGC_{tot}$ and VT_{tot})

To determine the whole product SHGC ($SHGC_{tot}$) and VT (VT_{tot}) for the glazing options in category 5.12.5.1 of ANSI/NFRC 100, use Equation 5-15 and Equation 5-16.

Equation 5-15:

$$SHGC_{tot} = SHGC_b + \frac{(SHGC_w - SHGC_b) \cdot (\ln(k_{eff}) - \ln(k_{eff}b))}{\ln(k_{eff}w) - \ln(k_{eff}b)}$$

Equation 5-16:

$$VT_{tot} = VT_b + \frac{(VT_w - VT_b) \cdot (\ln(k_{eff}) - \ln(k_{eff}b))}{\ln(k_{eff}w) - \ln(k_{eff}b)}$$

Where:

$SHGC_w$ = product SHGC with default high spacer system and the glazing option's center-of-glass SHGC

$SHGC_b$ = product SHGC with default low spacer system and the glazing option's center-of-glass SHGC

VT_w = product VT with default high spacer system and the glazing option's center-of-glass VT

VT_b = product VT with default low spacer system and the glazing option's center-of-glass VT

$SHGC_{tot}$ = glazing options whole product SHGC

VT_{tot} = glazing options whole product SHGC

k_{eff} = use either a Default or Specific spacer system

(i) Default spacer system use the k_{eff} per ANSI/NFRC 100, Section 5.12.6.1; or

(ii) Specific spacer system is the specific individual spacer system product option k_{eff} per ANSI/NFRC 100, Section 5.12.6.2.

(iii) k_{eff} is limited between $k_{eff}b$ and $k_{eff}w$,

$k_{eff}b$ = k_{eff} of default low spacer system from trendline $SHGC_b$ and VT_b

$k_{eff}w$ = k_{eff} of default high spacer system from trendline $SHGC_b$ and VT_b

The SHGC and VT rating of a fenestration product may vary by size. In order to provide a uniform rating procedure, as well as specified size information, the CTA as described in this section shall be used as the primary method. For the comparison rating of commercial fenestration systems, the SHGC and VT rating for model size per ANSI/NFRC 100 Table 4-3 is calculated. SHGC and VT ratings for specified sizes other than the model size can be calculated for informational purposes, when applicable, see Appendix A.

6. REFERENCES

1) *ANSI/NFRC 100-2023: Procedure for Determining Fenestration Product U-factors.* National Fenestration Rating Council: Greenbelt, MD; 2014. www.nfrc.org.

2) NFRC 201-2023: *Procedure for Interim Standard Test Method for Measuring the Solar Heat Gain Coefficient of Fenestration Systems Using Calorimetry Hot Box Methods*. National Fenestration Rating Council: Greenbelt, MD; 2014. www.nfrc.org.

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APPENDIX A (NON-MANDATORY INFORMATION)

This section includes methods that can be used to calculate fenestration SHGC and VT performance based on the specified size(s). This data can be used to provide more accurate inputs to building energy simulations to support more effective HVAC equipment sizing and better estimations of peak loads, annual energy use estimations and thermal comfort. These values shall not be used on NFRC labels nor shall they be included in the NFRC Certified Products Directory (CPD).

A.1 Determination of SHGC and VT at Specified 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.

A.2 Determination of SHGC and VT at Specified Sizes using Aspect Ratio Calculation

The SHGC and VT of a fenestration product may vary by size. In order to provide a uniform rating procedure for the comparison of fenestration systems, total product SHGC and VT ratings are calculated for the model size per ANSI/NFRC 100, Table 4-3.

Specified size SHGC and VT can be calculated for informational purposes. Total product SHGC results for the specified size product can be calculated from Equation 1 and Equation 2 and the VT results can be calculated from Equation 3.

Equation 1:

$$SHGC_{f-specified\ size} = \frac{(SHGC_{t-NFRC} * A_{pf-NFRC}) - (SHGC_{c-NFRC} * A_{c-NFRC}) - (SHGC_{d-NFRC} * A_{d-NFRC})}{A_{f-NFRC}}$$

Where:

$SHGC_{f\text{-specified size}}$ = frame SHGC for the specified size product

$SHGC_{t\text{-NFRC}}$ = total product SHGC for the individual glazing option at model size per Table 4-3 of ANSI/NFRC 100

$SHGC_{c\text{-NFRC}}$ = individual glazing options center-of-glass SHGC

$SHGC_{d\text{-}NFRC}$ = individual glazing options divider SHGC, assumed to be zero.

$A_{pf\text{-}NFRC}$ = total projected fenestration product area at model size per Table 4-3 of ANSI/NFRC 100

$A_{c\text{-}NFRC}$ = vision area at model size per Table 4-3 of ANSI/NFRC 100

$A_{d\text{-}NFRC}$ = divider area at model size per Table 4-3 of ANSI/NFRC 100

$A_{f\text{-}NFRC}$ = frame area at model size per Table 4-3 of ANSI/NFRC 100

Assume:

$SHGC_{c\text{-}NFRC} = SHGC_{e\text{-}NFRC} = SHGC_{de\text{-}NFRC}$

$SHGC_{d\text{-}NFRC} = 0$

$A_{g\text{-}NFRC}$ = Total glazing area = $A_{c\text{-}NFRC}+A_{d\text{-}NFRC}$

Then Equation 1 becomes:

Equation 1.1

$$SHGC_{f-specified\ size} = \frac{(SHGC_{t-NFRC} * A_{pf-NFRC}) - (SHGC_{c-NFRC} * A_{c-NFRC})}{A_{f-NFRC}}$$

Equation 1.2

$$A_{pf\text{-}NFRC} = W * H$$

Where:

W = width of the model size from Table 4-3 (mm)

H = height of the model size from Table 4-3 (mm)

1) When the projected frame height (PFD) of each modeled section is known and $A_{f\text{-}NFRC}$ and the divider area $A_{d\text{-}NFRC}$ can be calculated:

Equation 1.3

$$A_{c\text{-}NFRC} = A_{pf\text{-}NFRC} - A_{f\text{-}NFRC} - A_{d\text{-}NFRC}$$

2) When the projected frame height (PFD) is not known an average projected frame height ($\overline{H}_{fr}$) shall be calculated and used to determine A_g and A_f shall be calculated based on A_v as follows:

Equation 1.4

$$A_{c-NFRC} = \frac{VT_{t-NFRC} * A_{pf-NFRC}}{VT_{c-NFRC}}$$

Where:

$VT_{t\text{-}NFRC}$ = total product visible light transmission for the individual glazing option at model size per Table 4-3.

$VT_{c\text{-}NFRC}$ = individual glazing options center-of-glass visible light transmission

$VT_{f\text{-}NFRC}$ is assumed to be zero

For Rectangular Products

Equation 1.5

$$\overline{\mathrm{H_{fr}}} = \frac{(2 * \mathrm{W} + 2 * \mathrm{H} - \mathrm{E}) - \sqrt{(2 * \mathrm{W} + 2 * \mathrm{H} - \mathrm{E})^2 - 16 * ((\mathrm{W} * \mathrm{H}) - A_{c-NFRC} - D)}}{8}$$

Where:

Equation 1.6

$$\mathrm{A_{g-NFRC}} = \left(\mathrm{W} - 2 * \overline{\mathrm{H_{fr}}}\right) * (\mathrm{H} - 2 * \overline{\mathrm{H_{fr}}})$$

Equation 1.7

$$\mathrm{A_{d-NFRC}} = \mathrm{D} - (\mathrm{E} * \overline{\mathrm{H_{fr}}})$$

Equation 1.8

$$D = (W * H_d * N_h + H * H_d * N_v - H_d^2 * N_h * N_v)$$

Equation 1.9

$$E = (2 * H_d * N_h + 2 * H_d * N_v)$$

For Horizontal two-lite Products

Equation 1.10

$$\overline{\mathrm{H_{fr}}} = \frac{(2 * \mathrm{W} + 3 * \mathrm{H} - \mathrm{E}) - \sqrt{(2 * \mathrm{W} + 3 * \mathrm{H} - \mathrm{E})^2 - 24 * ((\mathrm{W} * \mathrm{H}) - A_{c-NFRC} - D)}}{12}$$

Where:

Equation 1.11

$$\mathrm{A_{g-NFRC}} = \left(\mathrm{W} - 3 * \overline{\mathrm{H_{fr}}}\right) * \left(\mathrm{H} - 2 * \overline{\mathrm{H_{fr}}}\right)$$

Equation 1.12

$$\mathrm{A_{d-NFRC}} = \mathrm{D} - \left(\mathrm{E} * \overline{\mathrm{H_{fr}}}\right)$$

Where:

Equation 1.13

$$D = (W * H_d * N_h + H * H_d * N_v - H_d^2 * N_h * N_v)$$

Equation 1.14

$$E = (3 * H_d * N_h + 2 * H_d * N_v)$$

For Vertical Two-lite Products

Equation 1.15

$$\overline{\mathrm{H_{fr}}} = \frac{(3 * \mathrm{W} + 2 * \mathrm{H} - \mathrm{E}) - \sqrt{(3 * \mathrm{W} + 2 * \mathrm{H} - \mathrm{E})^2 - 24 * ((\mathrm{W} * \mathrm{H}) - A_{c-NFRC} - D)}}{12}$$

Where:

Equation 1.16

$$\mathrm{A_{g-NFRC}} = \left(\mathrm{W} - 2 * \overline{\mathrm{H_{fr}}}\right) * \left(\mathrm{H} - 3 * \overline{\mathrm{H_{fr}}}\right)$$

Equation 1.17

$$\mathrm{A_{d-NFRC}} = \mathrm{D} - \left(\mathrm{E} * \overline{\mathrm{H_{fr}}}\right)$$

Equation 1.18

$$D = (W * H_d * N_h + H + H_d * N_v - H_d^2 * N_h * N_v)$$

Equation 1.19

$$E = (2 * H_d * N_h + 3 * H_d * N_v)$$

Where:

$A_{g\text{-}NFRC}$ = visible glass area and the divider area at model size per table 4-3

$A_{d\text{-}NFRC}$ = divider area at model size per table 4-3

$\overline{H_{fr}}$ = the average projected frame height for the product

H_d = divider PDF, divider $<$ 1" H_d =19mm, divider $\geq$ 1" H_d = 38mm

N_h = number of horizontal dividers in rated product

N_v = number of vertical dividers in rated product

Equation 1.20

$$A_{f\text{-}NFRC} = A_{pf\text{-}NFRC} - A_{g\text{-}NFRC}$$

Assume:$SHGC_{c\text{-}NFRC} = SHGC_{c\text{-specified size}}$

Equation 2:

$$SHGC_{t-\text{specified size}} = \frac{(SHGC_{f-\text{specified size}} * A_{f-\text{specified size}}) + (SHGC_{c-\text{specified size}} * A_{c-\text{specified size}})}{A_{pf-\text{specified size}}}$$

Where:

$SHGC_{t\text{-specified size}}$ = total product SHGC for the individual glazing option at the specified size

$SHGC_{f\text{-specified size}}$ = frame SHGC for the specified size product

$SHGC_c$ = individual glazing options center-of-glass SHGC

$A_{f\text{-specified size}}$ = frame area at the specified size

$A_{c\text{-specified size}}$ = vision area at the specified size

$A_{pf\text{-specified size}}$ = total projected fenestration product area at the specified size

Equation 2.1

$$A_{t\text{-specified size}} = W' * H'$$

Where:

H' = height of the specified size product (mm)

W' = width of the specified size product (mm)

1) When the projected frame height (PFD) of each modeled section is known and $A_{f\text{-specified size}}$ and the specified divider area $A_{d\text{-specified size}}$ can be calculated:

Equation 2.2

$$A_{c\text{-specified size}} = A_{pf\text{-specified size}} - A_{f\text{-specified size}} - A_{d\text{-specified size}}$$

2) When the projected frame height (PFD) is not known $A_{g\text{-specified size}}$ shall be calculated based on the average projected frame height ($\overline{H_{fr}}$) and $A_{f\text{-specified size}}$ shall be calculated based on $A_{v\text{-specified size}}$ and $A_{d\text{-specified size}}$ as follows:

Equation 2.3

$$A_{c\text{-specified size}} = A_{g\text{-specified size}} - A_{d\text{-specified size}}$$

Where:

$A_{g\text{-specified size}}$ = visible glass area and the divider area of the specified size product

$A_{d\text{- size}}$ = divider area of the specified size product

For Rectangular Products

Equation 2.4

$$A_{g-\text{specified size}} = \left(W' - 2 * \overline{H_{fr}}\right) * \left(H' - 2 * \overline{H_{fr}}\right)$$

Where:

Equation 2.5

$$A_{d-\text{specified size}} = D' - \left(E' * \overline{H_{fr}}\right)$$

Equation 2.6

$$D' = (W' * H_d * N'_h + H' * H_d * N'_v - H_d^2 * N'_h * N'_v)$$

Equation 2.7

$$E' = (2 * H_d * N'_h + 2 * H_d * N'_v)$$

For Horizontal two-lite Products

Equation 2.8

$$\mathrm{A_{g-specified\ size}} = \left(\mathrm{W'} - 3 * \overline{\mathrm{H_{fr}}}\right) * (\mathrm{H'} - 2 * \overline{\mathrm{H_{fr}}})$$

Where:

Equation 2.9

$$\mathrm{A_{d-specified\ size}} = \mathrm{D'} - (\mathrm{E'} * \overline{\mathrm{H_{fr}}})$$

Equation 2.10

$$D' = (W' * H_d * N'_h + H' * H_d * N'_v - H_d^2 * N'_h * N'_v)$$

Equation 2.11

$$E' = (3 * H_d * N'_h + 2 * H_d * N'_v)$$

For Vertical Two-lite Products

Equation 2.12

$$\mathrm{A_{g-specified\ size}} = \left(\mathrm{W'} - 2 * \overline{\mathrm{H_{fr}}}\right) * (\mathrm{H'} - 3 * \overline{\mathrm{H_{fr}}})$$

Where:

Equation 2.13

$$\mathrm{A_{d-specified\ size}} = \mathrm{D'} - (\mathrm{E'} * \overline{\mathrm{H_{fr}}})$$

Equation 2.14

$$D' = (W' * H_d * N'_h + H' * H_d * N'_v - H_d^2 * N'_h * N'_v)$$

Equation 2.15

$$E' = (2 * H_d * N'_h + 3 * H_d * N'_v)$$

Where:

N_h' = number of horizontal dividers in the specified size product

N_v' = number of vertical dividers in the specified size product

Equation 2.16

$$A_{f\text{-specified size}} = A_{pf\text{-specified size}} - A_{g\text{-specified size}}$$

Equation 3:

Assume:

$$VT_{c\text{-NFRC}} = VT_{c\text{-specified size}}$$

Equation 4:

$$VT_{t-\text{specified size}} = \frac{(VT_{c-\text{NFRC}} * A_{c-\text{specified size}})}{A_{pf-\text{specified size}}}$$

Where:

$VT_{t\text{-specified size}}$ = total product VT for the individual glazing option at the specified size

$VT_{c\text{-specified size}}$ = individual glazing options center-of-glass VT

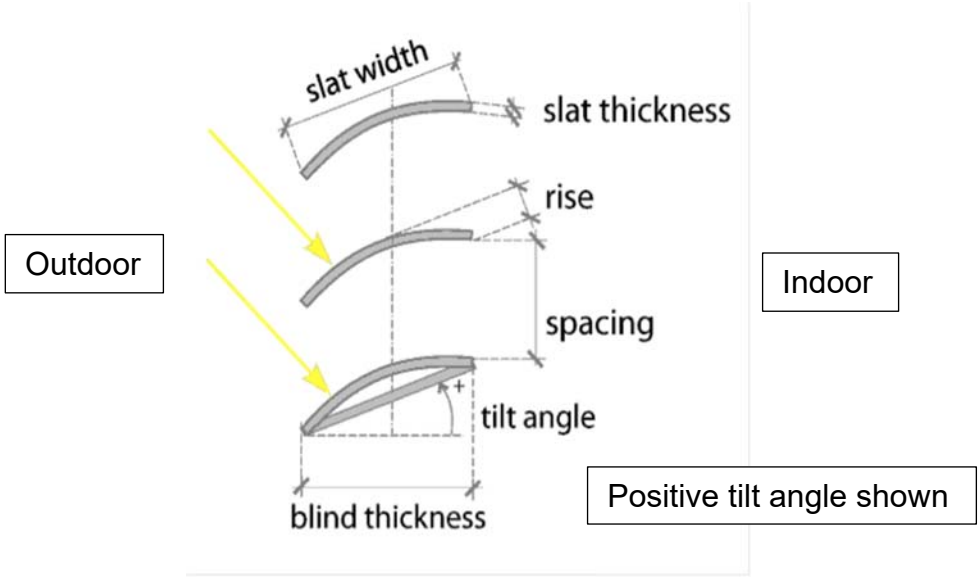
$A_{c\text{-specified size}}$ = vision area at the specified size

$A_{pf\text{-specified size}}$ = total projected fenestration product area at the specified size

A.3 Determination of SHGC and VT Determination of SHGCs and VTs for Dynamic Glazing Products at Additional Slat Angles

Determination of SHGCs and VTs for Dynamic Glazing Products with slatted blinds between glass shall be permitted at slat tilt angles other than Fully ON/CLOSED, Fully OFF/OPEN. Additional angles of -45º and +45º shall also be permitted as optional ratings that may be added to the CPD.

See figure below for angle descriptions.



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