



National Fenestration Rating Council Incorporated

ANSI/NFRC 100-2017^[E0A2]

Procedure for
Determining Fenestration Product U-factors

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FOREWORD

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

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

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

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

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

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

NFRC intends to ensure the integrity and uniformity of NFRC ratings, certification, and labeling by ensuring that responsible parties, testing and simulation laboratories, and IAs adhere to strict NFRC requirements.

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

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

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

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

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

Figure 1

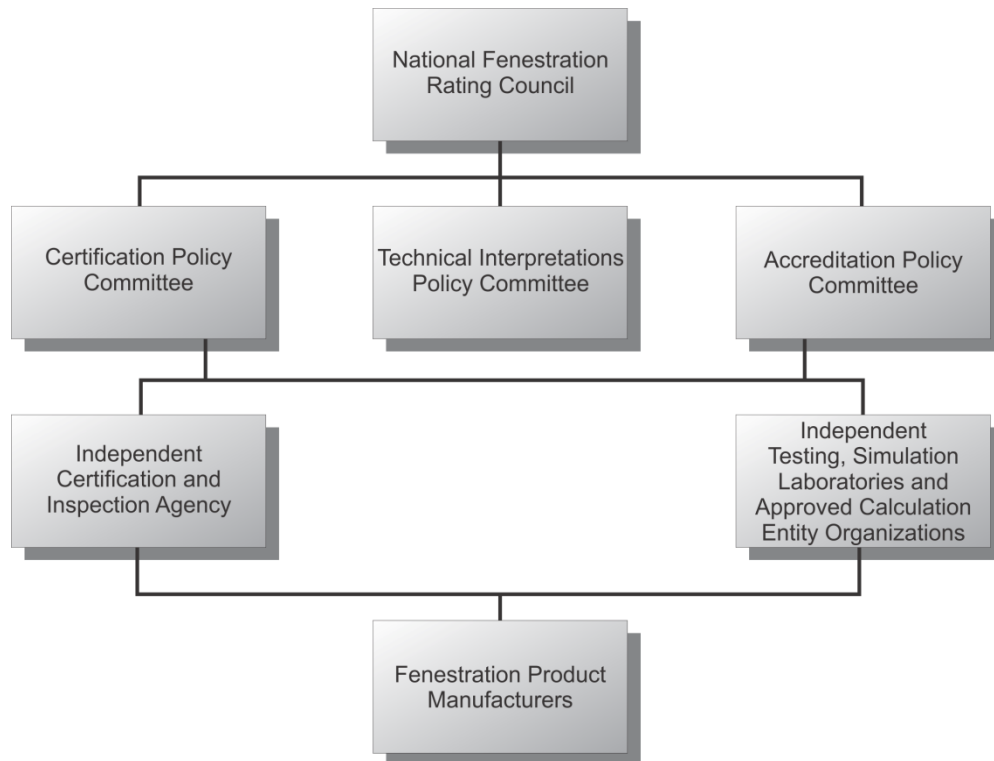


Figure 2

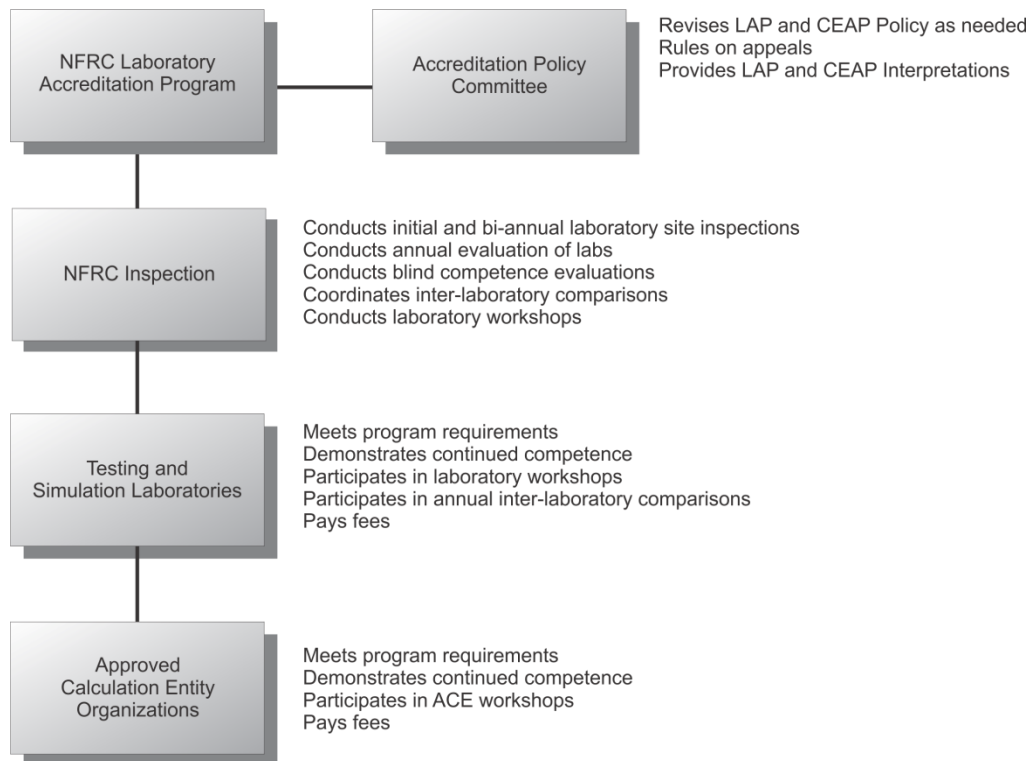
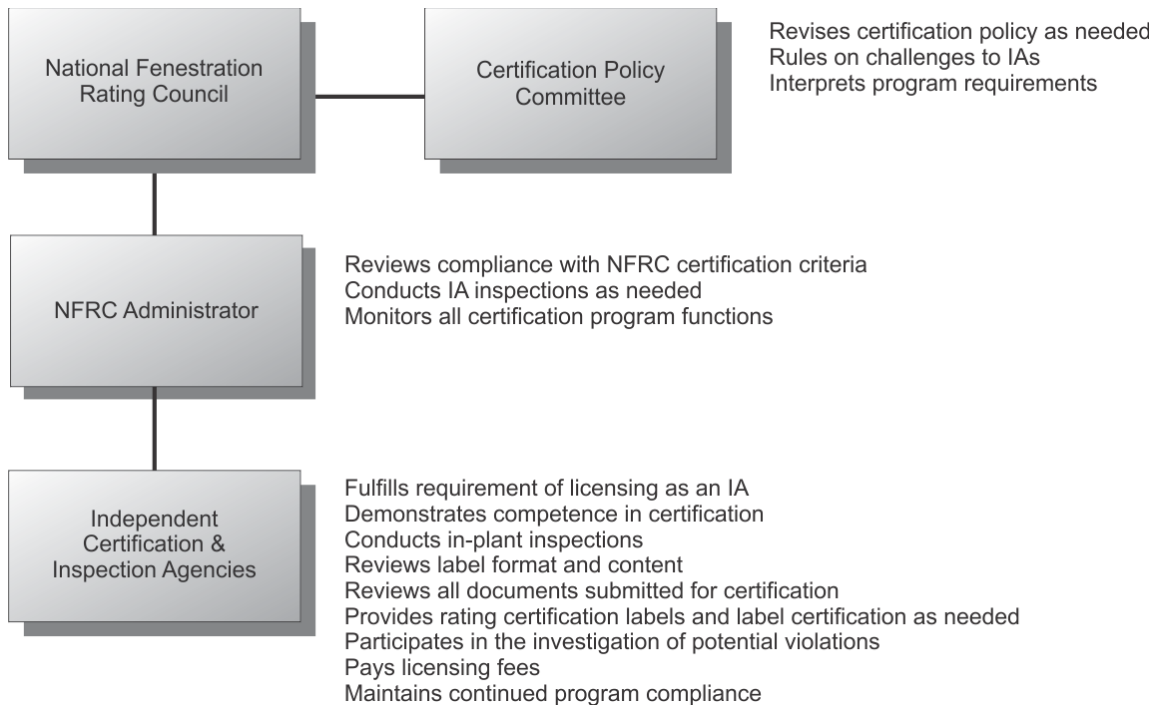


Figure 3



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1. PURPOSE

To specify a method for determining fenestration product U-factor (thermal transmittance).

2. SCOPE

2.1 Products and Effects Covered

The following products and effects are within the scope of ANSI/NFRC 100 and shall be permitted to be rated in accordance with this procedure.

- A. Products of all types as defined in Table 4-3;
- B. Products of all frame materials, including (but not limited to) aluminum, steel, thermally broken aluminum, wood, vinyl, reinforced vinyl, fiberglass, and plastic, used singularly or in combination, or products utilizing foam as a core material;
- C. Products of all glazing materials, tints, and types, including (but not limited to) clear glass, tinted glass, stained glass, fritted glazing, etched glazing, sandblasted glazing, glass block, thin plastic films (internally suspended, internally applied, or externally applied), rigid plastics, and translucent fiberglass with or without any solar control, low-E, or any other partially transparent coating, and products with manufactured decorative opaque insulated glazing panels, designed for interchangeability with other glazing options;
- D. Products with any or no gap width between glazing layers;
- E. Products with any spacer or spacer system between glazings, including (but not limited to) metallic, non-metallic, or composite spacers;
- F. Products utilizing any and all glazing dividers, including (but not limited to) interior, exterior or between glazing grilles, muntin bars, true divided lites, or simulated divided lites;
- G. Products with any gas-fill between glazing layers, including (but not limited to) air, argon, krypton, or mixes of these gases;
- H. Products utilizing shading or diffusing systems that are an integral part of the product as shipped from the manufacturer, including Dynamic Glazing Products;
- I. Dynamic Glazing Products, such as but not limited to electrochromatic glazed products; and
- J. Dynamic Attachment for Swinging Doors.

2.2 Products and Effects Not Covered

The following products and effects are beyond the scope of ANSI/NFRC 100 and shall not be rated in accordance with this procedure.

- A. Fenestration products with shading and/or diffusing systems other than those listed in Section 2.1;
- B. Thermal performance changes of a fenestration product over the course of time, i.e., long-term energy performance;
- C. Issues related to water tightness, structural capacity, and air leakage;
- D. Pet doors; and
- E. Permanently attached louvers.

3. DEFINITIONS

Air Leakage, AL : the volume of air flowing per unit time per unit area through a fenestration system due to air pressure or temperature difference between the outdoor and indoor environment.

Areas:

Center-of-glazing Area (A_c): all glazing areas except those within 63.5 mm (2.5 in) of any part of a primary sash, and/or frame, and/or divider; or any part of a primary door, and/or frame, and/or divider. See Figures 4-1, 4-2, 5-11, 5-12, 5-13, 5-14, 5-15, 5-19, and 5-20.

Divider Area (A_d): the projected area in the plane(s) parallel to the fenestration product's glazing of all interior or exterior applied non-removable dividers, true dividers, and simulated dividers or between glazing dividers. See Figures 4-1 and 4-2.

Door Core Area (A_{dc}): the projected area of the door less the frame, edge-of-frame, lite glazing frame, edge-of-glazing, center-of-glazing, edge-of-divider, divider, edge-of-panel and panel areas. See Figures 4-3, 5-1, 5-2, 5-11, 5-12, 5-13, 5-16, 5-17, and 5-18.

Edge-of-divider Area (A_{de}): all glazed vision areas within 63.5 mm (2.5 in) of any part of a divider area. The edge-of-divider area shall exclude any edge-of-glazing area. See Figures 4-1 and 4-2.

Edge-of-glazing Area (A_{eg}): all glazed vision areas within 63.5 mm (2.5 in) of any part of the frame and sash or of the door lite frame sight line, excluding any divider or edge of divider. See Figures 4-1, 4-2, 5-11, 5-12.

Edge-of-panel Area (A_{ep}): the projected area extending from the point 25 mm (1 in) of uniform thickness on the panel, to the point which includes 25 mm (1 in) of door core material from the interface of any decorative bead or from the interface of the panel cutout and the door core. See Figures 4-3, 5-1, 5-2, 5-11, 5-12.

End Stile Area (A_{es}): the projected area of the end stile in the plane(s) parallel to the garage door surface. See Figures 5-11, 5-12, 5-17.

Frame Area (A_f): the projected area of frame and sash in the plane(s) parallel to the glazing surface, except for doors, which shall include the projected areas of the door jambs, header, threshold, door bottom sweep and the peripheral structural elements of the door leaf, in a plane parallel to the door core surface. See Figures 4-1, 4-2, 5-1, 5-2, 5-11, 5-16, 5-17, 5-19, and 5-20.

Lite Frame Area (A_{lf}): specific to doors, the projected area extending from the sight line of the lite frame into the surrounding homogeneous door core surface for a distance of 25 mm (1 in) beyond the outer edge of the lite frame and parallel to the door core surface. See Figures 5-11 and 5-12.

Panel Area (A_p): the projected area of all decorative panels of uniform thickness and extending from a point 25 mm (1 in) of uniform thickness, in a plane parallel to the door core surface. See Figures 4-1, 4-2, 5-1, 5-2, 5-11, and 5-12.

Projected Fenestration Product Area (A_{pf}): the area of the rough opening in the wall or roof, for the fenestration product, less installation clearance.

[**Note:** Where a fenestration product has glazed surfaces facing in only one direction (typical products), the sum of the edge-of-divider area, the edge-of-glazing area, the divider area, the center-of-glazing area, and the frame area will equal the total projected fenestration product area (A_{pf}). Where a fenestration product has glazed surfaces in more than one direction (e.g., greenhouse/garden, bay/bow windows) the sum of the areas will exceed the projected fenestration product area.]

Total Fenestration Product Area (A): the area of the total fenestration product that includes all frame, divider, edge-of-glazing, edge-of-divider, and center-of-glazing areas.

Awning Window: a window with one (or more) sash that rotates about its top hinge and projects outward.

Base Profile: primary structural member of a fenestration product line which forms the basis for comparison, such as groupings.

Baseline Product: within a product line, the individual product selected for validation testing. To verify door glazing and lite frame simulations, the baseline product for door, sidelite, and garage (vehicular access) door product lines which include glazed options, shall include glazing.

Basement Window: a window usually with one sash that projects inward and is intended to be used at or below grade; rated as the appropriate product type.

Bay Window: a combination assembly which is composed of two or more individual windows joined side by side and which projects away from the wall on which it is installed. Center windows, if used, are parallel to the wall on which the bay is installed. The two side windows are angled with respect to the center window(s). Common angles are 30° and 45°, although other angles are sometimes employed. Individual windows are rated as the appropriate product type.

Bead: (1) a strip used around the periphery of the glazing to secure it in a frame or sash (also referred to as a “stop”); (2) a strip of sealant, such as caulking or glazing compound.

Blackbody: a perfect emitter and absorber of thermal radiation. A blackbody emits radiant energy at each wavelength at the maximum rate possible as a consequence of its temperature and absorbs all incident radiant flux.

Bow Window: a rounded bay window that projects from a wall in the shape of an arc. Individual windows rated as the appropriate product type.

Breather/Capillary Tube: a tube providing an intentional breach of the IG seals to allow for pressure equalization.

Caming: material that divides and holds pieces of glazing together to form a single decorative glazing panel.

Casement Window: a window containing one (or more) sash, hinged to open from the side, that project outward or inward from the plane of the window in a vertical plane. A conventional casement window has a sash that projects outward.

Certification: the affixing by a licensed Responsible Party of an NFRC label on a fenestration product, or on a box/package containing an attachment product, or the distribution of an NFRC Label Certificate for which Certification Authorization has been granted.

Certified Simulator: any individual who has attended at least one NFRC-sanctioned Simulation Training Workshop, completed and satisfactorily passed all necessary examinations, participated in NFRC simulation round robins, and is approved by NFRC to use at least one NFRC-approved simulation software tool.

Cladding: an applied rigid or semi-rigid covering that is placed over the interior and/or exterior framing member for the primary purpose of protection from environmental elements and/or aesthetics.

Combination Assembly: a window, door, or skylight assembly formed by a combination of two or more separate units whose frames are mullied together.

Composite Assembly(Unit): a window, door, or skylight unit consisting of two or more sash, leaves, lites, or sliding door panels within a single frame utilizing an integral mullion. (Not to be confused with products made from composite materials.)

Computer Simulation: the process by which a product is analyzed for energy performance characteristics utilizing NFRC-approved computer software and manufacturer supplied product specifications and drawings, in accordance with the requirements of the NFRC Rating System.

Convective Film Coefficient (h): the time rate of convection heat transfer from a unit area of a surface to its surroundings, induced by a unit temperature difference between the surface and the environment.

Curtain Wall: any building wall, of any material, that carries no superimposed vertical load (a non-bearing wall).

Curtain Wall System: that portion of the exterior wall that may consist entirely (or principally) of a combination of framing materials, glass and glazing, opaque infill, and other surfacing materials supported by (or within) a framework, in varying percentages per the design of the system.

Daylight Opening Size: the glazing infill dimension measured from the glazing sightline, also known as the vision area.

Decorative Panel/Panel Insert: a decorative raised molding that is inserted into a cut-out in an insulated door slab. Decorative panels are typically molded from a composite material. The gap between the two halves of the panel may be filled with an insulating material.

Detailed Door Rating (DDR) Method: a modeling procedure that combines opaque Door or Sidelite slab simulations with various glass simulations projected into the opaque unit(s) to determine a total product U-factor.

Diffuse (adj.): referring to radiometric quantities: indicates that flux propagates in many directions, as opposed to a direct beam, which refers to quasi-collimated flux from the sun, whose angular diameter is approximately 0.5 degree. When referring to reflectance, it is the directional hemispherical reflectance less the specular reflectance. Diffuse has been used in the past to refer to hemispherical collection (including the specular component); this use is deprecated in favor of the more precise term hemispherical.

Diffuser: a translucent glazing layer or fenestration product accessory designed to transmit direct-beam radiation diffusely, i.e. many directions.

Divider: any vertical or horizontal bar used to separate glazing into multiple lites or placed in the gap between sheets of glazing. Dividers may be external or internal, removable or non-removable, and real or simulated. Dividers may also be called grids, grilles, or muntins.

Doorglass Assembly Area (DGAA): sum of the Lite-Frame-Area (Alf), Edge-of-Glazing Area (Aeg), Center-of-Glazing Area (Ac), Edge-of-Divider-Area (Aed), Divider Area (Ad)

Door Leaf, Slab: the pivoted or swinging portion of a door system. Sometimes referred to as a door slab.

Composite (material) Door: a door manufactured from skins molded from plastics, fiberglass compounds, compressed composites, or other non-metallic materials. The door leaf may or may not incorporate a structural perimeter constructed from materials, including (but not limited to) wood, wood products, composites, or other reinforcing materials. The core of the door leaf may be filled with materials including, but not limited to insulating polyurethanes, styrenes, or honeycombs.

Steel Door: a door manufactured from steel skins, which may be coated with paint, plastic, wood veneers, or other finishes. The door leaf may or may not incorporate a structural perimeter, including (but not limited to) materials of wood, wood products, composites, or other reinforcing materials. The core of the door leaf may be hollow or filled with material, including (but not limited to) insulating polyurethanes, styrenes, or honeycombs.

Wood Door: a door manufactured from solid wood, wood veneers, wood laminates, or a combination thereof. Such doors are generally assembled from stiles, rails, and panels, but may also be wood flush doors of solid or hollow core construction.

Aluminum Door: a door manufactured from aluminum extrusions for the vertical stiles and horizontal rails with glazed panel area. Aluminum doors may also be flush doors manufactured with aluminum skins (exterior and interior sides) applied over the aluminum stiles and rails with an insulating core.

Door/Slab/Slab Door/Fixed Panel: a side-hinged attachment, greater than 600 mm (24 in) in width (whose primary function is to allow human egress) or non-operable panels greater than 700 mm (27 in) in width.

Dual Action Window: a window that operates into two different ways. Typically, the window consists of a sash that tilts from the top and swings inward from the side.

Dynamic Attachment: any Fenestration Attachment that incorporates Dynamic Glazing.

Dynamic Glazing Product: any fenestration product that has the fully reversible ability to change its performance properties, including U-factor, solar heat gain coefficient (SHGC), or visible transmittance (VT). This includes (but is not limited to) shading systems between the glazing layers and electronic or electrochemical switchable glass coatings or construction.

Embossed/Raised Panel: decorative areas on a door leaf. On a steel door these may be pressed into the steel skin or achieved by the application of plastics or other trim materials. On composite (material) doors these are usually molded into the door skin or may be achieved by the use of surface applied trim. Wood doors usually incorporate thinner wood sections assembled into the stiles and rails.

[**Note:** See Figure 5-3 for typical 6-panel layout.]

Emissivity (ϵ): the relative ability of a surface to reflect or emit heat by radiation. Emissivity ranges from 0.00 to 1.00. (Blackbody emissivity is 1.0).

Energy Panel: a glazed Fenestration Attachment designed to be mounted to the interior or exterior of a primary fenestration product such that a gap is created between the glazing systems of the attachment and the primary fenestration product. This includes, but is not limited to, storm windows, storm doors, and storm panels. Also, see “Fenestration Attachment.”

Exterior Bi-Fold Doors (aka Folding Walls, Bi-Fold Glass Wall System): a door with two or more panels, typically fully-glazed, where each panel folds on top of the adjacent panel to open. These are classified as Side-Hinged Exterior Door and shall be rated and tested as either single or double door products.

Exterior Door System: the total door system that includes all frame, lite frame, divider, edge-of-divider, edge-of-glazing, center-of-glazing, door core, edge-of-panel, and panel areas; the door, slab, or slab door together with the surrounding frame, weatherstrip, sill, and sweep.

Film: fenestration 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. See Fenestration Attachment.

Finish: the final treatment or coating of a surface.

Fixed Window: a window designed to be non-operable.

Frame: the enclosing structure of a window, door, or skylight which fits into the wall or roof opening and receives either, glazing, sash, or vents.

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.

Gap Width: the distance between two adjacent glazing surfaces.

Gas-fill: the process of adding a gas between glazing panes. Term typically used to indicate gases other than air, such as argon and krypton.

Glass: an inorganic, amorphous substance, usually transparent, composed of silica (sand), soda (sodium carbonate), and lime (calcium carbonate) with small quantities of other materials.

Glazing/Glazing Infill: a generic term used to describe an in-fill material, such as glass, plastic, or other transparent or translucent material, or assembly of glazing material, spacer, and desiccant, used to enclose openings in a building created by a specific framing system..

Glazing System: the assembly of the glazing, spacer, and desiccant combined to be placed in the opening in a window, skylight, door, or sidelite.

Greenhouse/Garden Window: a window unit that consists of a three-dimensional, five-sided structure generally protruding from the wall in which it is installed. Operating sash may or may not be included. (see Section 4.1.2).

Grid(s): See “Divider.”

Group Leader: the single option defined as representing all other options in that group for purposes of grouping.

Grouping: The process of reducing the number of individual options by selecting the worst performing option as representative.

Horizontal Sliding Window: a window that contains one or more manually-operated sash(es) that slide horizontally within a common frame. Operating sash (X) and a fixed lite (O) comprising a unit is termed a single slider (XO or OX). When two operating sashes are separated by a fixed lite, the unit is termed a picture slide (XOX) or end vent. When an operating sash separates two fixed lites, the unit is termed a center slide (OXO). When two bi-parting sashes are located at the center of the unit with the fixed lites at each end, the unit is termed a bi-part center slide (OXXO). When adjacent sashes bypass one another, the unit is termed a double slide (XX or XXO) or a double slide and vent (XXX).

Hybrid Tubular Daylighting Device (HTDD): the HTDD category has been retired and all products have been placed in the TDD category.

Individual Product: Any one specific fenestration product within a product line, specific to weather seals, glazing method, hardware, opening/non-opening configurations, ventilators, weep systems, and sills.

Inset Mount: an installation type where a skylight is mounted directly into the roof deck (as opposed to a curb mount).

Insulating Glass Unit (IGU), Sealed Insulating Glass Unit: a preassembled unit, comprising lites of glass which are sealed at the edges and separated by dehydrated space(s). The unit is normally used for windows, window walls, picture windows, sliding doors, patio doors, or other types of fenestration.

Label: permanent and/or temporary marker or device applied to a fenestration product, listing rating information and indicating compliance with certification requirements.

Label Certificate: a document used in lieu of an NFRC Temporary Label specific to certain products that have received certification authorization. See NFRC 705.

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.”

Low-E Coating: microscopically thin metal, metal oxide, or multilayer coating deposited on a glazing surface to reduce its thermal infrared emittance.

Model Size: the size listed in Table 4-3 that is used to rate a fenestration product.

Mullion: a horizontal or vertical structural member connecting two or more products. Mullions may be of the following types:

Combination Mullion: a member formed by joining two or more individual fenestration products together with or without an additional reinforcing member (mullion stiffener).

Integral Mullion: a member bound at both ends by crossing frame members.

Mullion Stiffener: an additional reinforcing member used in a reinforcing mullion. Mullion stiffeners may be designed to carry the total load or may share the load with the adjacent framing members.

Reinforcing Mullion: a member with an added continuous mullion stiffener joining two or more individual fenestration products along the sides of the mullion stiffener.

Nail Flange, Nailing Fin: an extension of a fenestration product frame that generally laps over the conventional stud construction and through which fasteners are used to secure the frame in place.

Obscure Glazing: glazing having an image, pattern, or texture that distorts the vision through the glazing.

Opaque In-fill Systems: fenestration systems that include opaque elements. See “Spandrel.”

Outdoor Air Ventilator Assembly (OAVA): a device, other than a sash unit, for the purpose of controlling the passage of air through a fenestration product. An OAVA shall not allow outside air access to cavities within the cross-sectional boundaries of the sash, frame, or glazing.

Product Line: a series of individual fenestration products of the same operator type, manufactured from the same profiles. Individual variations such as glazing, spacer, or small variations in frame profiles are considered individual products within product lines. See Section 4.2.1 for further details.

Product Type: a designation used to distinguish between fenestration products based on fixed and operable sash and frame members.

[**Note:** referred to as operator type in previous versions.]

Radiation: the transfer of heat in the form of electromagnetic waves or photons from one body to another.

Rating: performance values obtained using NFRC-approved procedures used for comparative purposes only (i.e., U-factor, SHGC, VT, etc.).

Rating System: a system that consists of NFRC simulation and test procedures for determining comparative fenestration product energy performance characteristics, as supported by the Certification Program.

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 Frame: the frame of the reference fenestration product. This may or may not correspond to an actual frame type available commercially.

Reference Glazing System: the glazing system in the reference fenestration product.

Representative Size: the actual size of a product specimen that is used for validation testing.

Roof Window: see “Unit Skylight/Roof Window.”

Rough Opening: the framed opening in a wall or roof where a fenestration product is to be installed.

Sash: the portion of a fenestration assembly that is installed in a frame and includes the glazing, stiles, and rails. Sash may be operating or fixed.

Sealant: a flexible material placed between two or more parts of a structure, with adhesion to the joining surfaces, to prevent the passage of certain elements such as air, moisture, water, dust, and other matter.

Sidelite: a fenestration product that is used as a companion product installed on one or both sides of a door. Sidelites may consist of a glazed frame or a non-operable sash within a frame and shall not exceed 700 mm (27 in) in width. (Products that exceed 700 mm (27 in) width are rated as fixed windows.)

Sightline: the line formed by the highest opaque member (frame, sash, spacer, divider, or shading system) that is interior, exterior, or within the glazing system cavity of the fenestration cross-section and the glazing in a plane perpendicular to the surface. A change in sightline will result in a change in the projected frame dimension (PFD) between frame cross-sectional profiles of individual products within a product line (see Figure 4-4).

Simplified Door Rating (SDR) Method: a modeling procedure allowing component simulations to be conducted by separate entities and re-assembled by an authorized end-user to calculate a total U-factor. Component U-factor and corresponding areas are determined for up to four size configurations of doorglass assemblies and up to five panel/door core/frame-sill configurations for each glass option.

Simulation Software: any computer software used for Computer Simulation.

Site-Built Products: fenestration products that are designed to be field-glazed or field-assembled units comprised of specified framing and glazing components including: operable and fixed windows, curtain walls, window walls, storefronts, sloped glazing, and skylights.

Skylight: see “Unit Skylight/Roof Window.”

Slab Sidelite: a non-operable door slab – (see Sidelite definition)

Sliding Glass Door: sliding glass doors contain one or more manually-operated panels that slide horizontally within a common frame. Operating panel (X) and a fixed lite (O) comprising a unit is termed a single slider (XO or OX). When two operating panels are separated by a fixed lite, the unit is termed a picture slide (XOX) or end vent. When an operating panel separates two fixed lites, the unit is termed a center slide (OXO). When two bi-parting panels are located at the center of the unit with the fixed lites at each end, the unit is termed a bi-part center slide (OXXO). When adjacent panels by-pass one another, the unit is termed a double slide (XX or XXO) or a double slide and end vent (XXX).

Sloped Glazing: a multiple-lite glazed system (similar to a curtain wall) that is mounted at a slope greater than 15° from the vertical plane. This category encompasses all types of skylights including but not limited to: Single Pitch Skylight, Single Pitch Skylight with Vertical Ends, Double Pitch Ridge Skylight, Double Pitch Ridge Skylight with Vertical Ends, Double Pitch Ridge Skylight with Hipped Ends, Pyramid Skylight, Polygonal Skylight, Continuous Vaulted Skylight and Continuous Vaulted Skylight with Vertical End Walls. These products shall be rated as sloped glazing products. Unit skylights are not included.

Spandrel: the opaque areas of a building envelope that typically occur at locations of the floor slabs, columns, and immediately below roof areas.

Spectral (adj): indicating that the property or quantity was evaluated at a specific wavelength, λ , within a small wavelength interval, $\Delta\lambda$ about λ . Usually indicated by placing the wavelength symbol λ , as a subscript following the symbol for the quantity, as with E_{λ} , thereby indicating that the flux-related quantity is a concentration of flux at the indicated wavelength, or it may be placed inside parentheses following the symbol for the material property, as with $\alpha(\lambda)$. It is permissible to indicate the wavelength dependence of a flux quantity as follows: $E_{\lambda}(\lambda)$.

Structurally Glazed Framing: a method of glazing where framing members are generally not exposed to the exterior (i.e., two-sided or four-sided structural glazed)

Sunroom/Solarium: a glazed envelope system that has one wall (or a portion thereof) that opens to a primary structure and remaining walls which may include a number of fenestration systems, such as windows, doors, skylights, kneewalls, etc, in varying percentages per the design of the system.

Surface Heat Transfer Coefficient, Surface Conductance, Film Coefficient (h): the time rate of heat flow between a surface and its surroundings per unit area, and per unit temperature difference.

Side-Hinged Exterior Door: a fixed and/or operable exterior door system. An operable door system shall have at a minimum, a slab and a frame, and hinge attachment of any type between a slab and jamb, mullion, or edge of another slab (e.g. bi-fold doors) or shall have a single, fixed vertical axis about which the slab rotates between open and closed positions. A fixed door system shall have at a minimum a slab and a frame.

Thermal Break: a material of low thermal conductivity that is inserted between members of high conductivity in order to reduce the heat transfer. Thermal barrier material conductivity shall not be more than 0.52 W/mK (3.60 Btu·in/h·ft²·°F).

Thermal Bridge: a path of high thermal conductance from the exterior to interior surfaces of a system that has lower thermal conductance in all other areas. An example would be metal fasteners penetrating an insulating wall or thermally broken frame.

Thermal Opening Area: The area of the TDD/HTDD product at the interior-most plane of the building's thermal envelope.

Thermally Broken (TB) Members: system members with a minimum of 5.30 mm (0.210 in) separation provided by a low conductance material (where thermal conductivity ≤ 0.5 W/mK, (≤ 3.6 Btu·in/h·ft²·°F) or open air space between the interior and exterior surfaces. Examples of such systems include (but are not limited to) pour and debridged urethane systems, crimped-in-place plastic isolator systems, and pressure glazed systems with intermittent fasteners.

[**Note:** Intermittent fasteners shall be manufacturer's standard. Nominal spacing of fasteners shall be 150 mm (6 in) apart or greater.]

Thermally Improved (TI) Members: system members with a separation ≥ 1.60 mm (0.062 in) separation provided by a material [where thermal conductivity ≤ 0.5 W/mK, (≤ 3.6 Btu·in/h·ft²·°F)] or open air space between the interior and exterior surfaces. Such systems include members with exposed interior or exterior trim attached with clips and all skip/debridged systems.

Transom: a non-operable fenestration product that is used as a companion product installed above a door. Transoms may consist of glazed frame or a non-operable sash within a frame. For purposes of complying with this procedure, transoms shall not exceed 700 mm [27 in] in height. (Products that exceed 700 mm (27 in) in height are rated as fixed windows. Operable transoms are rated as the appropriate product type from Table 4-3.)

Tubular Daylighting Device (TDD): a non-operable device primarily designed to transmit daylight from a roof surface to an interior ceiling surface via a tubular conduit. The device consists of an exterior glazed weathering surface, a light transmitting tube with a reflective inside surface and an interior sealing device, such as a translucent ceiling panel. See also "Hybrid Tubular Daylighting Device."

U-factor, Thermal Transmittance (U): The heat transfer per time per area and per degree of temperature difference. The U-factor multiplied by the interior-exterior temperature difference and by the projected fenestration product area yields the total heat transfer through the fenestration product due to conduction, convection, and long-wave infra-red radiation.

Center-of-glazing U-factor (U_c): the U-factor representative of the center-of-glazing area.

Divider U-factor (U_d): the U-factor representative of the divider area.

Door Core U-factor (U_{dc}): the U-factor representative of the door core area.

Edge-of-divider U-factor (U_{de}): the U-factor representative of the edge-of-divider area.

Edge-of-glazing U-factor (U_e): the U-factor representative of the edge-of-glazing area.

Edge-of-panel U-factor (U_{ep}): the U-factor representative of the edge-of-panel area.

End Stile U-factor (U_{es}): the U-factor representative of the garage door end stile area.

Frame U-factor (U_f): the U-factor representative of the frame and sash area.

Lite Frame U-factor (U_{lf}): the U-factor representative of the lite frame area.

Panel U-factor (U_p): the U-factor representative of the panel area.

Total Fenestration Product U-factor (U_t): the U-factor representative of the total system.

Unit Skylight/Roof Window: A window designed for sloped or horizontal application, the primary purpose of which is to provide daylighting and/or ventilation. Typically, the term “roof window” is not used for horizontal applications.

Validation Matrix: two or more product lines whose U-factor can be validated by a single test.

Vehicular Access (Garage Door): a door that is used for vehicular traffic at entrances of buildings (such as garages, loading docks, parking lots, factories, and industrial plants) that is not generally used for pedestrian traffic. The garage door includes vertical jamb tracks, all divider, edge-of-divider, edge-of-glazing, center-of-glazing, door panel core, edge-of-panel, and stile (end cap) areas.

Vertical Sliding Window: a window that contains at least one manually-operated sash that slides vertically within a common frame. Operating sash (X) and a fixed sash (O) comprising a unit are called single hung windows and units with two operating sash (X/X) are called double hung windows.

Weather Strip: a flexible component used to reduce air leakage or water penetration or both between the sash or panels and/or sash or panels and frame.

Window Wall: a type of wall or window system installed between floors or between floor and roof. Also referred to as a “strip window” or “horizontal ribbon window system.” (See “Curtain Wall,” “Storefront.”)

4. GENERAL

4.1 Compliance

Fenestration product ratings shall be determined following the procedures outlined in Section 4.1.1, in accordance with the criteria specified in Sections 4.2 through 4.8, as modified by applicable portions of Section 5.

4.1.1 Product Line Simulation and Testing

- A. Determine the representative size matrix of U-factors. List all individual products and associated representative sizes (see Section 4.4) within a product line. The representative size matrix of U-factors for a product line is given as follows:

Table 4-1 – Representative Size Matrix of U-factors

	U-factor for Model Size
Individual Product #1	
.	
.	
.	
Last Individual Product	

- B. Compute the total fenestration product U-factor for the baseline product in the representative size matrix of U-factors. Using the approved total fenestration product U-factor calculation procedure (see Section 4.3.1), compute the U-factor for the baseline product (see Section 4.2.6).

[Note: Compute as many U-factors in this representative size matrix as is necessary to definitely determine the baseline product.]

- C. Test the baseline fenestration product using the approved total fenestration product U-factor test procedure in Section 4.3.2.1.
- D. Validation of the simulation procedure: if the simulated and tested U-factors for the baseline product are equivalent (as defined in Section 4.7.1), then the computational procedure presented in Section 4.3.1 shall be considered validated for all the products in the product line. The approved total fenestration product U-factor calculation procedure presented in Section 4.3.1 shall then be used to determine U-factors for the model size matrix of U-factors of Section 4.5.1. These are the values that shall be reported. If the simulated and tested U-factors for the baseline product are not equivalent (as defined in Section 4.7.1), then the alternative test procedure presented in Section 4.1.2 may be used for all products within the product line—with written permission from NFRC.

4.1.2 Testing Alternative

If an individual product listed in Section 2.1 cannot be simulated in accordance with Section 4.3.1, the test procedure found in Section 4.3.2.1 shall be used to determine the U-factors of the individual fenestration product(s) for the size defined in Table 4-3.

Currently the following products cannot be simulated:

- a) Non-planar products including but not limited to:
 - 1) Greenhouse/garden windows
 - 2) Tubular daylighting devices
 - 3) Domed skylights without frames or flashing

- b) Complex glazed products other than the following:
 - 1) Vertical products with between-glass venetian blinds
 - 2) Products with outdoor woven shades
 - 3) Products with fritted glazing

The test specimen size shall be the size with the lowest deviation determined from Equation 4-2. If the test specimen cannot be fabricated at the Table 4-3 size, the tested U-factor shall be adjusted to the model size using the following, unless other provisions for specific products have been made in ANSI/NFRC 100:

$$U_{mod} = \frac{(U_{rep}A_{rep})}{A_{mod}}$$

Equation 4-1

Where:

- U_{mod} = U-factor at model size
- U_{rep} = U-factor at representative size (test size)
- A_{rep} = Area at representative size
- A_{mod} = Area of model size

4.1.3 Custom Product Rating

A custom product is an NFRC individual product which meets all of the following criteria:

- A. A custom product shall be composed of unique frame/sash components not covered within an existing standard product line's U-factor matrix;
- B. The specific configuration of a custom product shall not be offered publicly in a manufacturer's catalog or similar literature; and
- C. Fewer than 500 units shall be produced annually or shall be produced as part of one purchase order.

U-factors for custom products (which meet the criteria above) may be represented by U-factor ratings generated for a similar stock individual product made of the same product type and materials. A simulation analysis from an NFRC-certified simulator employed by an NFRC-accredited simulation laboratory, confirming that the custom product's U-factor is equal to or lower than the stock product, shall be provided to the NFRC or NFRC's designated representative.

4.1.4 Dynamic Glazing Product Rating

Products meeting 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 achieve the

stated positions. Rating procedures for these positions shall be the same as for non-Dynamic Glazing Products, as outlined in Section 4.1.1 or Section 4.1.2 as appropriate.

4.2 Product Lines and Individual Products

U-factors shall be determined for all individual products within a product line, except as allowed in Section 4.2.4. All product lines shall be simulated separately.

4.2.1 Product Lines

A product line is a series of fenestration products of the same product type (as listed in Table 4-3) manufactured from the same profiles and components. The following changes are the only allowable exceptions within a product line:

- A. Overall fenestration product size;
- B. Center-of-glazing and edge-of-glazing characteristics such as glazing types and thicknesses, glazing coatings, tints and obscuring, gas-fills, gap widths, shading systems between glazing layers, dividers, and spacers;
- C. Operating/non-operating configurations, as defined in Table 4-3 (including table footnotes);
- D. Changes to accommodate glazing unit variations, limited to changes of geometry, number, or material type to stops, beads, adhesives, or gaskets designed to retain the glazing. Changes to frame and sash profiles are allowed to accommodate glazing unit variations. This provision does not allow for interior and exterior glazed products to be in the same product line;
- E. Frame/sash modifications made to accommodate operating hardware and reinforcement for the purpose of addressing higher/lower loads and stresses: limited to changes that do not change the exterior perimeter shape of the assembled cross section;

[**Note:** "Exterior perimeter" is defined as the perimeter of the entire assembled cross-section (Interior, Adiabatic, and Exterior boundaries of the frame and sash).]

- F. Frame or sash changes where one component is replaced by another component of the same physical shape with a thermal conductivity that does not differ by more than 10 times the thermal conductivity of the original material;
- G. Products with and without cladding can be incorporated into one product line, provided that the only changes made to the unclad product are notches or grooves to accommodate the cladding, or removal of the frame/sash material up to the depth of the cladding;

- H. Changes to the frame/sash profiles to allow for different installations, limited to the following:
- i. Any changes to interior/exterior appendages added to the main web of the frame that are removable or not exposed after product installation, i.e., nailing fins,
 - ii. Changes in the width (dimension perpendicular to the plane of the glazing) of the main frame or main frame components to allow for installation in different wall thicknesses, i.e., lengthening, shortening, and the addition of extruded or pultruded walls within a hollow cavity (web walls),
 - iii. Door products manufactured in both in-swing and out-swing options when only the frame is modified,
 - iv. Any changes to the exterior beyond the plane of the nailing fin, J-channel, the exterior plane of the wall, or interior most point of exterior accessory groove, i.e. screen tracks, varying shapes of brickmold, J-channels, or stucco bars formed in (integral) or applied to the frame and that do not change the sightline,
 - v. Any changes or additions to accessory grooves or decorative flanges, i.e., lengthening, shortening, and the addition of reinforcing web wall(s);
 - vi. Any changes to trim/stops due to an application of a screen system that cover or hold the screen. The product offered without a screen system shall be used to represent this product and minor frame changes to accommodate the screen system are permitted.
- I. Any sightline changes due to:
- i. Lengthening or shortening of existing walls,
 - ii. Components added or replaced for equal and unequal lite configuration options,
 - iii. For the installation of an outside air ventilator assembly (OAVA), or
 - iv. Changes to the frame profiles to allow for different installations including pocket or sloped-sill configuration options and sill height modifications;
 - v. Sightline changes that occur due to any situation in 4.2.1 shall also be allowed. For example, the sightline change due to a change in the glazing bead shall be allowed per Section 4.2.1 (D).

[Note: A change in sightline will result in a change in the projected frame dimension (PFD) between frame profiles of individual products within a product line.]

- J. Changes to the following are deemed minor revisions made to the profiles:
 - i. Limited to changes in the size and shape of snap beads, stops, jamb extensions, dividers (including simulated and true divider lites), weather strip sockets and kerfs, exterior trim caps on curtain walls, window walls, and sloped glazing,

[Note: The term “stop” above refers to any stop and not just glazing stops.]

 - ii. Decorative elements such as grooves, beads, or brickmolds or exterior trim components and/or casings formed in or applied to the frame or sash are also allowed,
 - iii. Addition, removal, or modification of pull/lift handles utilized on the interior side of the product, whether it is an integral extrusion of the sash/glazing bead or mechanically fastened, or
 - iv. Addition, removal, or replacement of a snap-in extrusion (in which the thermal conductivity does not differ by more than 10 times of the original material) for sealing and /or interlocking purposes;
- K. Addition, deletion, or changes in hardware and reinforcement (may include reinforcing web walls);
- L. Changes to interior or exterior finishes or coatings;
- M. Sealing characteristic variables and elements: limited to changes in gaskets, sealants, adhesives, weather strips, or the addition/removal of drip-caps, in the same profile (profile changes to accommodate seal changes shall be allowed); and
- N. Vinyl caps attached to the interior.

4.2.2 Individual Products

An individual product is any one specific combination of the product line variables (singularly or in combination) allowed in Section 4.2.1. All individual products shall be simulated except as allowed in Section 4.2.1.

The following changes are the only allowable exceptions to an individual product:

- A. Variations in frame or sash interior/exterior finish, paint, varnish, or stain shall not constitute different individual products provided that each of these variations does not change the surface emittance by more than 0.1 or overall thickness by more than 0.400 mm (0.016 in);
- B. Products with different variations in glazing divider patterns do not need to be treated as different individual products:
 - i. The manufacturer shall be permitted to define a standard glazing divider pattern (which shall be a standard product

- offering) which uses glazing dividers 300 mm (12 in) on-center or less,
- ii. A glazing divider pattern with an on-center spacing closest to but not greater than 300 mm (12 in) shall be designated as the glazing divider pattern, or
- iii. The overall window dimension shall be used to determine the number of dividers;
- C. Fenestration products that include an outdoor air ventilator assembly (OAVA) shall be considered the same individual product if the OAVA projected dimension (including any components to facilitate installation of the OAVA) is less than or equal to 45 mm (1.75 in). If this dimension exceeds 45 mm (1.75 in) it shall be simulated as an individual product; and
- D. Dynamic glazing products shipped with integral or attached shading systems shall be considered individual products within the product line.

4.2.3 Validation Test Matrix

A validation test matrix of multiple product lines of the same product type or multi-purpose products of different product types shall be permitted to be created.

4.2.3.1 Same Product Type

When the changes listed below are made, two or more product lines of the same product type (as listed in Table 4-3) shall be permitted to be included within the same validation test matrix if the overall U-factor difference between the product lines is $\pm 0.06 \text{ W/m}^2\text{K}$ ($0.01 \text{ Btu/h}\cdot\text{ft}^2\cdot^\circ\text{F}$) or less when simulated with the lowest center-of-glazing option.

- A. Changes to shift the location of the glazing relative to the sash or frame – exterior to interior;
- B. Changes (to sash profiles only) to accommodate interior and exterior glazed products;
- C. Product lines fabricated with both pocket and sloped sill options;
- D. Changes to installation orientation of a product where the product has been designed to function when installed facing into or out of the room; or
- E. Changes to accommodate in-swing and out-swing product lines with nearly identical frame/sash base profiles. Minor changes to profiles to accommodate the in-swing and out-swing operation change are allowed, but are limited to: (a) movement, addition, or deletion of specific elements (i.e. walls & cavities), (b) weatherstripping and associated sealing

characteristics, and (c) any component changes that occur as a direct result of any hardware changes.

4.2.3.2 Multi-Purpose Products

Multi-purpose products incorporating nearly identical frame/sash base profiles shall be permitted to be within one validation matrix provided that the differences between the base profiles are limited to minor changes to accommodate different product types. The minor changes allowed are:

- A. The movement or addition of specific elements (i.e. walls and cavities) to accommodate the differing operating hardware;
- B. Adding or deleting components to adapt a channeled frame to use a tilt sash;
- C. The use of the hung window sash stiles as the bottom rail;
- D. Deleting of the roller track of the horizontal slider;
- E. The addition of sash balance covers; or
- F. Any other component changes that occur as a direct result of the hardware changes.

Any elements added to the profile to accommodate operating hardware shall be of the same material types used in the original profile.

4.2.4 Grouping of Products

This section presents rules that shall be permitted to reduce the number of simulations for individual products that represent a product line. If this approach is used, the total fenestration product U-factor for the group leader shall be used to represent the total fenestration product U-factors for all individual products within that group. These grouping rules shall not be used to group individual products from different product lines into one product line.

To ensure consistent ratings, groupings shall be done in the following order:

Center-of-glazing (includes dividers)	Section 4.2.4.1
Shading systems between glazing layers	Section 4.2.4.2
Frame/Sash	Section 4.2.4.3
Spacer	Section 4.2.4.4
Sightline Grouping	Section 4.2.4.5

Any combination of groupings shall be done in the order established above. All grouping comparisons shall be based on three significant digits.

4.2.4.1 Center-of-Glazing Grouping

For the purpose of determining U-factors, center-of-glazing groups shall consist only of variations in glazing thickness, gap width, gas fill, low-E coatings, and the presence or absence of internal grids. Once all center-of-glazing options have been identified within a product line, the center-of-glazing U-factor shall be simulated for each option. Then these products shall be permitted to be grouped, with each group represented by the center-of-glazing group leader (which shall be the center-of-glazing option with the highest center-of-glazing U-factor):

- A. Glazing options with different numbers of glazing layers shall not be grouped together;
- B. Glazing options with clear glazing in all layers shall not be grouped with glazing options with one or more low-E layers (E is less than or equal to 0.50); and
- C. Only individual products that contain the same mixture of gases shall be permitted to be grouped. Variable concentrations of the same mixture of gases shall be permitted to be grouped as a center-of-glazing grouping as long as the total gas concentration, other than air, is more than 60% and does not vary by more than $\pm 10\%$ from the group leader.
- D. For the purpose of determining U-factors, divider groups shall consist only of variations in divider materials and shapes. After all divider options have been identified within a product line the divider heat loss shall be simulated for each divider option using the glazing option with the lowest center-of-glazing U-factor in the product line. These products shall be permitted to be grouped with each group represented by the divider group leader, which shall be the divider option with the highest divider frame heat loss. If this approach is used, the total fenestration product U-factor for the divider group leader shall be used to represent the total fenestration product U-factors for all individual products within that divider group.
 - i. For glazing matrix consisting of both double pane and triple pane glazing configurations, dividers can be grouped by simulating each divider option in the appropriate glazing category (double pane or triple pane) with the lowest center-of-glazing U-factor in the glazing category. Divider group leaders for double pane and triple pane configurations shall represent the double pane group and triple pane group, respectively.
 - ii. Products with glazing dividers, or decorative tape-applied coming bars between layers of an insulated

glass (IG) unit shall be permitted to be assumed to have the same U-factors as identical products without such dividers, providing the following:

- a. For dividers, there is at least 3.00 mm (0.118 in.) air/gas space between the divider and both adjacent glazing surfaces.
- b. For simulated coming bars applied with decorative tape, there shall be a minimum airspace of 9.5mm (0.375 in.) between the coming bar and adjacent glazing surface.

4.2.4.2 Grouping of Shading Systems between Glazing Layers

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

- A. Shading systems within a group shall vary only by color of the shading systems. The shading system used in the group leader shall be permitted to be of any color; and
- B. Glazing layers within a group, and the corresponding glazing layers used in the group leader, shall be determined in accordance with the center-of-glazing grouping rules of Section 4.2.4.1.

4.2.4.3 Frame/Sash Grouping

- A. For the purpose of determining U-factors, frame groups shall consist only of frame/sash base profile variations consistent with the definition of a product line. After all frame options have been identified within a product line, the frame and edge-of-glazing heat loss shall be simulated for each option with the lowest center-of-glazing U-factor in the product line. The frame group leader shall be identified as the set of frame options within the highest whole product heat loss. If this approach is used, the total fenestration product U-factor for the frame group leader shall be used to represent the total fenestration product U-factors for all individual products within that group.
- B. To determine the frame group leader the spacer used in simulation shall be a spacer used by the manufacturer. If more than one spacer is available, the spacer used shall be selected from the list below in the following order:

Group 1 – Spacer containing aluminum

Group 2 – Spacer containing mild steel (i.e. galvanized steel, tin-plated steel)

Group 3 – Spacer containing stainless steel

Group 4 – Spacer containing all non-metallic materials

4.2.4.4 Spacer Grouping

For the purpose of determining U-factors, spacer groups shall consist only of variations in spacer assembly materials and shapes. After all spacer options have been identified within a product line, the frame and edge-of-glazing heat loss shall be simulated for each spacer option with the lowest center-of-glazing U-factor and the frame group leader in the product line. These products shall be permitted to be grouped with each group represented by the spacer group leader (which shall be the option with the highest whole product heat loss). If this approach is used, the total fenestration product U-factor for the spacer group leader shall be used to represent the total fenestration product U-factors for all individual products within that group.

- A. For glazing matrix consisting of both double pane and triple pane glazing configurations, spacers can be grouped by simulating each spacer option in the appropriate glazing category (double pane or triple pane) with the lowest center-of-glazing U-factor in the glazing category. Spacer group leaders for double pane and triple pane configurations shall represent the double pane group and triple pane group, respectively.

4.2.4.5 Sightline Grouping

- A. 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, which shall be the sightline option within the group with the highest total fenestration product U-factor. Since sightline changes may be in small size increments, the determination of the highest total fenestration product U-factor for each sightline group shall be determined for the frame/sash with the greatest and least daylight opening areas, using the lowest center-of-glazing U-factor option and the model size for the product type per Table 4-3.

4.2.5 General Simulation Rules

- A. If a nail flange is not removable and is identified as such by the manufacturer, the product shall be simulated and tested with the nail flange covered with a nominal 1 in x 4 in fir trim. If a nail

flange is removable, the product shall be simulated and tested without the nail flange;

- B. Products with integral appendages that extend beyond the rough opening and are not exposed after installation shall be permitted to be assumed to have the same U-factors as identical products without such appendages;
- C. Products with elements added to the outer surface of the framing so as to expand the frame in the direction parallel to the plane of installation and allow for different installations, shall be permitted to have the same U-factors as identical products without such added elements:
 - i. Examples of such elements include, but are not limited to, subsills and frame expanders;
- D. Nominal glass thickness shall be permitted to be used for determining U-factor provided the emissivity of the glass is taken from the approved NFRC Spectral data file and the air gap dimension is maintained at the dimensions specified by the manufacturer. The nominal glass thickness to be used shall be listed in ASTM C 1036 [Reference 6]. If the glass thickness does not fall within the nominal thickness ranges, the actual thickness shall be used;
- E. An infill system with a “Center-of-Glazing Component Test” that utilizes an adaptor between the infill and frame which allows for direct replacement of the standard glazing shall be considered an individual product in the same product line with the standard glazing, as long as all components (including the adaptor) are included in the simulation for the infill glazing system;
- F. Non-rectangular fenestration products shall be rated as rectangular fenestration products per the standard size in Table 4-3 (develop a product line with the same frame cross sections as the non-rectangular fenestration product); and
- G. IG units manufactured with breather or capillary tubes designed to remain closed after manufacturing shall be simulated as having the same gas content; IG units manufactured with breather tubes intended to be opened at some point after manufacturing shall be simulated as air-filled IG units;
- H. For the purpose of determining U-factors, only glazing tint and/or obscuration (including obscure glass, fritted glass, or wired glass) shall be permitted to be assumed to have the same U-factor as the clear glass and does not need to be simulated separately unless this change is associated with a change in coating properties; and
- I. Products with removable or non-removable dividers (e.g. SDL) or decorative tapes that are applied to glazing to simulate the appearance of dividers applied to the room side and/or exterior side glazing surface shall be permitted to be assumed to have the

same U-factors as identical products without such dividers. However, any component (shadow bar) of an SDL that is within the cavity of the IGU shall be treated as a normal internal divider. At the discretion of a manufacturer, a simulator shall be permitted to model a SDL in accordance with Section 8.3.2 of the NFRC Simulation Manual.

4.2.6 General Testing Rules

The baseline product shall be the individual product selected for validation testing (see Section 4.1.1). The individual product selected as the baseline product shall have a simulated U-factor within $0.60 \text{ W/m}^2\text{K}$ ($0.10 \text{ Btu/h}\cdot\text{ft}^2\cdot^\circ\text{F}$) or 20% of the lowest simulated U-factor, whichever is greater. Size variations shall be limited to the representative size as defined in Section 4.6.1 for the product type. If more than one product type is being validated with a single test, then the baseline product shall be selected from the product lines in the validation test matrix.

4.2.7 General Rating Rules

- A. Combination products shall not be rated in combination.
- B. Sash kits, sliding door panels, and side hinged door slabs shall be rated using one of two options:
 - Option1: Simulate and test (if required) in a frame of similar material and design as the proposed installation. Manufacturers of sash kits, sliding door panels, and side hinged door slabs shall provide information on the intended installations for those products. (See Figure 5-6 for an example of a default double hung frame when a sash kit is intended to be installed in a wood double hung window.)
 - Option 2: Sash kits, sliding door panels, and side hinged door slabs that are identical in material and design as a manufacturer's rated product line may use the same ratings. The manufacturer shall verify the rated frame meets the requirements of Option 1.

4.2.8 Additions to the Product Line

The product line validated simulation procedure (see Section 4.1.1) may be used to determine U-factors of additions to a validated product line if the simulated U-factor for the additional product(s) is either higher than the previously computed baseline product U-factor, or not more than $0.60 \text{ W/m}^2\text{K}$ ($0.10 \text{ Btu/h}\cdot\text{ft}^2\cdot^\circ\text{F}$) or 20% (whichever is greater) lower than a previously simulated baseline product U-factor.

If the simulated U-factor of the addition to the product line is outside these bounds, a new baseline product shall be established and validated by testing.

If a manufacturer introduces a new individual product into multiple product lines (see Section 4.2.6 for an example of glazing or spacer options) that has simulated U-factor more than $0.60 \text{ W/m}^2\text{K}$ ($0.10 \text{ Btu/h}\cdot\text{ft}^2\cdot^\circ\text{F}$) or 20% lower than the simulated baseline product U-factor, only one product line

with a new individual product shall be tested. If the simulation of the new baseline product validates, then all other product lines using this option shall be validated and those new individual products shall be permitted to be simulated to obtain U-factors.

4.3 Standard Conditions

This section presents standard simulations, tests, and calculations for determining total or component fenestration product U-factors.

4.3.1 Simulation

The requirements of Reference 2 (NFRC Simulation Manual) and of Section 4.3.2.1 shall be used to determine total fenestration product U-factors.

Skylights and other sloped glazing products shall be simulated and rated at a slope of 20° above the horizontal. Until accurate simulation software is available, tubular daylighting devices (TDDs) shall be tested and rated with the tube in a vertical orientation (Figures 5-10a and b). All other products shall be simulated and rated in the vertical position.

All calculations shall be based on computer simulations using the latest approved software (which shall be in compliance with ISO 15099), with the following exceptions:

- A. For calculating the overall U-factor (per ISO 15099), the area-weighted method as described in Section 4.1.3 of ISO 15099 shall be the only method permitted;
- B. Thermophysical properties of materials shall be determined in accordance with NFRC 101;
- C. For fenestration products incorporating venetian blinds:
 - a. Include models for venetian blinds slats (See References 13 and 14);
 - b. Thermal radiation from venetian blinds shall be calculated using directional diffuse radiation (See References 13 and 14);
- D. Include models for fritted, etched, or sand-blasted glazing (See References 14 and 15);
- E. Section 8.2 in ISO 15099 addresses environmental conditions. The following conditions shall be used for the determination of U-factor:

NFRC Simulation Conditions:

T_{in}	=	interior ambient temperature of 21.0° C (69.8° F)
T_{out}	=	exterior ambient temperature of -18.0° C (-0.4° F)
V	=	wind speed of 5.5 m/s (12.3 mph)
$T_{rm,out}$	=	T_{out}
$T_{rm,in}$	=	T_{in}

$$I_s = 0 \text{ W/m}^2 \text{ (0 Btu/h}\cdot\text{ft}^2\text{)}$$

- F. Section 8.3 in ISO 15099 addresses convective film coefficients on the interior and exterior of the window product;
- G. The indoor side convective heat transfer coefficient shall be based on the center of glass temperature and the entire window height; this film coefficient shall be used on all glass and edge of glass indoor surfaces. Frame section indoor convective film coefficients shall be constants, which depend on frame material type; these values are listed in Table 4-2;
- H. The outdoor side convective heat transfer coefficient shall be calculated based on wind speed (as defined under 4.3.1.E) and shall be applied to all of outdoor surface, glass and frame. Standard values for outdoor convective surface heat transfer coefficients is listed in Table 4-2;
- I. On the indoor side of a fenestration product, detailed radiation model, based on gray body radiation model as described in Section 8.4.2.1 in ISO 15099, shall be used for all products. This model applies to both glass and frame surfaces;
- J. The use of detailed radiation model on indoor fenestration surfaces makes the use of “slightly or partially ventilated cavities” on the indoor frame surfaces redundant (see Section 6.7.1 of ISO 15099). The standard frame convective film coefficients (h_c) shown in Table 4-2 and detailed radiation model referenced above shall thus be applied to all interior frame surfaces;
- K. On the outdoor side of a fenestration product, black body radiation model (as defined in ISO 15099) shall be used. This model applies to both glass and frame surfaces; and
- L. All cross-sections shall include 150 mm (6 in) of glazing section from the sightline to the end of the glazing section, while maintaining a 63.5 mm (2.5 in) edge-of-glazing dimension.

Table 4-2 – Boundary Conditions

Boundary Condition	Radiation Model	Convective Film Coefficient Boundary	
		Tilt = 90° W/m ² K (Btu/h·ft ² ·°F)	Tilt = 20° W/m ² K (Btu/h·ft ² ·°F)
NFRC 100-2001 Exterior	Blackbody	26.00 (4.578)	26.00 (4.578)
Interior Aluminum Frame (convection only)	Automatic Enclosure Model	3.29 (0.579)	4.65 (0.819)
Interior Thermally Broken Frame (convection only)	Automatic Enclosure Model	3.00 (0.528)	4.09 (0.720)
Interior Thermally Improved Frame (convection only)	Automatic Enclosure Model	3.12 (0.549)	4.32 (0.761)
Interior Wood/Vinyl Frame (convection only)	Automatic Enclosure Model	2.44 (0.429)	3.09 (0.544)

Boundary Condition	Radiation Model	Convective Film Coefficient Boundary	
		Tilt = 90° W/m ² K (Btu/h·ft ² ·°F)	Tilt = 20° W/m ² K (Btu/h·ft ² ·°F)
Interior Glazing System boundary condition	Automatic Enclosure Model	Depends on the WINDOW calculations for the imported glazing system	

4.3.2 Testing

4.3.2.1 Total Fenestration Product Test Procedure

The NFRC 102 [Reference 1], shall be used to determine tested total fenestration product U-factors. The following conditions also apply:

- A. Test specimen size tested shall be in accordance with Section 4.6.1;
- B. All test specimens shall be tested without screens, removable grilles and trims, or any other applied devices;
- C. All test specimens shall be tested in the vertical position, except tubular daylighting devices (TDDs). TDDs shall be tested and rated with the tube in a vertical orientation (see Figures 5-10a and b). For determining validation of the baseline product only, skylights and other sloped glazing products shall be simulated in a vertical position; and
- D. The test specimen shall not be modified by the testing laboratory, except as allowed in Reference 1 for sealing against air leakage and as required in this section.

4.3.2.2 Center-of-Glazing Component Test Procedure

If the U-factor for the product cannot be simulated in accordance with Section 4.3.1, the test methods in ASTM C1363-97 (or later versions) using NFRC environmental conditions, shall be used to determine the conductance of the center-of-glazing. The conductance value shall be used to determine an effective conductivity at the thickness of the glazing/frame insert which can be used to build a glazing layer in WINDOW.

The specimen shall be 1000 mm x 1000 mm (39 in x 39 in) or closest deviation as determined using Section 4.6. This size represents all product types in Table 4-3.

For a product that consists of a glazing panel only (without frame), the tested U-factor per this section, standardized in accordance with NFRC 102, shall be the U-factor of the product.

Obscure, patterned, and tinted versions of a clear glazing tested using this procedure may be represented by the clear glazing results as long as the product emissivity does not change.

4.3.2.3 Component Substitution

Component substitutions may be made if using approved NFRC simulation tools to verify the performance equivalence to three significant digits. The original certified U-factors shall be used to represent the new product.

For products certified under the testing alternative method (Section 4.1.2), component substitution shall apply only if the simulation laboratory states in the simulation report that the simulation tools are appropriate for the simulation of the components being substituted.

- A. For spacer substitutions, only the spacer shall be modeled, or
- B. For glazing system changes, only the center-of-glazing shall be modeled.

4.4 Model Sizes and Configurations

For each individual product, total fenestration product U-factors shall be reported for the specified configuration at the model size as shown in Table 4-3.

For products that, when area-weighted at the standard NFRC size, have less than 63.5 mm (2.5 in) edge-of-glazing area or edge-of-divider area, the overall product dimensions shall be increased as needed to restore the standard 63.5 mm (2.5 in) of edge-of-glazing for each section (including dividers). The increase in size shall result in zero center-of-glass area.

Table 4-3 – Product Types and Model Sizes

Product Type	Opening (X) Non-operating (O)	Model Size (width by height)
		SI (IP)
Casement – Double ¹	XX, XO, OO	1200 mm x 1500 mm (47 in x 59 in)
Casement – Single	X ⁶	600 mm x 1500 mm (24 in x 59 in)
Dual Action	X ⁶	1200mm x 1500 mm (47 in x 59 in)
Fixed (includes non-standard shapes)	O	1200 mm x 1500 mm (47 in x 59 in)
Garage(Vehicular Access)/Rolling Door	X ⁶	2134 mm x 2134 mm (84 in x 84 in)
Greenhouse/Garden ²	X ⁶	1500 mm x 1200 mm (59 in x 47 in)
Hinged Escape	X ⁶	1500 mm x 1200 mm (59 in x 47 in)
Horizontal Slider	XO or XX	1500 mm x 1200 mm (59 in x 47 in)
Jal/Jal Awning	X ⁶	1200 mm x 1500 mm (47 in x 59.in)
Pivoted	X ⁶	1200 mm x 1500 mm (47 in x 59 in)
Projecting (Awning, Dual)	XX ⁶	1500 mm x 1200 mm (59 in x 47 in)
Projecting (Awning – Single)	X ⁶	1500 mm x 600 mm (59 in x 24 in)
Door Sidelite ⁵	X or O	600 mm x 2090 mm (24 in x 82 3/8 in)
Skylight/Roof Window	X ²	1200 mm x 1200 mm (47 in x 47 in)
Sliding Patio Door with Frame	XO or XX ⁸	2000 mm x 2000 mm (79 in x 79 in)
Curtain Wall/Window Wall/Storefront/Sloped Glazing	OO ³	2000 mm x 2000 mm (79 in x 79 in)
Spandrel Panel	OO	2000 mm x 1200 mm (79 in x 47 in)
Side-Hinged Exterior Door	O, X, XO or XX ⁴	960 mm x 2090 mm (37 3/4 in x 82 3/8 in); or 1920 mm x 2090 mm (75 1/2 in x 82 3/8 in)
Door Transom ^{5,7}	O	2000 mm x 600 mm (79 in x 24 in)
Tropical Awning	X ⁶	1500 mm x 1200 mm (59 in x 47 in)
Tubular Daylighting Device	O	350 mm Dia. (14 in Dia.)
Vertical Slider	XO or XX	1200 mm by 1500 mm (47 in by 59 in)

¹Double Casements and Dual Awning are to be rated only in the case where single units are not manufactured.

²If not manufactured, use O (non-operable version). Non-operating versions of this type may be included in the same product line as the operable version as long as the changes to render the product non-operable comply with Section 4.2.

³Two lites with one vertical mullion. A multi-story system shall be simulated as a curtain wall and a single-story system shall be simulated as a window wall. Curtain walls shall be simulated and tested with intermediate verticals as jambs and intermediate horizontals as head/sill frame members. Window walls and storefronts shall be simulated and tested with intermediate verticals as jambs and standard head and sill members. For rating of curtain walls d window walls and storefronts, area weight intermediate members based on centerline dimensions. Sloped glazing may also be rated based on the centerline dimensions if utilized like a curtain or window wall, except for solariums and sunrooms. Sloped glazing of solariums and sunrooms shall be simulated and tested with standard jamb, head, and sill members (see Section 5.6.4.2). Other sloped glazing not similarly used like a flat curtainwall or windowwall, as identified under the "Sloped Glazing" definition, shall also be rated as sloped glazing products based on centerline dimensions and they shall be simulated and tested with purlins as head and sill and rafters as jambs and intermediate verticals.

⁴The single door shall be used to represent all door assemblies (single, double, multiple) unless the manufacturer does not produce a single door, in that case the double door shall be used to represent double and multiple door assemblies.

⁵Sidelites greater than 700 mm wide (27 in) and transoms greater than 700 mm (27 in) high shall be rated as fixed windows. Slab sidelites greater than 700 mm wide (27 in) shall be rated as swinging doors. Operable sidelites are rated as the appropriate operator type.

⁶Non-operating versions (O) of this type may be included in the same product line as the operable version as long as the changes to render the product non-operable comply with Section 4.2. If there is no operable version of the product, it is classified as a fixed window.

⁷Operable transoms are rated as the appropriate operator type.

⁸Representative of all sliding patio doors and combinations of sliding patio doors and fixed unit(s).

4.5 Simulation Procedures

4.5.1 Total Fenestration Product U-factors for Model Sizes

For a given product line, list all individual products and the associated model size U-factors (see Section 4.4). The model size matrix of U-factors for a given product line shall be outlined as shown in Table 4-1.

This matrix shall include all individual products within a product line that are available from the manufacturer, including but not limited to the number of glazing layers, glazing types, glazing coatings, gas fills, gap widths, spacer types, and use of dividers. See Section 4.2.1 for the definition of a product line and Section 4.2.2 for the definition of an individual product.

In order to determine total fenestration product U-factors for all of the entries in this matrix, use the product line validated simulation procedure, presented in Section 4.1.1. The testing alternative, presented in Section 4.1.2, may only be used to determine the U-factor for an individual product(s) within a product line if that individual product(s) cannot be simulated in accordance with Section 4.3.1.

Thus, the only time a product line may contain tested as well as simulated total fenestration product U-factors shall be when an accredited simulation laboratory states in the simulation report that it cannot simulate an individual product(s) to a reasonable accuracy. In addition, the written permission of NFRC shall be required.

4.5.2 Total Fenestration Product

The U-factor of a fenestration product may vary by size, depending upon the component materials and the glazing. To simplify the system, ratings are based on a specific model size. The U-factor for the model size in Table 4-3 shall be representative of all variations in configuration with dual or more lites (opening/non-opening) for the product type, except as indicated in any applicable footnote. The U-factor for the model size shall be representative of all variations in size and factory assembled operable and fixed units in a common frame.

For gas fills other than air, the gas fill concentration percentages represent the initial nominal design value. The maximum gas concentration used in the simulations shall not exceed the following values:

Evacuated Chamber Filling	97% for any gas type
Two-Probe filling with concentration sensor	95% for Argon 90% for any other
Single-Probe Timed Filling	90% for any gas type

Non-continuous elements including (but not limited to: screws and bolts in sloped glazing and poured and debridged thermal barriers that are not fully debridged), shall be simulated as indicated in Reference 2.

The total fenestration product U-factor calculation procedure can be found in the applicable fenestration product section, see Sections 5.1 to 5.10.

4.5.3 Component

4.5.3.1 Approved Center-of-Glazing Simulation Programs

Approved center-of-glazing software shall be used. NFRC approved software is listed in Reference 3.

4.5.3.2 Approved 2-D Heat Transfer Simulation Programs

Approved 2-D heat transfer software shall be used. NFRC approved software is listed in Reference 3.

4.6 Test Procedures

There are two different test procedures used in ANSI/NFRC 100:

Total Fenestration 4.6.1

Glazing 4.6.2.1

Section 4.3.2.1 defines the total fenestration product test procedure, its standard conditions and requirements. The total fenestration product test procedure shall be used to validate the product line simulations (see Section 4.1.1) and shall be used under the testing alternative (see Section 4.1.2), which shall be used only if the U-factor for the product cannot be simulated in accordance with Section 4.3.1. Section 4.3.2.2 defines a glazing component test procedure, which may be used only if the U-factor for the center-of-glazing cannot be simulated in accordance with Section 4.3.1. Since the glazing system may include non-homogeneous elements (e.g. spacers, thermal bridges, etc.), an average conductance shall be assigned to the whole glazing system. Insertion of such a glazing system in the 2-D heat transfer program shall be done as a continuous slab of material with the conductivity equal to the average conductivity of the glazing system.

4.6.1 Total Fenestration Product

For the purposes of testing (see Section 4.3.2), production line units and sizes shall be used. The test specimen size shall be the production line size with the least deviation (D) from the model size (see Table 4-3) as defined by Equation 4-2:

$$D = \sqrt{(W_p - W_m)^2 + (H_p - H_m)^2} \quad \text{Equation 4-2}$$

Where

D = Deviation in mm (in)
 W_p, H_p = Width, height of production size in mm (in)
 W_m, H_m = Width, height of model size in mm (in)

For rectangular fenestration products, the representative sizes reported by the simulation laboratory shall not vary by more than 13.0 mm (0.5 in) in width or 13.0 mm (0.5 in) in height (25 mm [1 in] for doors) from the reported sizes of the tested specimens.

For non-rectangular products, the simulated product area shall meet the following relationship with the tested specimen area:

$$A_{test} - C(W_m + H_m) \leq A_{sim} \leq A_{test} + C(W_m + H_m)$$

Equation 4-3

Where

- A_{sim} = Area of product simulated in mm² (in²)
- A_{test} = Area of specimen tested in mm² (in²)
- C = A constant, 25 mm (1 in)
- W_m, H_m = Width, height of model size in mm (in)

4.6.2 Component

4.6.2.1 Glazing Component Test Procedure

The test methods in Reference 6, using NFRC environmental conditions, shall be used to determine the average conductivity of the glazing. The test results are applicable only to the unit tested, with no variations in shape or material allowed.

4.6.3 Calculation Procedure

The total fenestration product U-factor shall be calculated as outlined below:

- A. Determine all of the following, as applicable:
 - i. Center-of-glazing U-factor per the total product height procedure (as defined in Reference 2) using an approved center-of-glazing simulation program or the approved glazing test procedure given in Section 4.3.2.2,
 - ii. Edge-of-glazing U-factor, using an approved 2-D heat transfer simulation program. In the case that center-of-glass thermal performance is simulated, this center-of-glass configuration shall be inserted into the frame and spacer assembly shall be added. In the case that the glazing component test procedure had to be utilized, entire glazing system shall be represented as a homogenous slab of material with conductivity equal to average conductivity of the measured specimen. For mullions and meeting rails, two glazing systems shall be inserted on each end and the reported U-factor shall be the average of the two edge-of-glass U-factors,
 - iii. Divider U-factor, using an approved 2-D heat transfer simulation program. Divider shall be simulated with two glazing systems pointing in opposite directions, simulated in a vertical orientation,

- iv. Edge-of-divider U-factor, using an approved 2-D heat transfer simulation program. Edge-of-divider U-factor shall be the average of the two edge-of-glass section U-factors,
 - v. Frame U-factor using an approved 2-D heat transfer simulation program. Frame U-factor is always calculated on the exposed indoor side of frame, starting at the bottom of the frame and ending at the indoor sight line. For mullion and meeting rail cross-sections, frame surface is counted from one indoor sight line to another,
 - vi. The component areas of:
 - a) Center-of-glazing area,
 - b) Edge-of-glazing area,
 - c) Divider area,
 - d) Edge-of-divider,
 - e) Frame area, and
 - f) Projected fenestration product area;
- B. Perform the following calculations as explained:
- i. Multiply the center-of-glazing, edge-of-glazing, divider, edge-of-divider, and frame U-factors by their corresponding areas,
 - ii. Total these quantities, and
 - iii. Divide this total by the projected fenestration product area to produce simulated total fenestration product U-factors for all the fenestration products in the matrix of required U-factors.

4.6.4 Reporting of Ratings

The U-factor shall be reported to 0.05 W/m²K (0.01 Btu/h·ft²·°F). The full floating point accuracy of any software shall be used for all calculations. The final U-factor shall be rounded to two digits following the decimal point after truncating the full precision result to six decimal places.

4.7 Validation

4.7.1 Equivalence

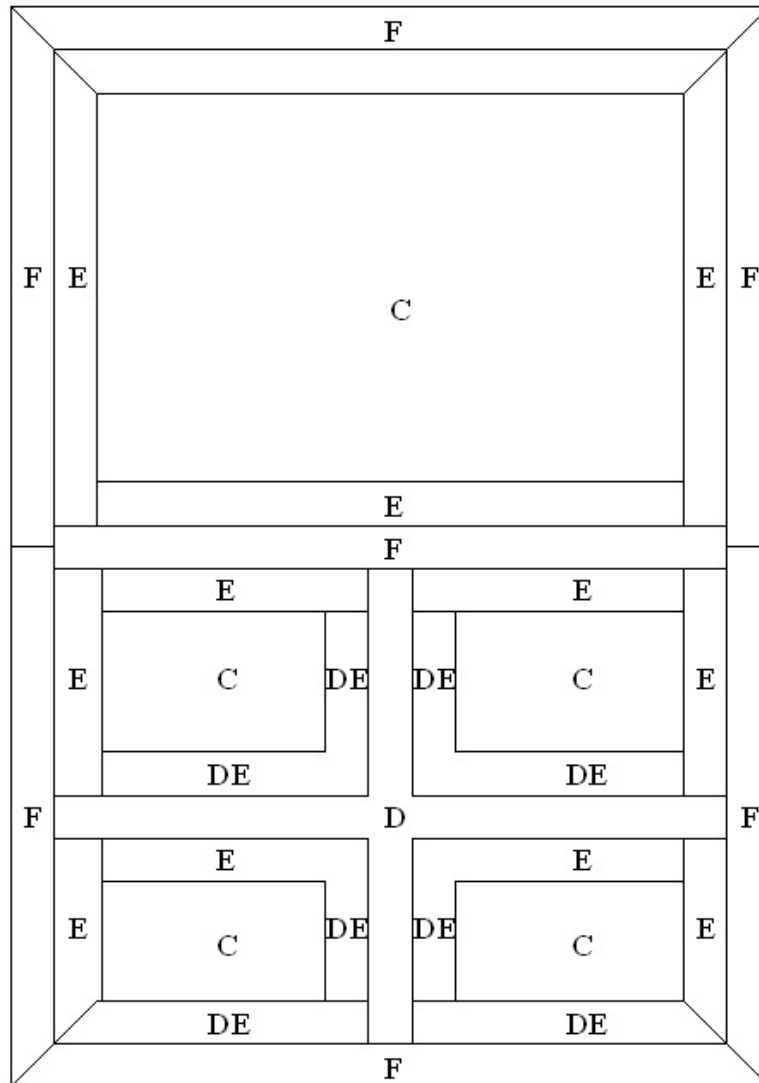
Simulated and tested U-factors for a given total fenestration product shall be considered equivalent if the agreement between the two numbers is within the ranges in Table 4-4.

Table 4-4 -- Equivalence

Simulated U-factor	Accepted Difference Between Tested and Simulated U-factor
1.7 W/m ² K (0.3 Btu/h·ft ² ·°F) or less	0.17 W/m ² K (0.03 Btu/h·ft ² ·°F) or less
Greater than 1.7 W/m ² K (0.3 Btu/h·ft ² ·°F)	10% of Simulated U-factor

4.8 Figures

Figure 4-1 – Fenestration Product Schematic – Vertical Elevation

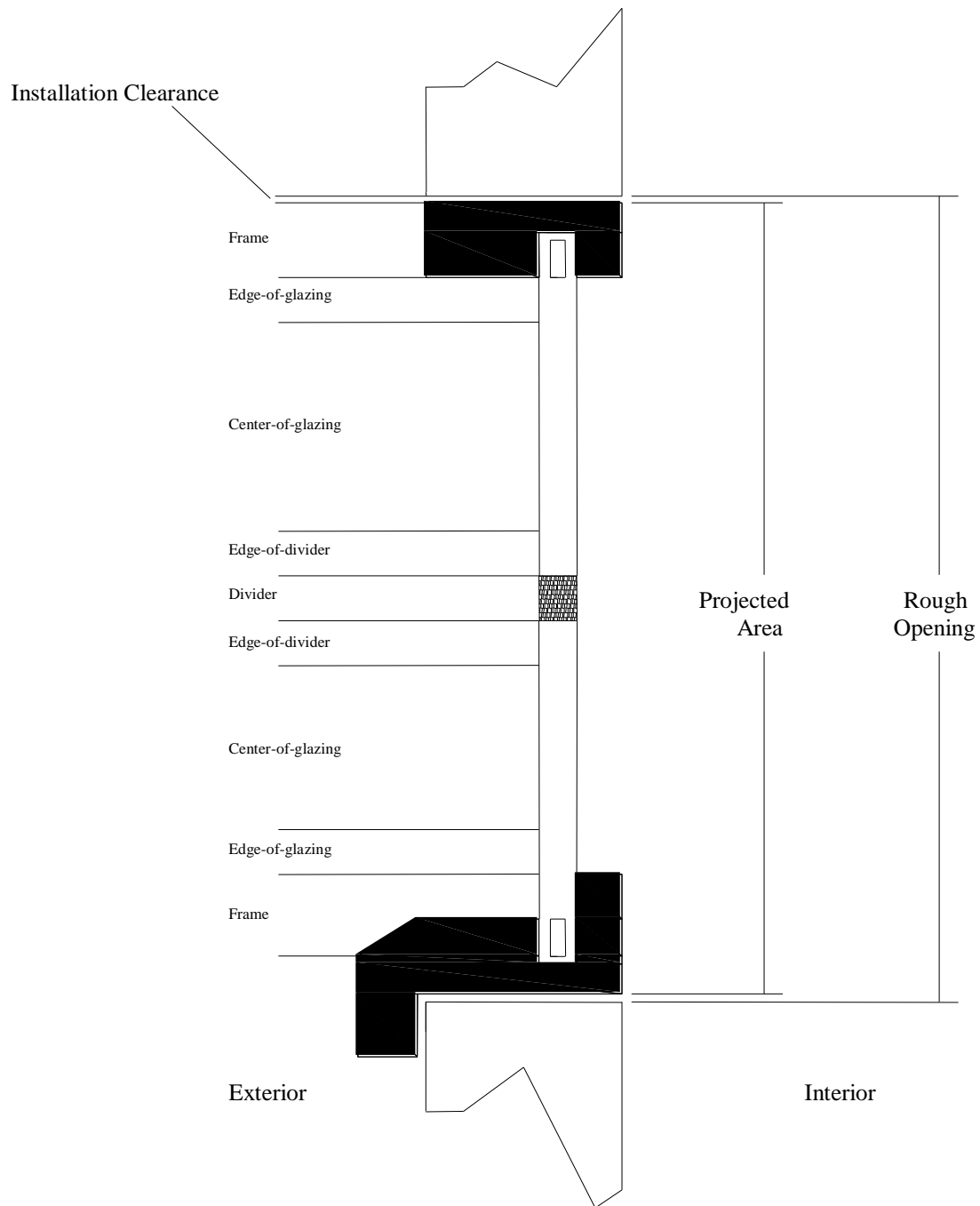


LEGEND

- C Center-of-glazing
- E Edge-of-glazing
- F Frame
- D Divider
- DE Edge-of-divider

Center-of-glazing, edge-of-glazing, divider, edge-of-divider, and frame areas for a typical fenestration product. Edge-of-glazing and edge-of-divider are 63.5 mm (2.5 in) wide. The sum of these component areas equals the total projected fenestration product area.

Figure 4-2 – Fenestration Product Schematic – Vertical Section



Center-of-glazing, edge-of-glazing, divider, edge-of-divider, and frame areas for a typical fenestration product. Edge-of-glazing and edge-of-divider are 63.5 mm (2.5 in) wide. The projected fenestration product area is the rough opening less installation clearances.

Figure 4-3 – Divider Height and Divider Width

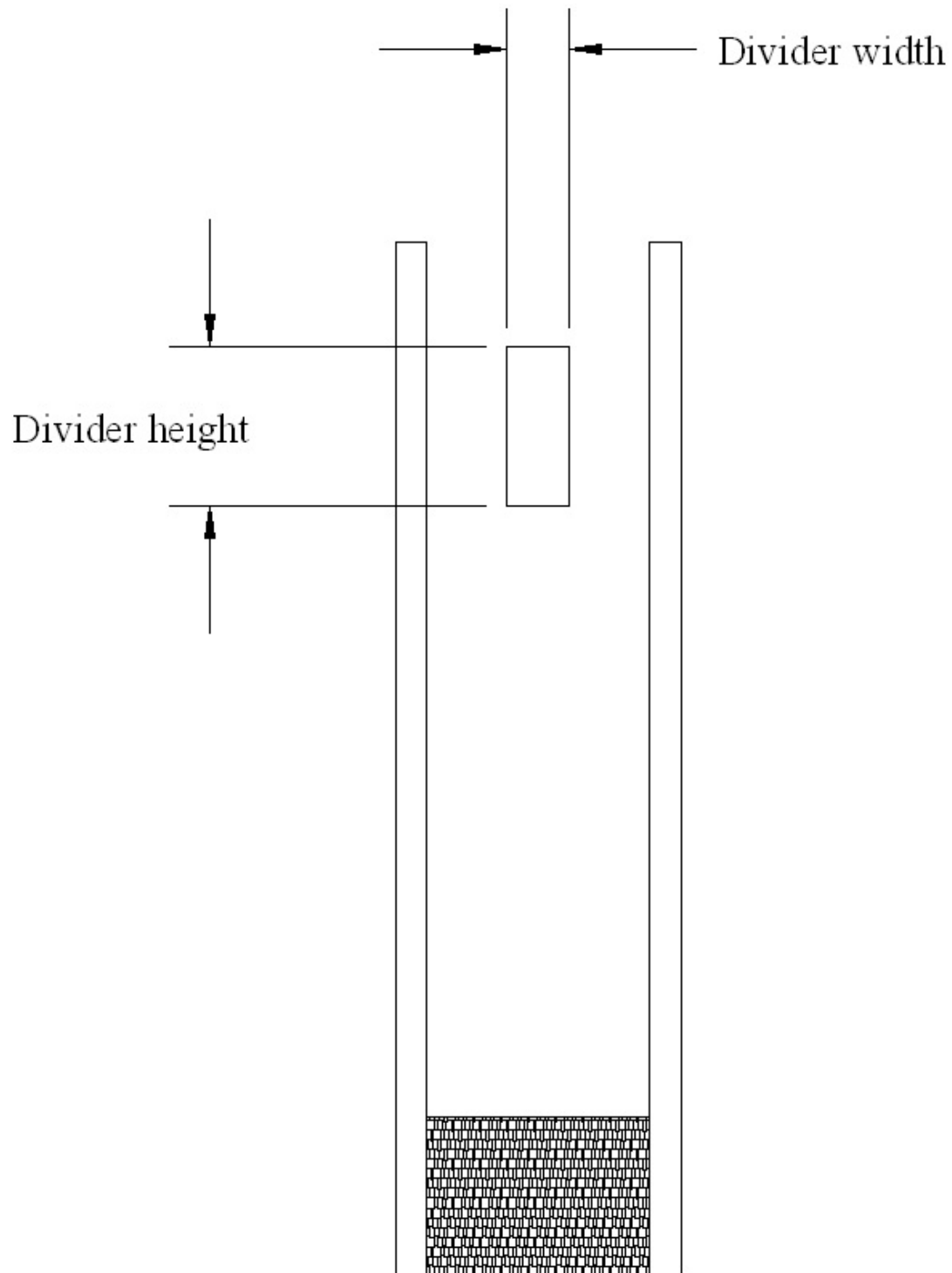
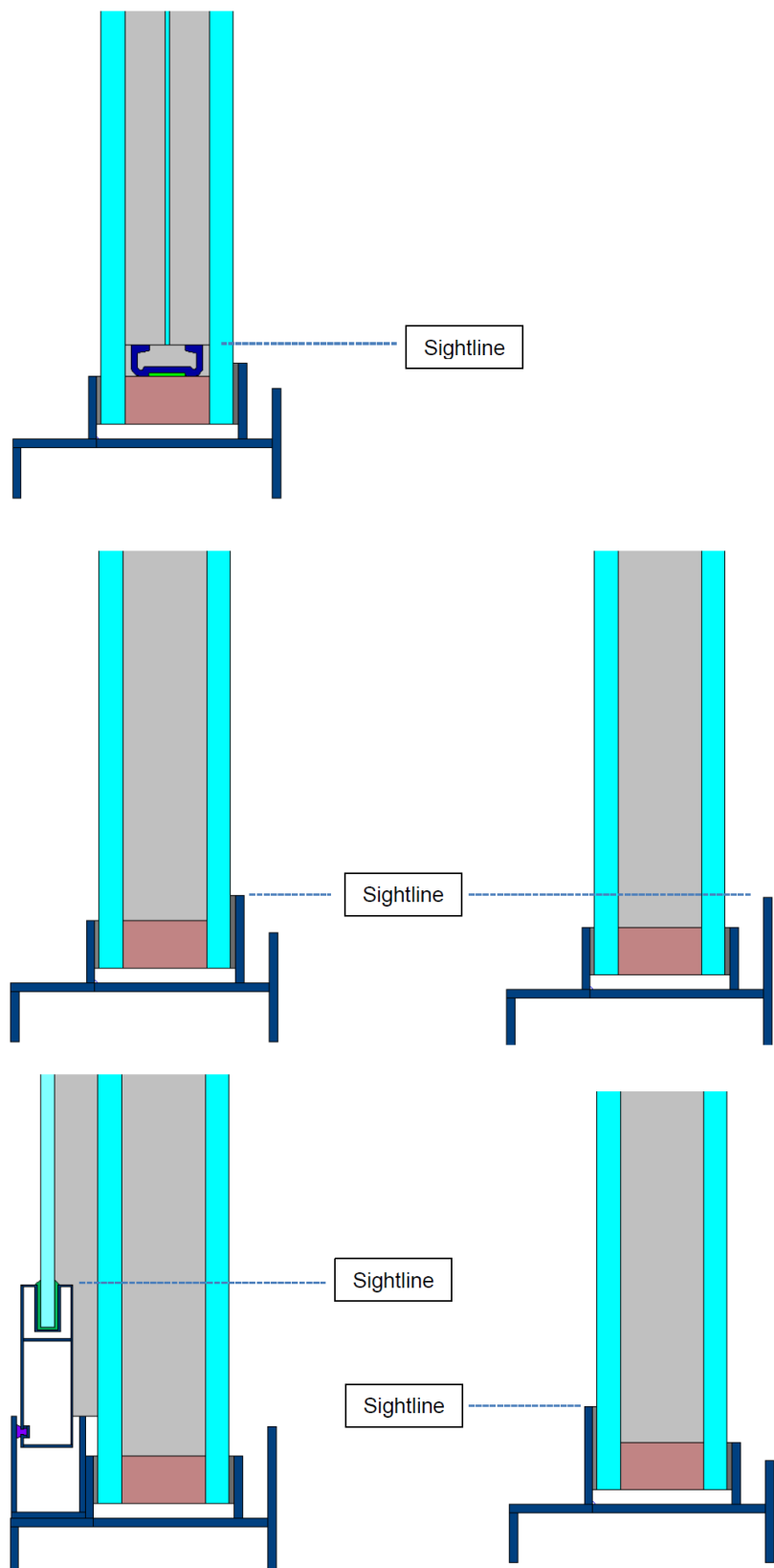


Figure 4-4 – Sightline Examples



5. VARIATIONS FROM THE GENERAL REQUIREMENTS

This section presents and references methods for determining specific product system heat transfer properties or quantities used in the determination of these properties. At this time, the scope of these properties is limited to total product system U-factor.

5.1 Windows and Sliding Glass Doors

5.1.1 Scope

This section presents additional details specific to windows and sliding glass doors.

This section presents and references methods for determining windows and sliding glass doors product system heat transfer properties or quantities used in the determination of these properties. The scope of these properties is limited to windows and sliding glass doors total product system U-factor.

5.1.2 Variations from Standard Product Lines

None

5.1.3 Variations from Standard Individual Products

None

5.1.4 Variations from Standard Simulation and Test Conditions

None

5.1.5 Calculation of Total Product Rating

The total fenestration product U-factor shall be calculated as per Section 4.6.3. Perform the following calculation to determine total product rating.

$$U_t = \frac{[\Sigma(U_f A_f) + \Sigma(U_d A_d) + \Sigma(U_e A_e) + \Sigma(U_{de} A_{de}) + \Sigma(U_c A_c)]}{A_{pf}}$$

Equation 5-1

Where

U_t	=	Total product U-factor
A_{pf}	=	Projected fenestration product area
U_f	=	Frame U-factor
A_f	=	Frame area
U_d	=	Divider U-factor
A_d	=	Divider area

U_e	=	Edge-of-glazing U-factor
A_e	=	Edge-of-glazing area
U_{de}	=	Edge-of-divider U-factor
A_{de}	=	Edge-of-divider area
U_c	=	Center-of-glazing U-factor
A_c	=	Center-of-glazing area

5.1.6 Figures

None

5.2 Side-Hinged Exterior Doors and Sidelites

5.2.1 Scope

This section presents additional details specific to side-hinged exterior doors, sidelites, and exterior bi-fold doors (a.k.a folding wall) to determine a total product U-factor.

This section presents and references methods for determining specific heat transfer properties and areas used in the determination of these properties for exterior doors, sidelites, and exterior bi-fold doors. These values shall be determined using one of three methods as listed below. Manufacturers may choose to perform their simulations using any of the techniques applicable to their specific product.

5.2.1.1 Simplified Door Rating (SDR) Method

The Simplified Door Rating (SDR) method is described in detail in Section 5.2.5.1, and shown in Figure 5-10 for Doors and 5-11 for Sidelites.

Products Eligible for the SDR Method:

- A. Skinned slabs with a foam, wood, or other core;
- B. Wood stile and rail doors;
- C. Composite assemblies comprised of a side-hinged exterior door slab with a sidelite slab within a single frame (see Composite Assembly definition in Section 3). If the side-hinged exterior door or sidelite are not offered as individual products, the SDR methodology may be used to determine the U-factor of the side-hinged exterior door slab with a default or proprietary frame/sill;
- D. Slab sidelites within a proprietary and/or default frame/sill.

5.2.1.2 Detailed Door Rating (DDR) Method

The Detailed Door Rating method utilizes basic NFRC techniques and is described in detail in Section 5.2.5.2.

A side-hinged exterior door system which is configured to only support a full-lite option, shall be permitted to be modeled using the standard techniques (as for windows) described in Section 5.1. Product Line Grouping and simplifications that are allowed in Sections 5.2.2 through 5.2.4 may be applied to these systems. These systems typically use extruded or moulded profiles (aluminum, fiberglass, vinyl, wood, etc.) and can only support the glass size dictated by the profiles.

Adding panels to an existing factory assembled full-lite product line does not require re-simulation of the full-lite option; however, the SDR or DDR method shall be used to simulate and calculate U-factors for the opaque, 1/4, 1/2, and 3/4 lite options, as applicable (e.g. manufacturer is adding a 1/2 lite option so they are only required to simulate the 1/2 lite).

5.2.2 Variations from Standard Product Lines

A given series of side-hinged exterior door or sidelite assemblies is defined by skin material, core material, and edge-of-door construction that are allowed to differ by:

- A. Size;
- B. Panel and cut out configurations;
- C. Products with multiple slab thickness;
- D. Products with multiple panel thickness (i.e. different thicknesses of wood panels, or different depth of embossments);
- E. The replacement of core and/or panel area with glazing system;
- F. Center-of-lite characteristics and edge-of-lite characteristics, such as glazing types, gap widths, glazing lite areas, use of dividers, use of spacers, glazing coatings, gas fills;
- G. Opening/non-opening configurations, e.g. X, O, XX, XO, OXXO etc;
- H. In-swing or out-swing operation;
- I. Door slab changes where one component of the same physical shape with a thermal conductivity that does not differ by more than a factor of 10;
- J. Frame components, e.g. headers, jambs and threshold; and
- K. Variations in frame and/or door interior/exterior finish, paint, varnish, or stain do not constitute different product lines provided that each of these variations does not change the surface emittance by more than 0.10.

5.2.3 Variations from Standard Individual Products

- A. Products with a pre-installed storm door from the manufacturer shall be rated with the storm door and associated parts removed from the assembly, or be rated as Test Only for each storm door with side-hinged exterior door panel/glazing configuration;
 - (i) Exception: full-lite swinging door with a pre-installed full-lite storm door may be rated using simulation;
- B. Doors which are designed to be installed in a variety of curtain wall / storefront systems shall be rated in the curtain wall/storefront system framing in which it is installed.
 - (i) If the door utilizes an additional frame which is inserted into the glazing pocket of the curtain wall / storefront system (typically termed an insert frame), the door shall be rated using only the insert frame and shall not include the primary curtain wall / storefront framing in which the insert frame is installed (See Figures 5-12 through 5-14.
- C. A door or sidelite slab without a frame shall be rated using default frame components. However products with the same slab and different proprietary frames shall be treated as individual products within one product line. All frame options shall be individually modeled or grouped.
- D. Products with multiple sill options, where the sill design changes to accommodate different installation requirements, made of the same materials type shall be different individual products within the same product line.

5.2.4 Variations from Standard Simulation and Test Conditions

This section presents rules that may be used to reduce the number of simulations of individual products necessary to represent a product line. These rules may be used either with the product line validated simulation procedure (see Section 4.1.1) or with the testing alternative (see Section 4.1.2).

A door offered with one or more door slabs shall be rated in the configuration with the least number of slabs (i.e. single door) of the same style or model. If a door is not offered in a single or double unit, a representative double unit shall be rated, incorporating the two end most panels and a representative intermediate vertical member, as determined and reported by the simulator.

For opaque doors with flat, raised, or embossed panels, a 6-panel layout shall be representative of all panel doors (regardless of the number of panels). This layout may also be considered representative of flush doors. See Figure 5-3 for a typical 6-panel layout. A specific 6-panel layout

which is required for the SDR method and may be used as a default pattern in any other case is shown in Figure 5-10.

When simulating U-factors where a decorative lite (continuous or non-continuous) is used, the decorative lite glass shall be assumed to have the same properties as clear glass of the same glass thickness and each decorative lite coming pattern shall be considered to be a different individual option or the optional coming pattern as shown in the Table 5-1 and Table 5-2 may be used to represent all decorative lite coming patterns. The default coming profile may be used to represent any coming profile.

Default and/or proprietary components may be used at the manufacturer's discretion for door slab and/or slab sidelites. These can be used to represent proprietary frames (with the limitations noted below). (See Reference 2 for drawings):

A. Default Frame Components (Head and Jambs)

- a. Default Wood Frame: (Representative of any wood, vinyl, or composite material frame) 115 mm (4.56 in) softwood single rabbeted frame of 8% to 12% moisture content, with a specific gravity of 0.35 to 0.45, with a dual durometer plastic compression weatherstrip and flexible sweep. The default door sill shall be a standard combination wood/aluminum sill (where the aluminum does not extend to the interior) that performs as well or better than the default door sill illustrated in Figure 5-8a;
- b. Default Steel Frame: (Representative of any steel frame, or other metal of equal or lower conductivity) 145 mm (5.75 in) - 16 Ga. pressed painted steel frame with a minimum 120 mm (4.75 in) throat depth, applied weather-strip,. Frame shall consist of a head jamb, hinge jamb, lock jamb, and reinforcement for hinges and locks. See Figure 5-5 and Figure 5-6;

B. Default Sill Components

- a. Default Thermally Broken Aluminum Sill (Representative of any thermally broken aluminum sill with similar construction or non-metal sill): A standard combination wood/aluminum sill as illustrated in Figure 5-8a;
 - b. Default Non-Thermal Sill (Representative of any non-thermally broken metal sill): A standard aluminum non-thermally broken sill with a sill wall thickness of 1.4 mm to 1.6 mm (0.055 in to 0.065 in) and no substrate as illustrated in Figure 5-8b;
- C. Default Door Lite Frame (Representative of any non-metal door lite frame). A polypropylene door lite frame as illustrated in Figure 5-9;
- D. Default Coming Profile (See Reference 2).
- E. Default SDR foam and wood materials used around the perimeter shall be as follows:

- a. Polyurethane Foam Insulation: 0.024 W/m·K (0.166 Btu·in/hr·ft²·F);
 - b. Expanded Polystyrene: 0.038 W/m·K (0.263 Btu·in/hr·ft²·F);
 - c. Hardwood: 0.160 W/m·K (1.109 Btu·in/hr·ft²·F)
- F. Allowable SDR door slab dimensions:
- a. Door slabs thickness shall be 44mm ± 2mm (1.75" ±0.079")
 - b. Steel Skin thickness shall be no greater than 0.6mm (0.024")
 - c. Fiberglass skin thickness shall be no greater than 1.9mm (0.075")

Add-Ons

If a manufacturer wishes to simulate a door or sidelite slab in multiple frames, either proprietary or default the manufacturer may either simulate all individual products in the matrix or develop an add-on for the additional frames. To develop the frame add-on, all the individual products in the matrix shall be simulated in the best performing framing system. The best performing product in the best performing framing system shall then be simulated in the additional frame options. The difference between these two U-factors shall be the frame add-on. The U-factor for the products in the additional frame shall be the U-factor for that product in the best performing frame plus the frame add-on.

For manufacturers offering multiple sill options:

- A) Sill systems that meet the requirement of a thermally broken member shall use the product values for the NFRC default sill system;
- B) Sill systems that are metal and do not meet the requirement of a thermally broken member may be given total product U-factor of 0.10 W/m²·K (0.02 BTU/hr·ft²·F) higher than the same door system option with the NFRC default sill system.

5.2.5 Calculation of Total Product Rating

Total fenestration product U-factors for model sizes and configurations shall be calculated in accordance with Section 5.2.5.1 for the Simplified Door Rating (SDR) method and with Section 5.2.5.2 for the Detailed Door Rating (DDR) method.

To reduce the number of individual products necessary to represent a product line, refer to the guidelines prescribed in Sections 4.2.4, 5.2.2, 5.2.3 and 5.2.4.

5.2.5.1 Simplified Door Rating (SDR) Method

- A. Modeling of opaque side-hinged exterior doors is based on using a six-panel or flush configuration door product area.
- Modeling of glazed side-hinged exterior doors will consist of two elements, the door opaque area (slab, frame, and sill); plus the Door Glass Assembly Area (DGAA);
 - 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 5-2, for the opaque, $\frac{1}{4}$ lite, $\frac{1}{2}$ lite, $\frac{3}{4}$ lite, and full-lite opaque areas;
 - The DGAA of the door shall be simulated using 4 configurations, calculated per Equation 5-3, at the $\frac{1}{4}$ lite, $\frac{1}{2}$ lite, $\frac{3}{4}$ lite and full-lite sizes (See Figure 5-10 of door slab with various panel sizes);
- B. Modeling of sidelites is based on a three-panel or flush configuration product area.
- Modeling of glazed sidelites will consist of two elements, the sidelite opaque area (slab, frame, and sill); plus the Door Glass Assembly Area (DGAA);
 - The opaque area (that is, the area outside the DGAA, including sidelite frame and sill) shall be simulated in five configurations, calculated per Equation 5-2, for the opaque, $\frac{1}{4}$ lite, $\frac{1}{2}$ lite, $\frac{3}{4}$ lite, and full-lite opaque areas;
 - The DGAA of the sidelite shall be simulated using 4 configurations, calculated per Equation 5-3, at the $\frac{1}{4}$ lite, $\frac{1}{2}$ lite, $\frac{3}{4}$ lite and full-lite sizes (See Figure 5-11 of sidelite slab with various panel sizes);
- C. The total product U-factor will be calculated, per Equation 5-4, by adding the product of the glazed assembly ($U_{DGAA}A_{DGAA}$), and the product of the remaining opaque door or sidelite slab assembly ($U_{sd}A_{sd}$) divided by the total product area, where:

Equation 5-2:

$$U_{sd}A_{sd} = [(U_f A_f) + (U_{dc} A_{dc}) + (U_p A_p) + (U_{ep} A_{ep})]$$

Equation 5-3:

$$U_{DGAA}A_{DGAA} = [(U_{lf} A_{lf}) + (U_d A_d) + (U_{de} A_{de}) + (U_{eg} A_{eg}) + (U_c A_c)]$$

Note: U_{DGAA} and A_{DGAA} shall be determined using WINDOW.

Equation 5-4:

$$U_t = \frac{[(U_{sd}A_{sd}) + (U_{DGAA}A_{DGAA})]}{A_t}$$

Where:

U_f	=	Frame U-factor
A_f	=	Frame area
U_{lf}	=	Lite frame U-factor
A_{lf}	=	Lite frame area
U_d	=	Divider U-factor
A_d	=	Divider area
U_{de}	=	Edge-of-divider U-factor
A_{de}	=	Divider area
U_{eg}	=	Edge-of-lite U-factor
A_{eg}	=	Edge-of-lite area
U_c	=	Center-of-lite U-factor
A_c	=	Center-of-lite Area
U_{dc}	=	Door or Sidelite core U-factor
A_{dc}	=	Door or Sidelite core area
U_p	=	Panel U-factor
A_p	=	Panel area
U_{ep}	=	Edge-of-panel U-factor
A_{ep}	=	Edge-of-panel area
U_{DGAA}	=	Doorglass Assembly Area U factor
A_{DGAA}	=	Doorglass Assembly Area at ¼ Lite, ½ Lite, ¾ Lite, Full-Lite
U_{sd}	=	U-factor 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
U_t	=	Total Product U-factor

5.2.5.2 Modeling using the Detailed Door Rating (DDR) Method

The Detailed Door Rating Method total door system U-factor shall be calculated as outlined below:

- (a) Determine all of the following, as applicable, using the approved 2-D heat transfer computational program for all frame, panel, and core modeling and WINDOW for the center-of-lite U-factor:
 - (1) Panel(s) U-factor;

- (2) Edge-of-panel U-factor;
 - (3) Door core U-factor;
 - (4) Center-of-lite U-factor using WINDOW;
 - (5) Lite frame U-factor;
 - (6) Edge-of-lite U-factor;
 - (7) Divider U-factor;
 - (8) Edge-of-divider U-factor;
 - (9) Frame U-factor;
 - (10) The component areas of:
 - Frame area
 - Lite frame area
 - Divider area
 - Edge-of-divider area
 - Edge-of-lite area
 - Center-of-lite area
 - Door core area
 - Panel area
 - Edge-of-panel area
 - Projected total door system area
- (b) Perform the following calculations as shown in Equation 5-5:
- (i) Multiply the center-of-lite, divider, edge-of-lite, edge-of-divider, panel, door core, lite frame, edge-of-panel, and frame U-factors by their corresponding areas;
 - (ii) Total these nine quantities; and
 - (iii) Divide this total by the projected total exterior door system area to produce computed total door system product U-factors for all the door systems in the matrix of required U-factors.

Equation 5-5:

$$U_t = \frac{\left[(U_f A_f) + (U_{lf} A_{lf}) + (U_d A_d) + (U_{de} A_{de}) + (U_{eg} A_{eg}) + (U_c A_c) + (U_{dc} A_{dc}) + (U_p A_p) + (U_{ep} A_{ep}) \right]}{A_t}$$

Where the variables are defined in Section 5.2.5.1 above.

5.2.6 Baseline Product

- A. The simulation report shall include simulation results for the exact option as tested.
- B. For representative production line specimens; doors, sidelites, and transoms of the complete system (slab, frame, and sill) shall be within ± 25 mm (1 in) of the appropriate model size listed in Table 4-3.
- C. For door and sidelite product lines which include glazed options, the baseline product shall be a 1/2 Lite product with a height/width tolerance of the glazing to be within ± 13 mm (0.5 in) of the dimension listed in Figures 5-10 (Doors) and 5-11 (Sidelites).

Table 5-1 – Glazing and Divider Patterns for Doors

Individual Product	For Doors with	Simulate or Test as ¹	Optional Caming Pattern
1/4 glazing	glazing $< 0.265 \text{ m}^2$ (411 in ²)	534 mm x 457 mm (21 in x 18 in)	5 vertical 1 horizontal
1/2 glazing	$0.265 \text{ m}^2 \geq \text{glazing} < 0.581 \text{ m}^2$ (411-901 in ²)	534 mm x 889 mm (21 in x 35 in)	5 vertical 8 horizontal
3/4 glazing	$0.581 \text{ m}^2 \geq \text{glazing} < 0.710 \text{ m}^2$ (901-1101 in ²)	534 mm x 1194 mm (21 in x 47 in)	5 vertical 10 horizontal
Full glazing	glazing $\geq 0.710 \text{ m}^2$ (1101 in ²)	534 mm x 1600 mm (21 in x 63 in)	5 vertical 13 horizontal

¹Glazing dimensions indicate daylight opening size

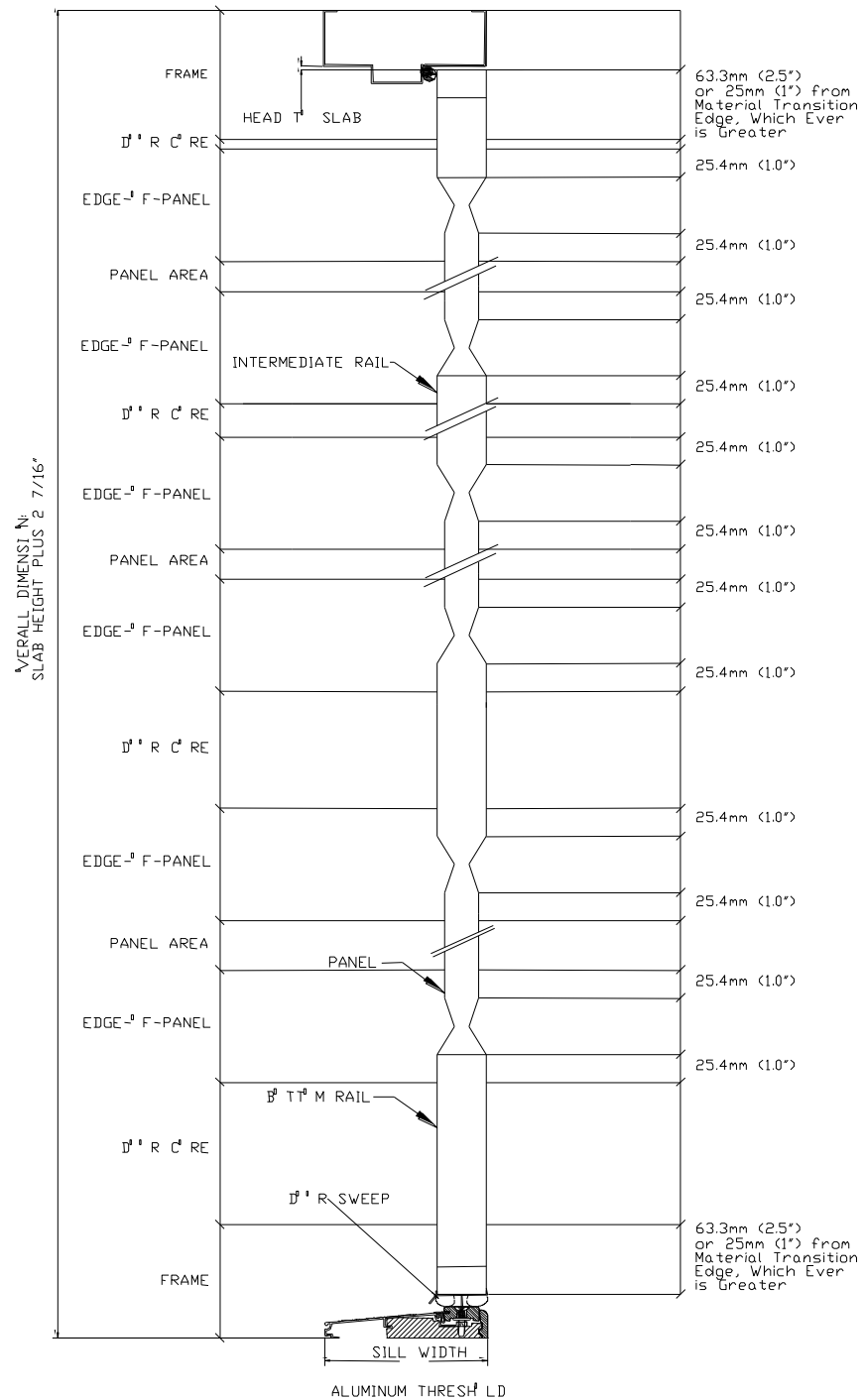
Table 5-2 – Glazing and Divider Patterns for Sidelites

Individual Product	For Sidelites with	Simulate or Test as ¹	Optional Caming Pattern
1/4 glazing	glazing $< 0.042 \text{ m}^2$ (65 in ²)	178 mm x 178 mm (7 in x 7 in)	1 vertical 1 horizontal
1/2 glazing	$0.042 \text{ m}^2 \geq \text{glazing} < 0.181 \text{ m}^2$ (65 in ² to 281 in ²)	178 mm x 889 mm (7 in x 35 in)	1 vertical 8 horizontal
3/4 glazing	$0.181 \text{ m}^2 \geq \text{glazing} < 0.252 \text{ m}^2$ (281 in ² to 391 in ²)	178 mm x 1194 mm (7 in x 47 in)	1 vertical 10 horizontal
Full glazing	glazing $\geq 0.252 \text{ m}^2$ (391 in ²)	178 mm x 1600 mm (7 in x 63 in)	1 vertical 13 horizontal

¹Glazing dimensions indicate daylight opening size

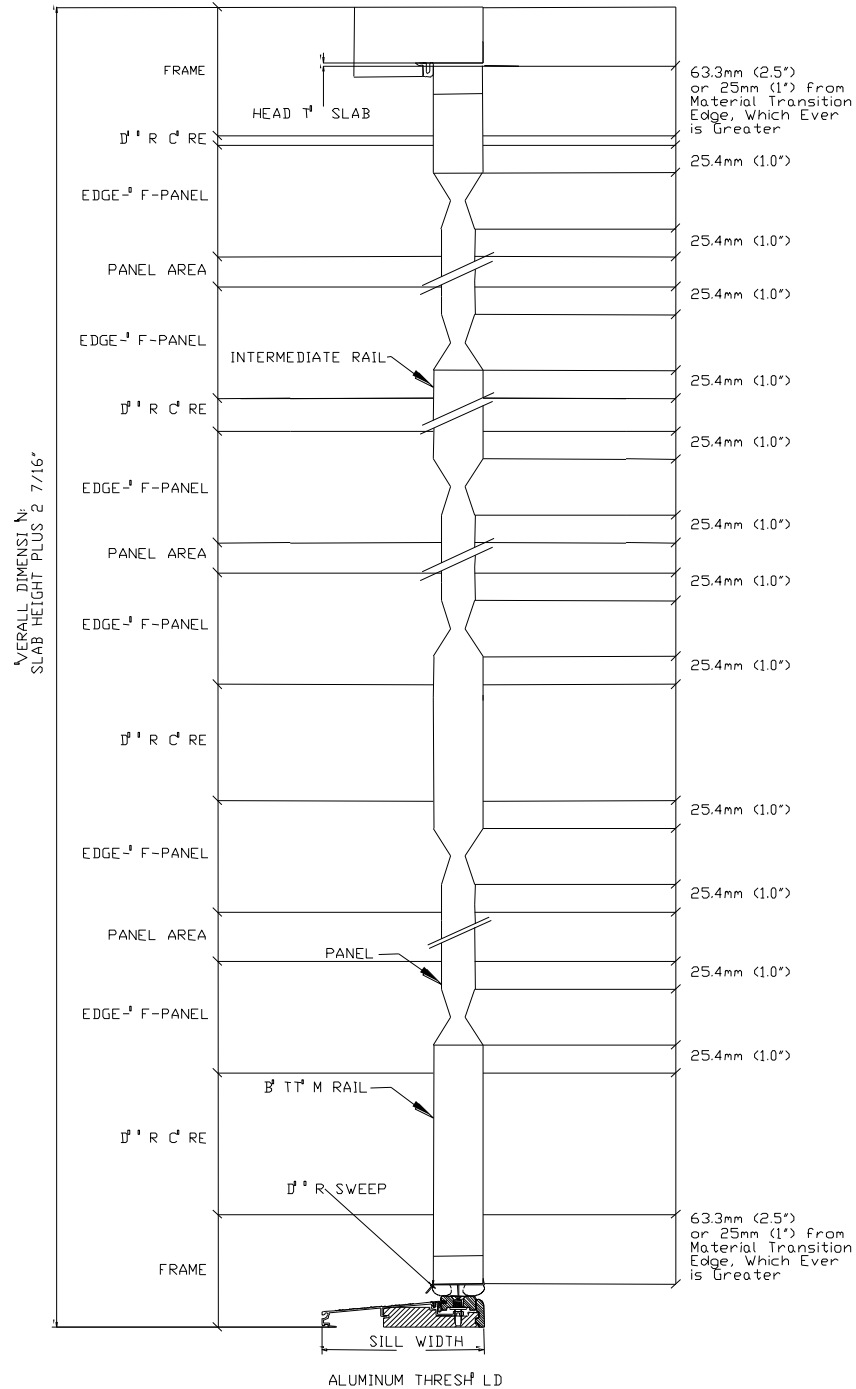
5.2.7 Figures

Figure 5-1a – Exterior Steel/Composite Door System – Vertical Elevation in Steel Frame



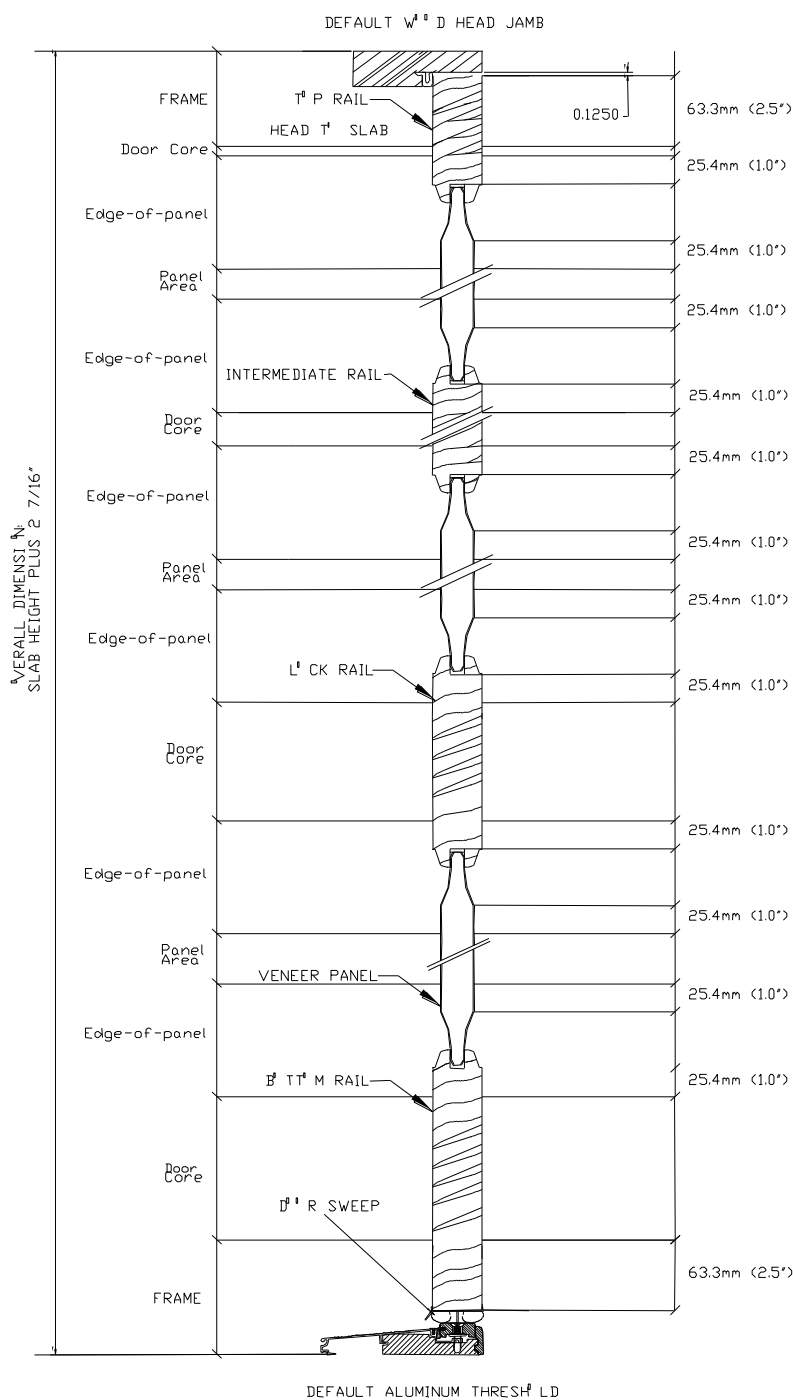
The projected door area is the rough opening area less installation clearances. Sidelite area schematic may be identical or similar without perimeter weatherstrip and bottom sweep.

Figure 5-1b – Exterior Steel/Composite Door System – Vertical Elevation in Wood Frame



The projected door area is the rough opening area less installation clearances. Sidelite area schematic may be identical or similar without perimeter weatherstrip and bottom sweep.

Figure 5-2 – Exterior Wood Door System – Vertical Elevation



The projected door area is the rough opening area less installation clearances. Sidelite area schematic may be identical or similar without perimeter weatherstrip and bottom sweep.

Figure 5-3 – Typical 6-Panel Layout

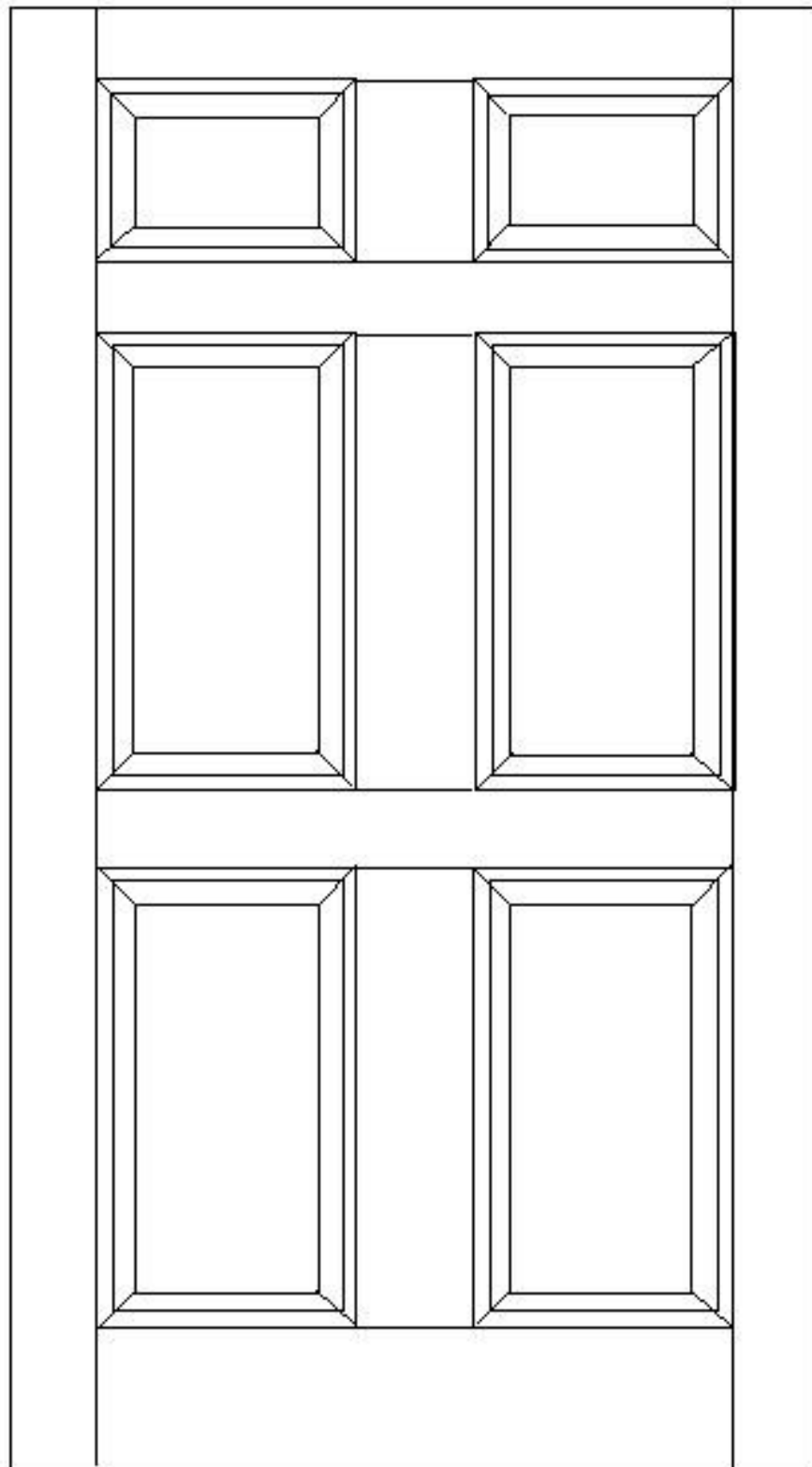


Figure 5-4 – Common Pressed-Steel Frame – Single Unit Type Pressed-Steel Frame

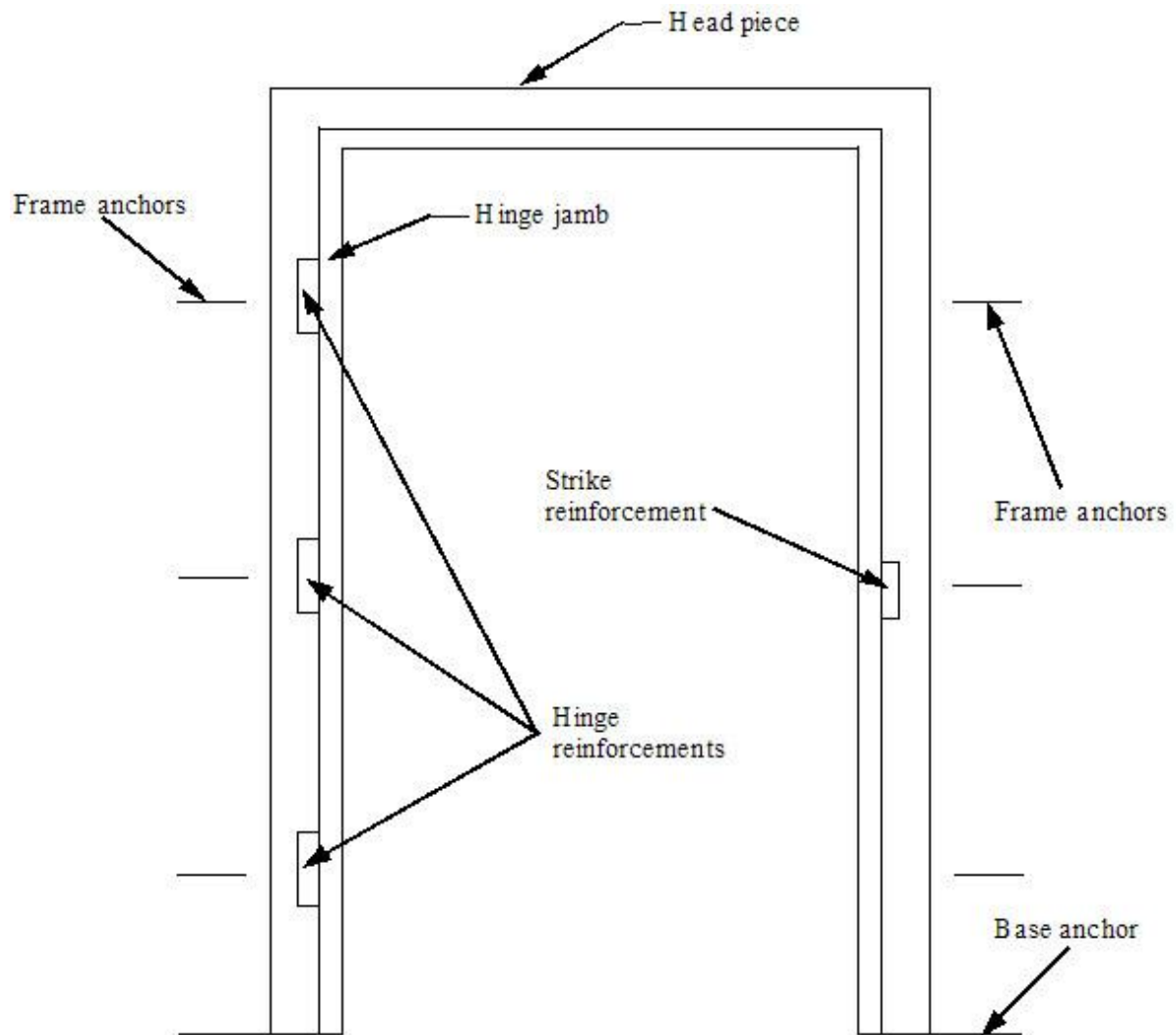
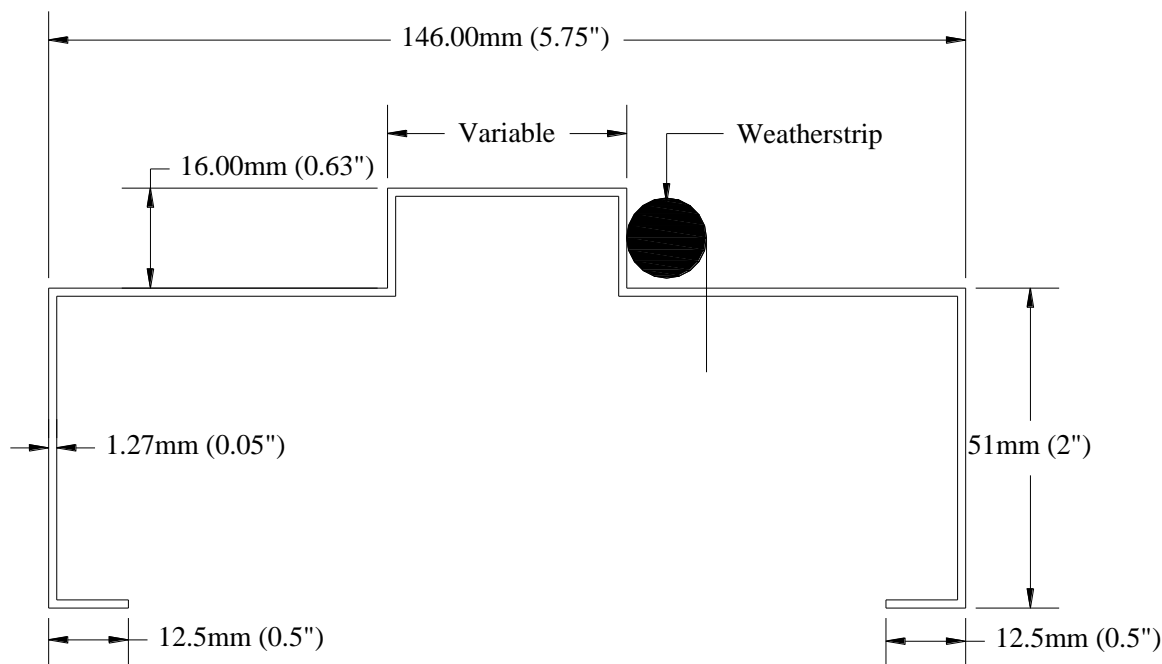


Figure 5-5 – Frame Cross Section



Pressed Steel Frame Specification (16 G)

Pressed Steel Frame Specification

Single-unit type pressed steel frames shall consist of a head, a sill and two jamb pieces, hinge reinforcements, a strike plate reinforcement, and base and wall anchors

The wall anchors provided shall be adjustable or fixed masonry anchors, bolts with expansion shells, channel clips, "Z" clips, wood stud anchors, or steel anchors.

The head and jamb pieces shall be constructed, as shown in Figure 5-4.

Figure 5-6 – Wood Default

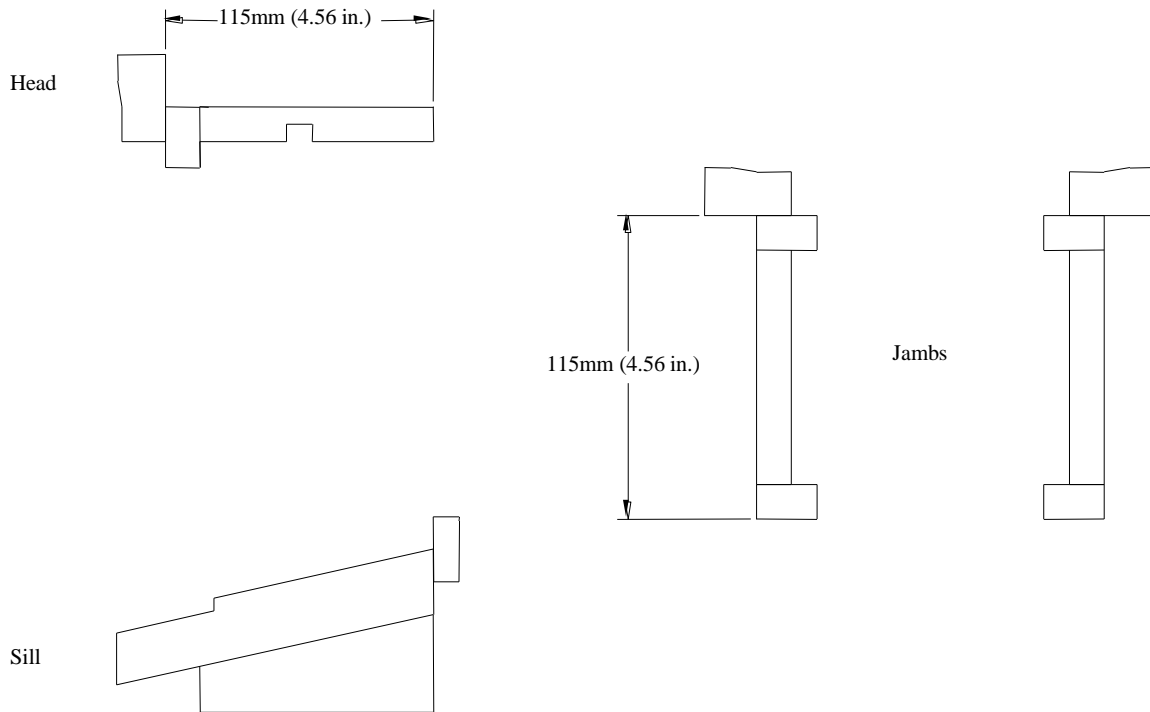


Figure 5-7 – Default Wood Door Head Jamb and Side Jamb

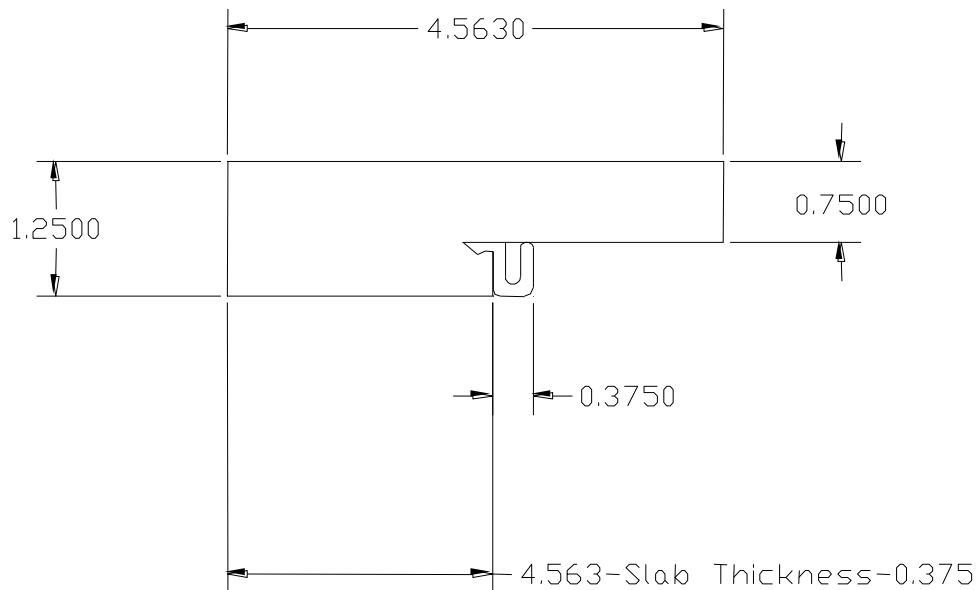


Figure 5-8a – Default Thermally Broken Aluminum Door Sill

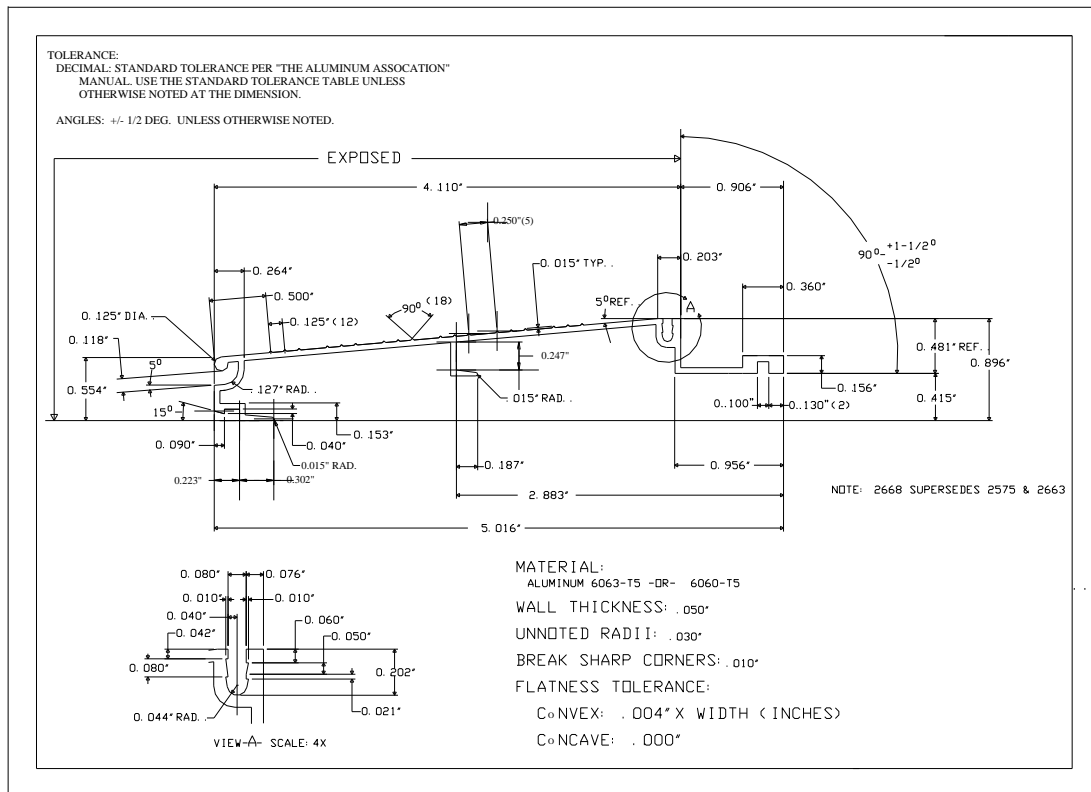
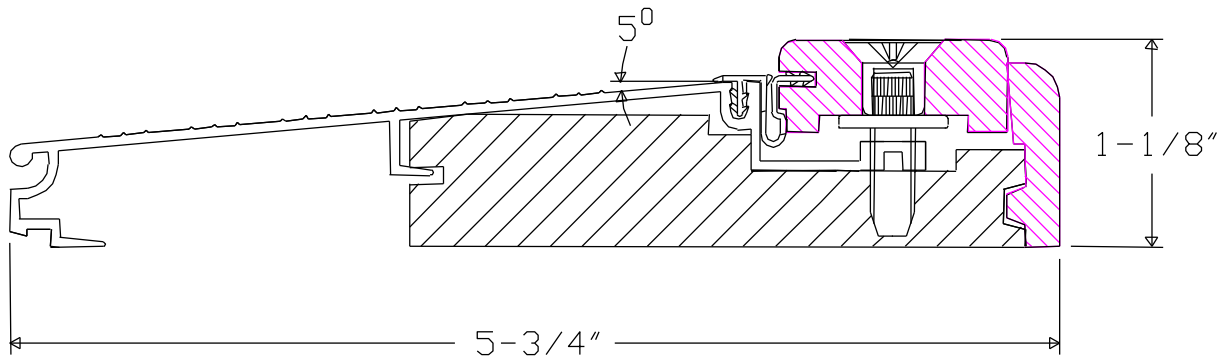


Figure 5-8b – Default Non-Thermal Door Sill

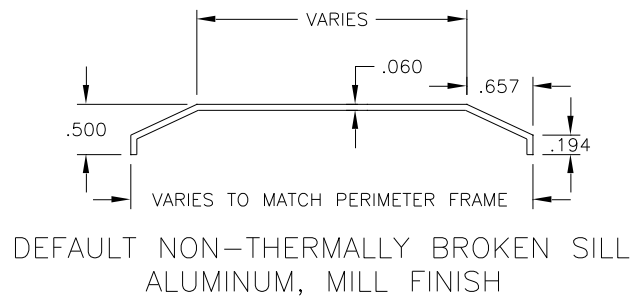
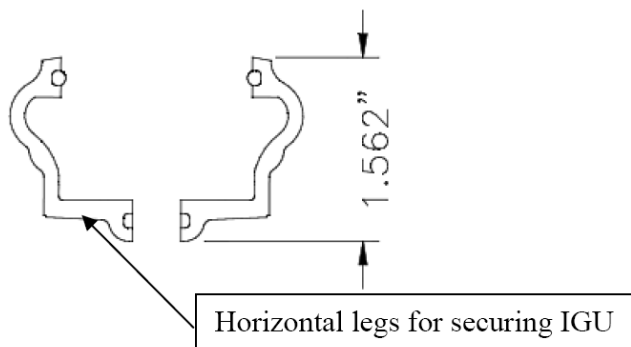


Figure 5-9 – Default Door Lite Frame

The following illustration shall be used. To make a specific IG width fit properly, extend or extract the material of the horizontal legs, as identified below.



A door lite frame DXF file is available on the NFRC website.

Figure 5-10 – SDR Configurations of Single Door

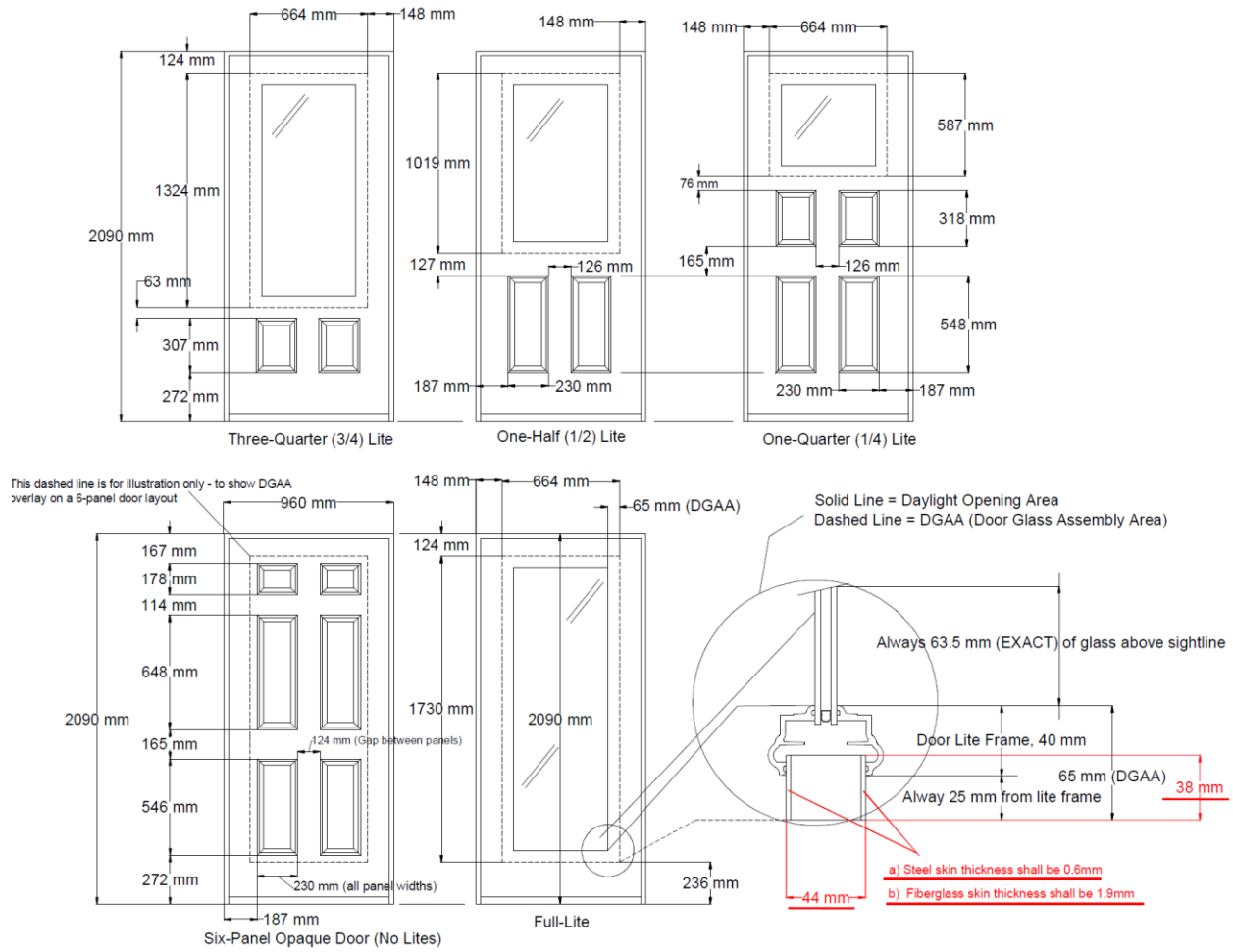


Figure 5-11 – SDR Configurations of Sidelite

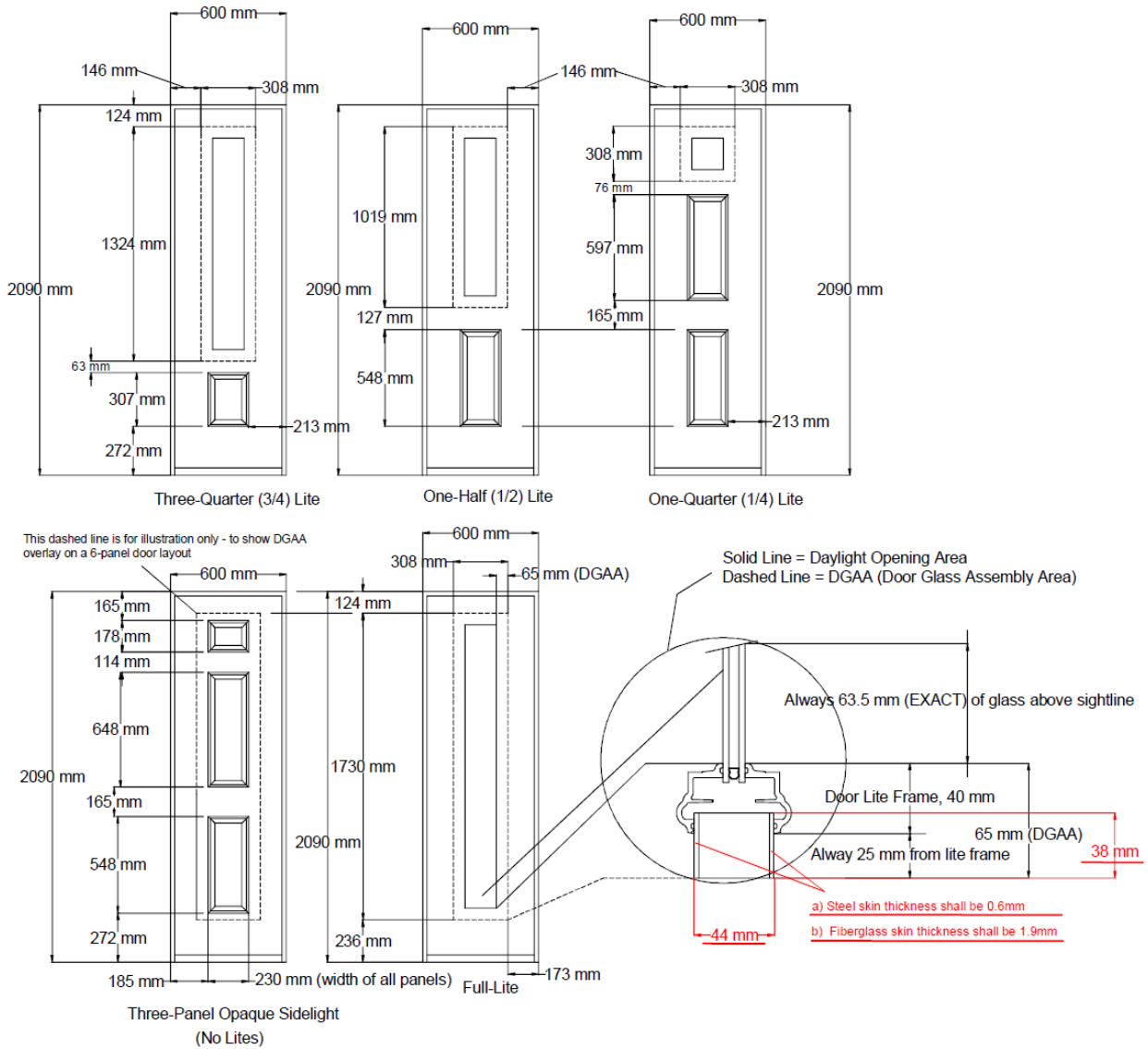


Figure 5-12 – Commercial Door Example in a Curtainwall/Storefront System

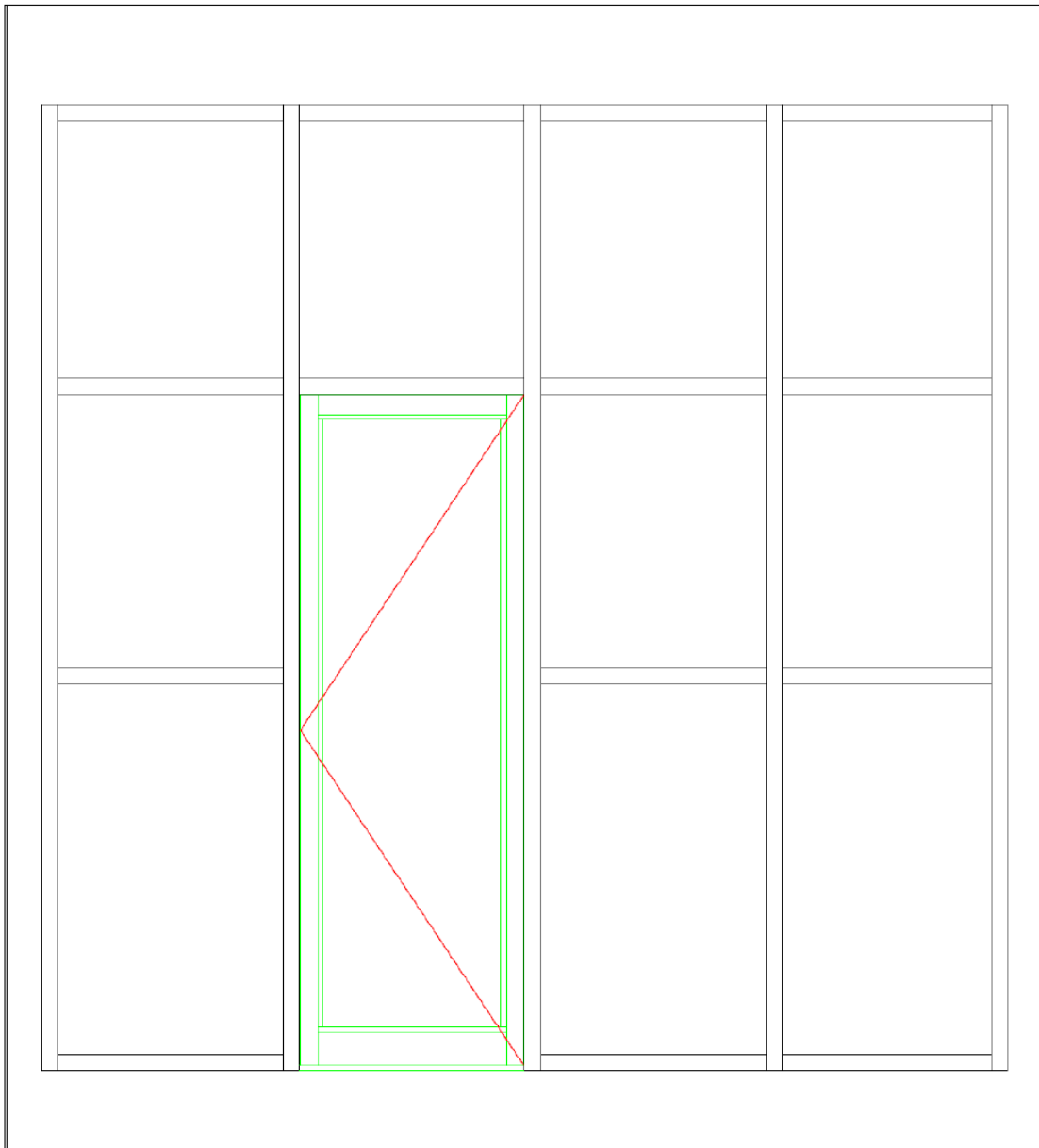


Figure 5-13 – Door Inside Storefront System

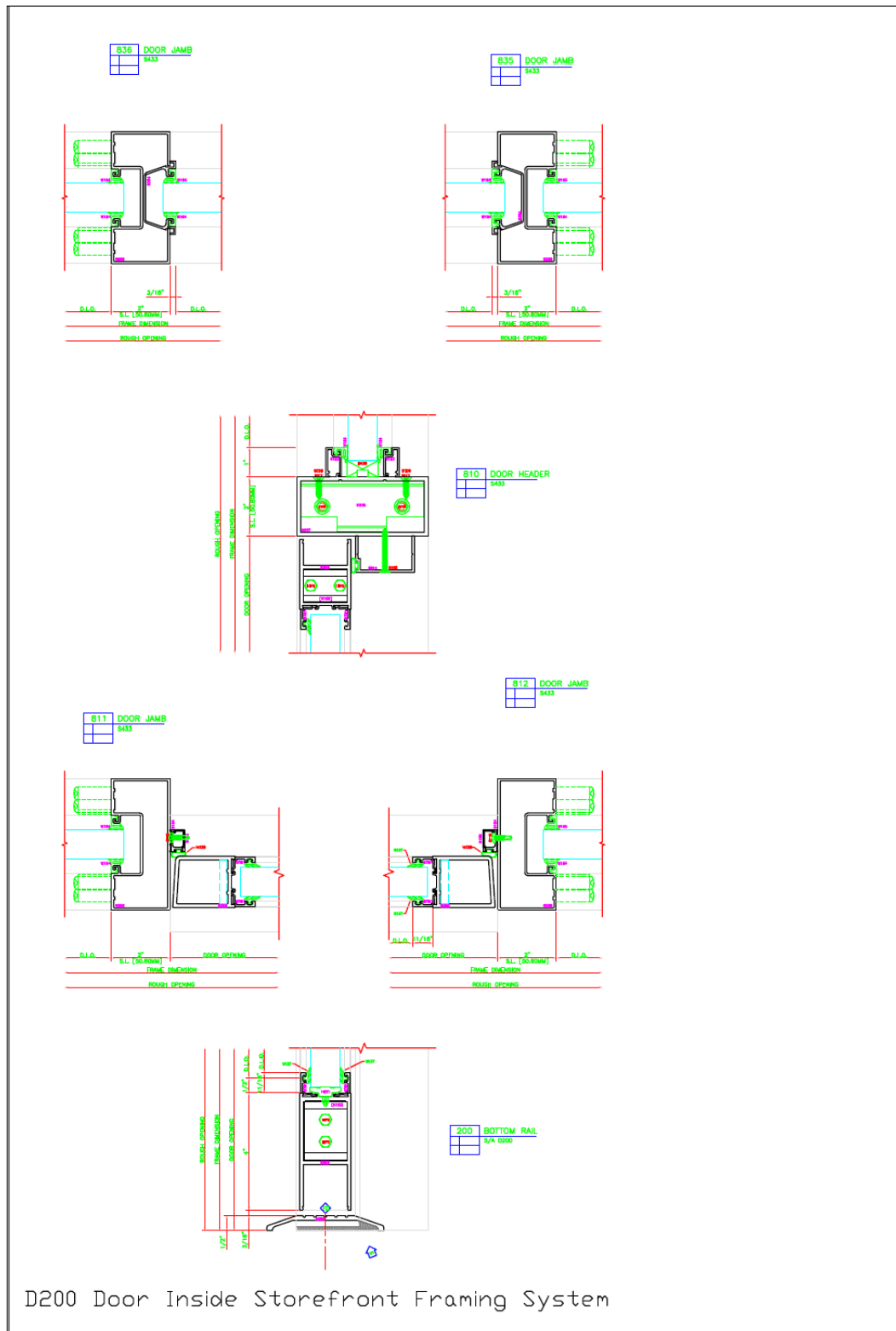
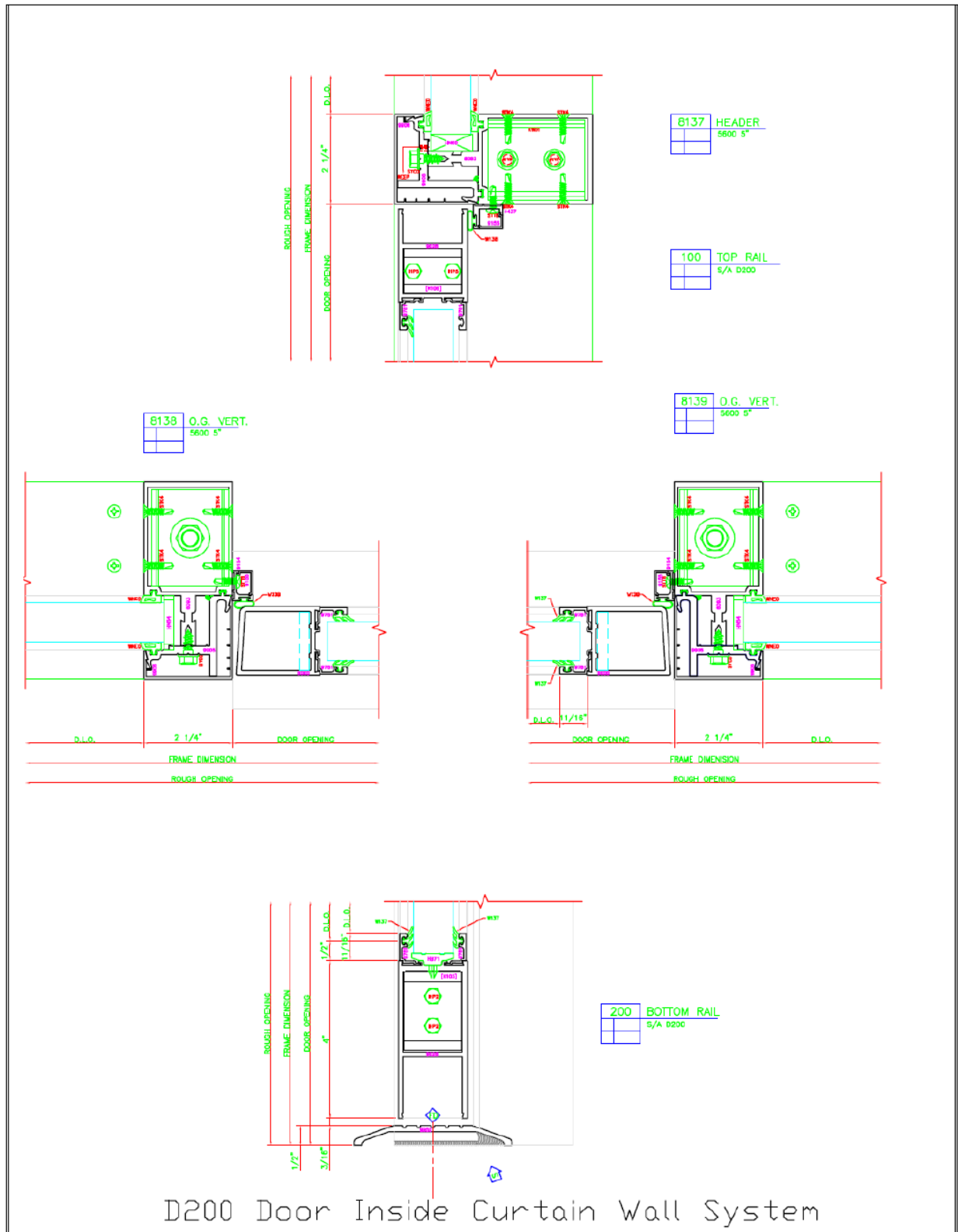


Figure 5-14 – Door Inside Curtainwall System



5.3 Skylights

5.3.1 Scope

This section presents additional details specific to skylights.

This section presents and references methods for determining specific skylight system heat transfer properties or quantities used in the determination of these properties. At this time, the scope of these properties is limited to total skylight system U-factor. For additional simulation parameters see Reference 2.

5.3.2 Variations from Standard Product Lines

If a skylight can be installed using more than one of the installation methods listed below, the skylight product line shall include all of the pertinent options as individual products. The method in which skylights are mounted will affect the U-factor of the skylight. Mounting variations include:

- A. Inset mount where the curb of the skylight extends into the rough opening in the roof;
- B. Curb mount where the outside of the curb is equal to the rough opening in the roof; and
- C. Curb mount where the inside of the curb is equal to the rough opening in the roof.

Variations of each mounting type may occur.

A skylight with an interior diffuser is rated with the interior tube and/or diffuser removed from the assembly. Any solar tracking devices or other auxiliary elements shall also be removed for rating purposes.

5.3.3 Variations from Standard Individual Products

None

5.3.4 Variations from Standard Simulation and Test Conditions

Skylights and other sloped glazing products shall be simulated and rated at a slope of 20° above the horizontal. For determining validation of the baseline product only, skylights and other sloped glazing products shall be simulated and tested in a vertical position. Ratings for test only products shall be converted to the 20° slope from the vertical position by multiplying the tested value at vertical by 1.20.

5.3.4.1 Curb

Curb mounted skylights that do not have an attached integral curb when manufactured shall be simulated and tested installed on a nominal 2 in x 4 in wood curb made from douglas fir(with no knots).

5.3.5 Calculation of Total Product Rating

The total fenestration product U-factor shall be calculated as outlined in Section 5.1.5.

5.3.6 Figures

None

5.4 Tubular Daylighting Devices (TDD)

5.4.1 Scope

This section presents and references methods for determining specific TDD system heat transfer properties or quantities used in the determination of these properties. At this time, these products can only be rated using the testing alternative procedure (Section 4.1.2). The specific details for testing TDDs are outlined in Appendix 3 of NFRC 102.

5.4.2 Variations from Standard Product Lines

A TDD product line shall only consist of individual products of the same tube material, exterior dome material, and interior diffuser material.

5.4.3 Variations from Standard Individual Products

None

5.4.4 Variations from Standard Simulation and Test Conditions

5.4.4.1 Orientation

U-factors for TDDs shall be rated with the tube in a vertical orientation (see Figures 5-10a and 5-10b). Therefore the heat flow shall be in the vertical direction. Standardized rating conditions are defined in Section 5.4.4.4.

5.4.4.1.1 Insulation at Ceiling Configuration

The diffuser is attached to the insulated ceiling. The tubular section is located in the attic space connecting the interior diffuser to the exterior dome. The exterior dome/flashing assembly is mounted to the roof deck.

5.4.4.1.2 Insulation at Roof Configuration

The diffuser is attached to the tubular section which is located in the interior space. The tubular section is connected to the exterior dome. The exterior dome/flashing assembly is mounted to the insulated roof deck.

5.4.4.2 Sizes

The standard TDD size listed in Table 4-3 is based on the Thermal Opening Area, as defined in Section 3. For the purpose of testing, this is the interior side of the 254 mm (10 in.) foam panel. The standard TDD size is 350 mm (14 in) diameter tube opening. The closest production size to the standard size shall be tested. In the event that the device is not manufactured in the standard model size, the production size with the closest area (as defined in 5.4.4.3) shall be used and the result for that unit shall be the product's rating. For TDD products with non-circular Thermal Opening Area, the product shall use an opening area equivalent to the actual size of the manufactured product as tested. Equation 4-1 shall not be used to adjust the results to model size.

5.4.4.3 Tubular Daylighting Device Area

The U-factor for all TDDs shall be based on the Thermal Opening Area, as defined in Section 3. This area shall be used when calculating the total product U-factor.

5.4.4.4 Standard Testing Conditions

5.4.4.4.1 Insulation at Ceiling Configuration

- A. 750 mm (30 in) shift length (interior ceiling line to exterior roof line);
- B. Ceiling insulation shall be represented by a surround panel, 250mm (10 in) in depth;
- C. An exterior 13 mm (0.5 in) thick plywood roof deck, painted to limit moisture transfer;
- D. ASHRAE attic space boundary conditions on the exposed surface of the vertical shaft material, from the top of the insulation material to the underside of the 13 mm (0.5 in) plywood roof deck;
- E. Exterior boundary conditions applied to the exposed surface of the dome; and
- F. Bottom of the tubular skylight covered with a light diffusing plate (manufacturer specific).

5.4.4.4.2 Insulation at Roof Configuration

- A. 750 mm (30 in) shaft length (from the exterior roof line to the top of the diffuser);
- B. Roof insulation shall be represented by a surround panel, 250mm (10 in) in depth;
- C. Exterior boundary conditions applied to the exposed surface of the dome; and

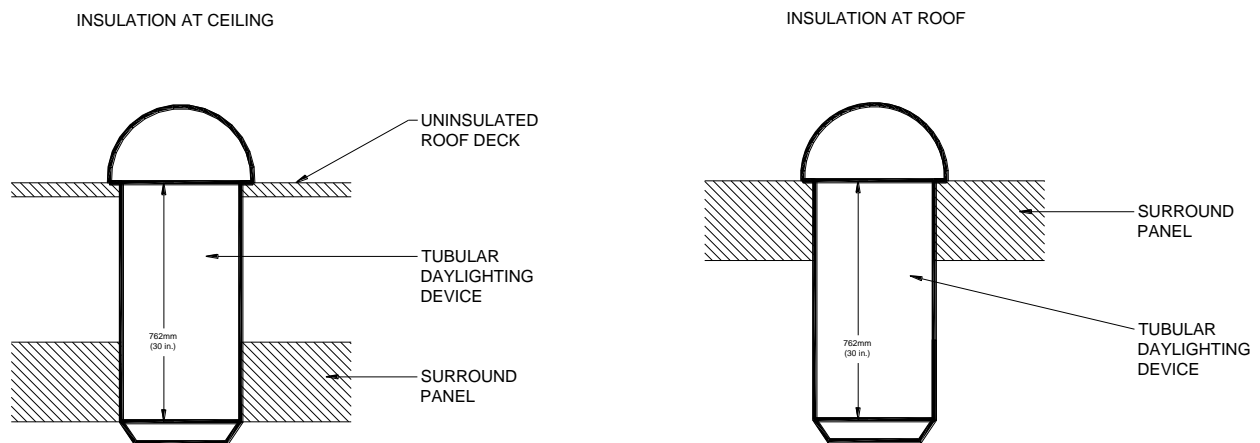
- D. Bottom of the tubular skylight covered with a light diffusing plate (manufacturer specific).

5.4.4.5 Calculation of Total Product Rating

The total TDD system U-factor shall be determined as noted in Appendix A3 of NFRC 102.

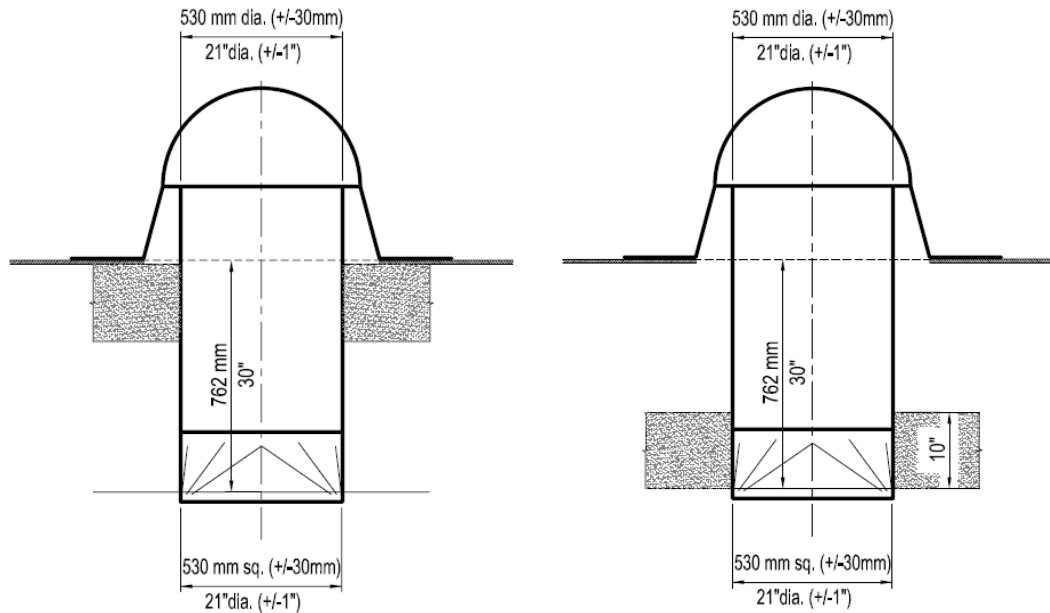
5.4.5 Figures

Figure 5-10a – Tubular Daylighting Device Product Schematic – Vertical Elevation



See Reference 12 for a more detailed drawing of the rough opening and diffuser plate attachment.

Figure 5-10b – Hybrid Tubular Daylighting Device Product Schematic – Vertical Elevation



5.5 Vehicular Access (Garage) Doors

5.5.1 Scope

This section presents and references methods for determining specific garage door system heat transfer properties or quantities used in the determination of these properties. At this time, the scope of these properties is limited to total garage door system U-factor. For additional simulation parameters, see Reference 2.

5.5.2 Variations from Standard Product Lines

A given series of garage door systems defined by skin material, core material, and edge of garage door 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 and edge-of-glazing characteristics, such as glazing types, gap widths, glazing areas, use of dividers, use of spacers, glazing coatings, and/or gas fills;
- E. Panel changes where one component of the same physical shape has a thermal conductivity that differs by more than a factor of 10;
- F. Jamb track and/or hardware components, variations in panel interior/exterior finish, paint, varnish, or stain; and
- G. Variations in end stile design, intermediate stile design, and door bottom edge design.

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 validation testing for simulated garage door products, sectional garage doors shall have the U-factor determined using a specimen to fill a 2.13 m (7 ft) wide by 2.13 m (7 ft) tall opening (the aperture is smaller than the test specimen).
- B. For doors with glazing options, the 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 when glazing is included. The glazed garage door option which meets the validation sample requirement shall be chosen for testing.
- C. Door opening framing and sill shall be included in simulation calculations. The framing (nominal 2 in x 4 in) and the sill (nominal 2 in x 6 in) shall consist of 38 mm (1 1/2 in) wood surrounding the perimeter of the door (See Figures 5-11 through 5-13).

5.5.5 Total Product Rating

The total garage door system U-factor shall be calculated as outlined below:

- A. Determine all of the following, as applicable:
 - i. Top rail (i.e., top edge of door) U-factor using the approved 2-D computational program, including the wood framing in the surround panel,
 - ii. Bottom rail (i.e., bottom edge of door) U-factor using the approved 2-D computational program, including the wood sill in the surround panel,
 - iii. End stile (i.e., side edge of door) U-factor using the approved 2-D computational program, including the wood framing in the surround panel,
 - iv. Meeting rail (i.e. section interface between door panels) U-factor using the approved 2-D computational program,
 - v. Door panel core U-factor using the approved 2-D computational program (this will only include portions of those top, intermediate, and bottom panels that are not glazed),
 - vi. Edge-of-glazing U-factor, including the glazing frame, using the approved 2-D computational program,
 - vii. Center-of-glazing U-factor per the total product height procedure as defined in Reference 2 using the approved center-of-glazing computational program, with input as

needed from the approved center-of-glazing conductance test procedure given in Section 4.5.3, and

- viii. The component areas in square feet, to the nearest 0.001 m² (0.010 ft²) of:
- a) Top rail area, which includes the greater of 63 mm (2.5 in) or 25 mm (1 in) into a homogeneous area of the door core, measured from the top edge of the wood opening framing,
 - b) Bottom rail area, which includes the greater of 63 mm (2.5 in) or 25 mm (1 in) into a homogeneous area of the door core, measured from the bottom edge of the wood opening sill,
 - c) End stile area, which includes the greater of 63 mm (2.5 in) or 25 mm (1 in) into a homogeneous area of the door core, measured from the outside edge of the wood opening framing,
 - d) Meeting rail area, which for each door panel includes the greater of 63 mm (2.5 in) or 25 mm (1 in) into a homogeneous area of the door core, measured from the interface of the door panels,
 - e) Door panel core area,
 - f) Edge-of-glazing area,
 - g) Center-of-glazing area, and
 - h) Projected total exterior door system area (including framing and sill areas);

- B. Perform the following calculations as shown in Equation 5-3:
- i. Multiply the top rail, bottom rail, end stile, meeting rail, door panel core, edge-of-glazing, and center-of-glazing area U-factors by their corresponding areas,
 - ii. Total these seven quantities, and
 - iii. Divide this total by the projected total exterior garage door system area to produce computed total garage door system product U-factors for all the door systems in the matrix of required U-factors.

$$U_t = [(U_{tr}A_{tr}) + (U_{br}A_{br}) + (U_{es}A_{es}) + (U_{mr}A_{mr}) + (U_{dpc}A_{dpc}) + (U_{eg}A_{eg}) + (U_{cg}A_{cg})]/A_{pt}$$

Equation 5-3

Where

U_t	=	Total door system U-factor
U_{tr}	=	Top rail U-factor
A_{tr}	=	Top rail area
U_{br}	=	Bottom rail U-factor
A_{br}	=	Bottom rail area
U_{es}	=	End stile U-factor
A_{es}	=	End stile area
U_{mr}	=	Meeting rail U-factor
A_{mr}	=	Meeting rail area
U_{dpc}	=	Door panel core U-factor
A_{dpc}	=	Door panel core area
U_{eg}	=	Edge-of glazing U-factor
A_{eg}	=	Edge-of-glazing area
U_{cg}	=	Center-of-glazing U-factor
A_{cg}	=	Center-of-glazing area
A_{pt}	=	Projected total door system area

5.5.6 Figures

Figure 5-11 – Garage Door U-factor Area Weighting, Sectional

Legend

- 1 Top Rail*
- 2 Bottom Rail*
- 3 Meeting Rail*
- 4 Door Panel Core
- 5 Edge-of-Glazing; 63 mm (2.5 in.)
around perimeter, including glazing
framing
- 6 Center-of-Glazing

*greater of 63 mm (2.5 in.) or 25 mm (1 in.) into a
homogeneous area

Notes

- 1. Glazing is optional.
- 2. Number of glazing lites may
vary.
- 3. Glazing locations may vary.

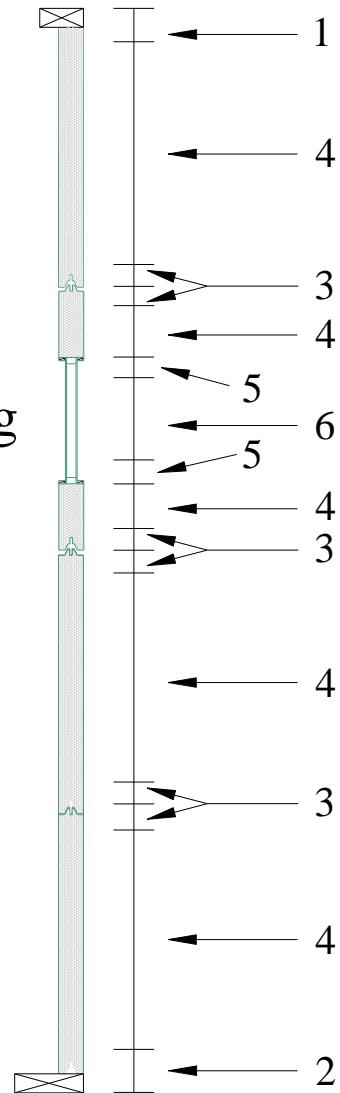
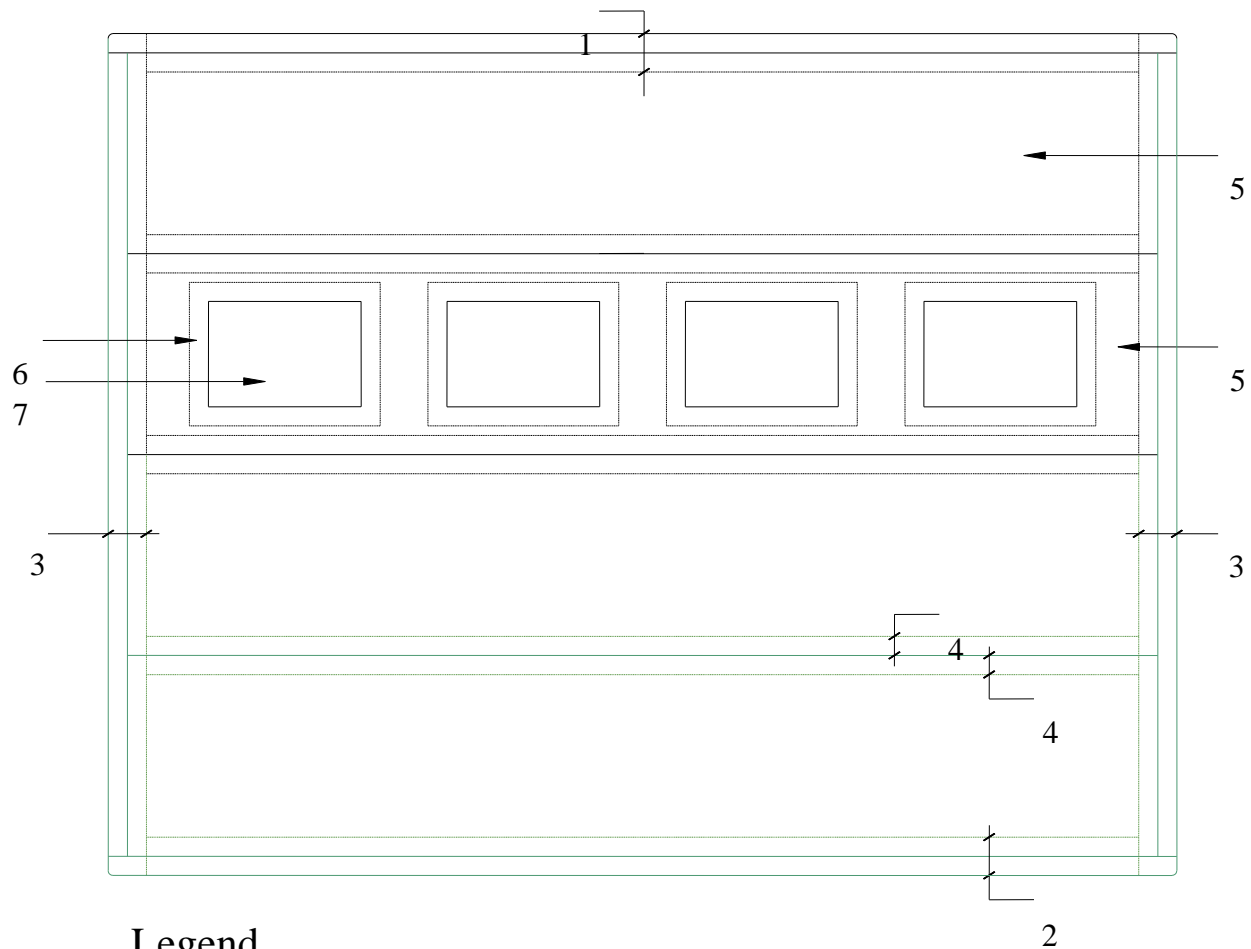


Figure 5-12 – Garage Door U-factor Area Weighting, Front Elevation View

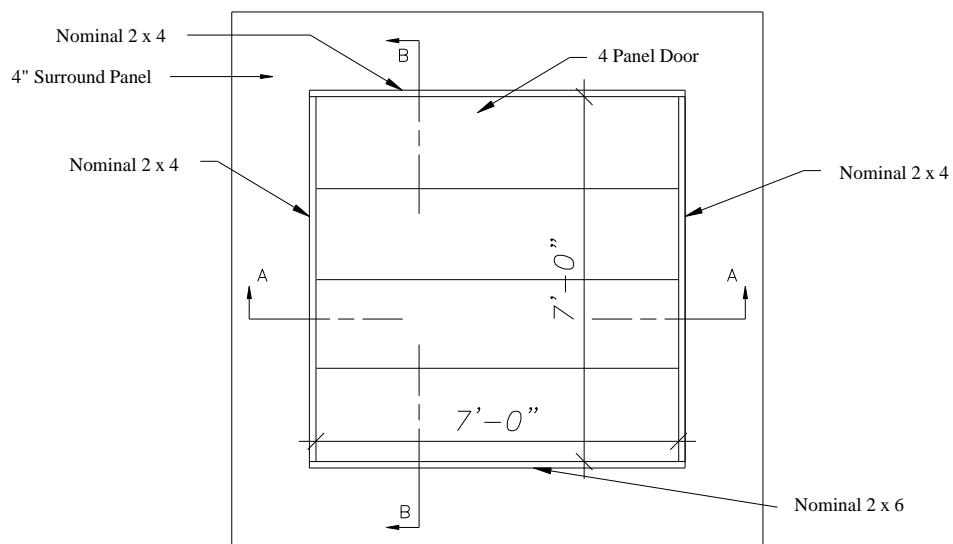


Legend

- 1 Top Rail*
- 2 Bottom Rail*
- 3 End Stile*
- 4 Meeting Rail*
- 5 Door Panel Core
- 6 Edge-of-Glazing; 63 mm (2.5 in)
around perimeter, including glazing
framing
- 7 Center-of-Glazing

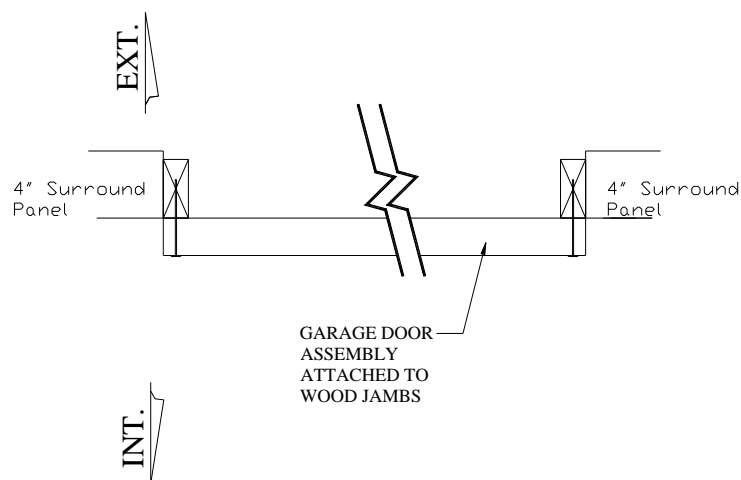
*greater of 63 mm (2.5 in) or 25 mm (1 in) into a
homogeneous area

Figure 5-13 – Garage Door Front Elevation View and Perimeter Details



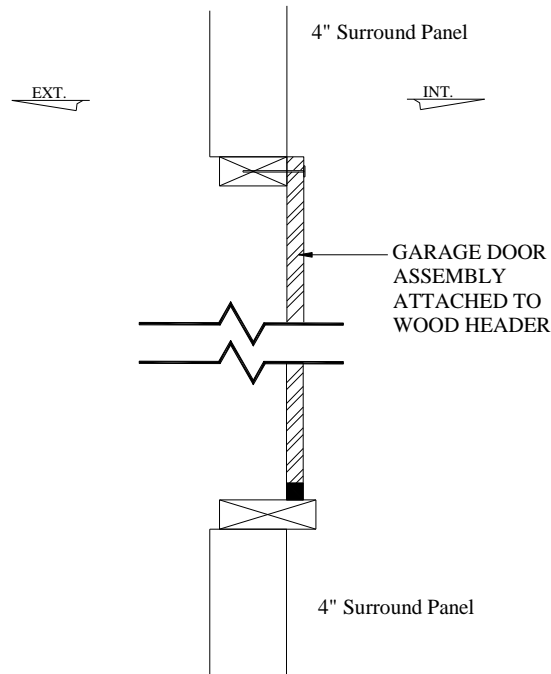
EXTERIOR ELEVATION

N.T.S.



SECTION A-A

N.T.S.



SECTION B-B

N.T.S.

5.6 Non-Residential Products

5.6.1 Scope

Non-residential fenestration systems covered by this method include products that are designed to be field glazed or field assembled units comprised of specified framing and glazing components, including but not limited to:

5.6.1.1 Products and Systems Covered

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

- A. Glazed wall support and framing systems;
- B. Products of any size and design;
- C. Products with single or multiple glazing layers;
- D. Products with spacer systems between glazings;
- E. Horizontal, vertical and sloped systems;

- F. Products that, by design, may have multiple framing components and/or glazing combinations;
- G. Fenestration systems using unitized construction, where a system is field assembled from factory assembled sub-units; and
- H. Dynamic glazing products.

5.6.1.2 Products and Systems Not Covered

Include totally opaque walls and pre-assembled or pre-glazed fenestration products (See Table 4-3).

5.6.2 Variations from Standard Product Lines

If a single-story or multi-story system is capable of being applied as both a curtain wall and window wall system, the system shall be rated as both operator types. Products modeled as both operator types shall be separate product lines and shall be permitted to be validated by either operator type.

5.6.3 Variations from Standard Individual Products

None

5.6.4 Variations from Standard Simulation and Test Conditions

5.6.4.1 Unspecified Product Sample Validation Criteria

If the product to be used for validation purposes is not specified, then the individual product used for validation purposes shall be simulated and tested using the following criteria: The test specimen shall be constructed in such a manner as to be identical to the individual product simulated and have outside dimensions measuring 2000 mm x 2000 mm (79 in x 79 in), having one vertical mullion and two glazed lites. The glazing system configuration for the validation testing shall be nominal 25 mm (1 in) outside dimension insulating glass utilizing two lites of 6 mm (1/4 in) clear (uncoated glass), a typical dual-sealed aluminum spacer system, and air-filled. There shall be no insulation of any type applied to the test specimen during validation testing. Validation will be achieved per Section 4.7.1

This section is to be used only in those instances where the representative sample for validation purposes has not been prescribed by a specifying authority, such as an architect, project manager, engineering firm, building owner, etc.

For simulating and testing of all other fenestration operator types other than glazed wall systems, sloped glazing, and solarium/sunroom systems model sizes shall be consistent with the sizes listed in Table 4-3 of this standard.

5.6.4.2 Determining the Thermal Transmittance for Solarium/Sunroom Systems

[**Note:** This procedure is to be used when the solarium is glazed on-site. If manufactured window or door systems are used to create the glazed walls in a solarium, the thermal transmittance shall be determined in accordance with Section 4 of this standard.]

- A. The thermal transmittance of solarium/sunroom systems shall be determined in accordance with Section 4.1 of this standard;
- B. For simulating and testing site-built vertical glazed wall sections of solarium/sunroom systems, each product line shall have one baseline product validated in accordance with Section 4.1.1 and 4.3.1, with the following exception--the individual product used for validation purposes shall be simulated and tested using the following criteria: the test specimen shall be constructed in such a manner as to be identical to the individual product simulated and have outside dimensions measuring 2000 mm x 2000 mm (79 in x 79 in), having one vertical mullion and two glazed lites; the glazing system configuration for the validation testing shall be nominal 25 mm (1 in) outside dimension insulating glass utilizing two lites of 3 mm (1/8 in) clear (uncoated glass), a typical dual-sealed aluminum spacer system, and air-filled; and there shall be no insulation of any type applied to the test specimen during validation testing. Validation will be achieved per Section 4.1.1;
- C. Sloped glazing systems shall be rated in accordance with Section 4.1 utilizing sample construction as described in Section 5.6.4.2.B; and
- D. For simulating and testing all other fenestration operator types other than glazed wall systems and sloped glazing systems, model sizes shall be consistent with the sizes listed in Table 4-3 of this standard with glazing in accordance with Section 5.6.4.2.B.

5.6.5 Calculation of Total Product Rating

None

5.6.6 Figures

None

5.7 Dynamic Attachment for Swinging Door Products (DASD)

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

5.7.1 Scope

This section presents additional details specific to DASD. This section presents and references methods for determining specific dynamic attachments for swinging doors U-factor rating.

5.7.2 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 (see Table 5-3 and Figures 5-14 and 5-15).

The dynamic attachment for swinging door shall be simulated with the attachment in the “fully open” position.

The DASD shall be tested as a whole product system (attachment and reference door) in the “fully closed” position. Center-of-glazing tests are not acceptable for this purpose.

Individual product ratings shall be determined for each of the four configurations.

5.7.3 Approved Computational Program

The DASD product U-factor shall be determined using approved glazed swinging door simulation. The DASD shall be modeled on the following reference swinging doors.

Table 5-3 – Reference Swinging Doors

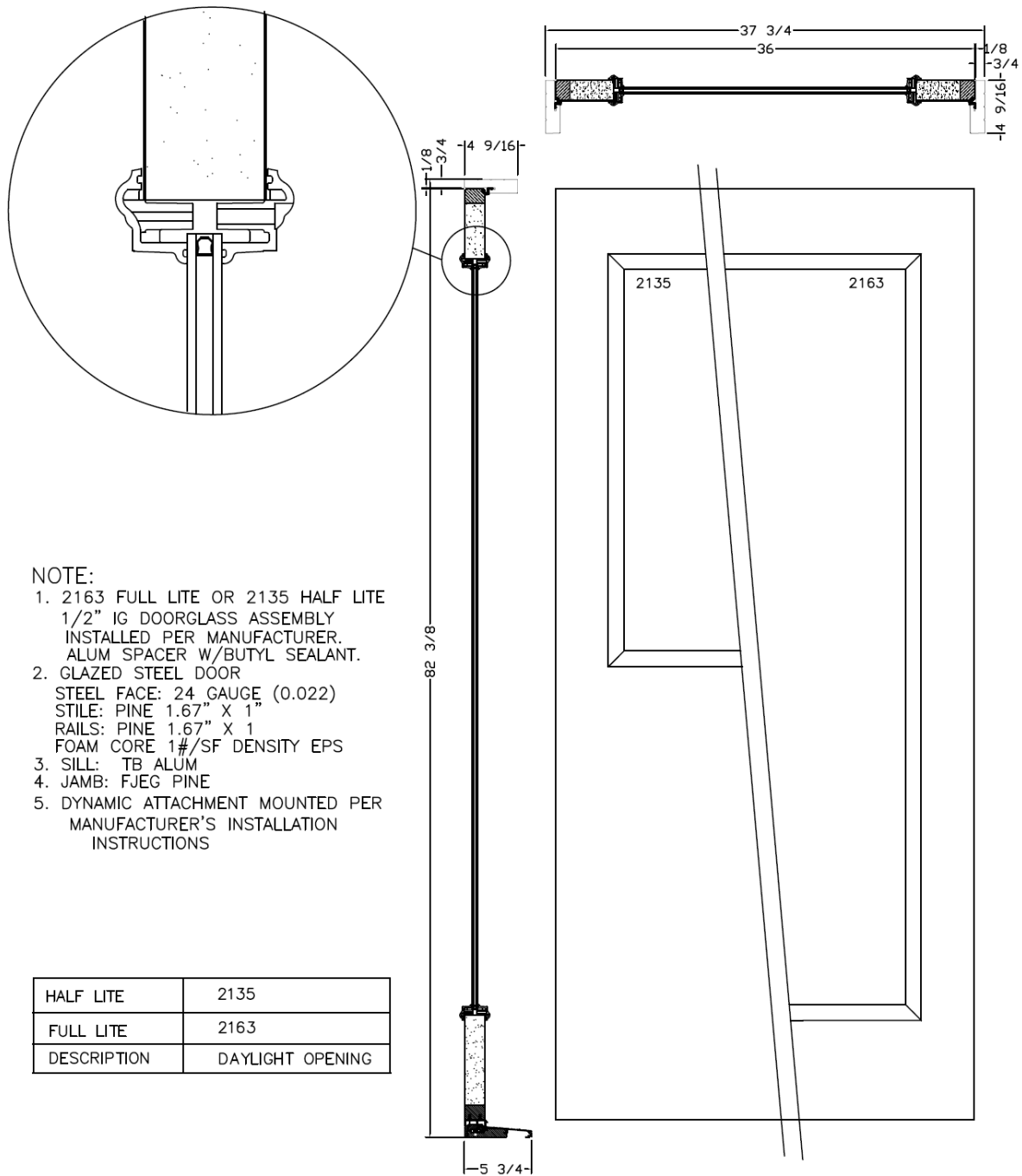
3068; Steel skin; wood edge; EPS core door ½” IG Full and Half Lite See Figure 5-14
3068; Fiberglass skin; wood edge; urethane core door ½” IG Full and Half Lite See Figure 5-15

Reference Swinging Door Glazing Detail

The glazing system shall consist of two panes of 3 mm (1/8 in) clear glass with a 1/4 in air gap separated by an aluminum spacer system. For simulation purposes, the 3 mm (1/8 in) clear glass shall be the generic 3mm clear glass file (ID#102) from the approved NFRC spectral data files with the International Glazing Database (IGDB).

5.7.4 Figures

Figure 5-14 – Reference Swinging Door Details



NOTE:

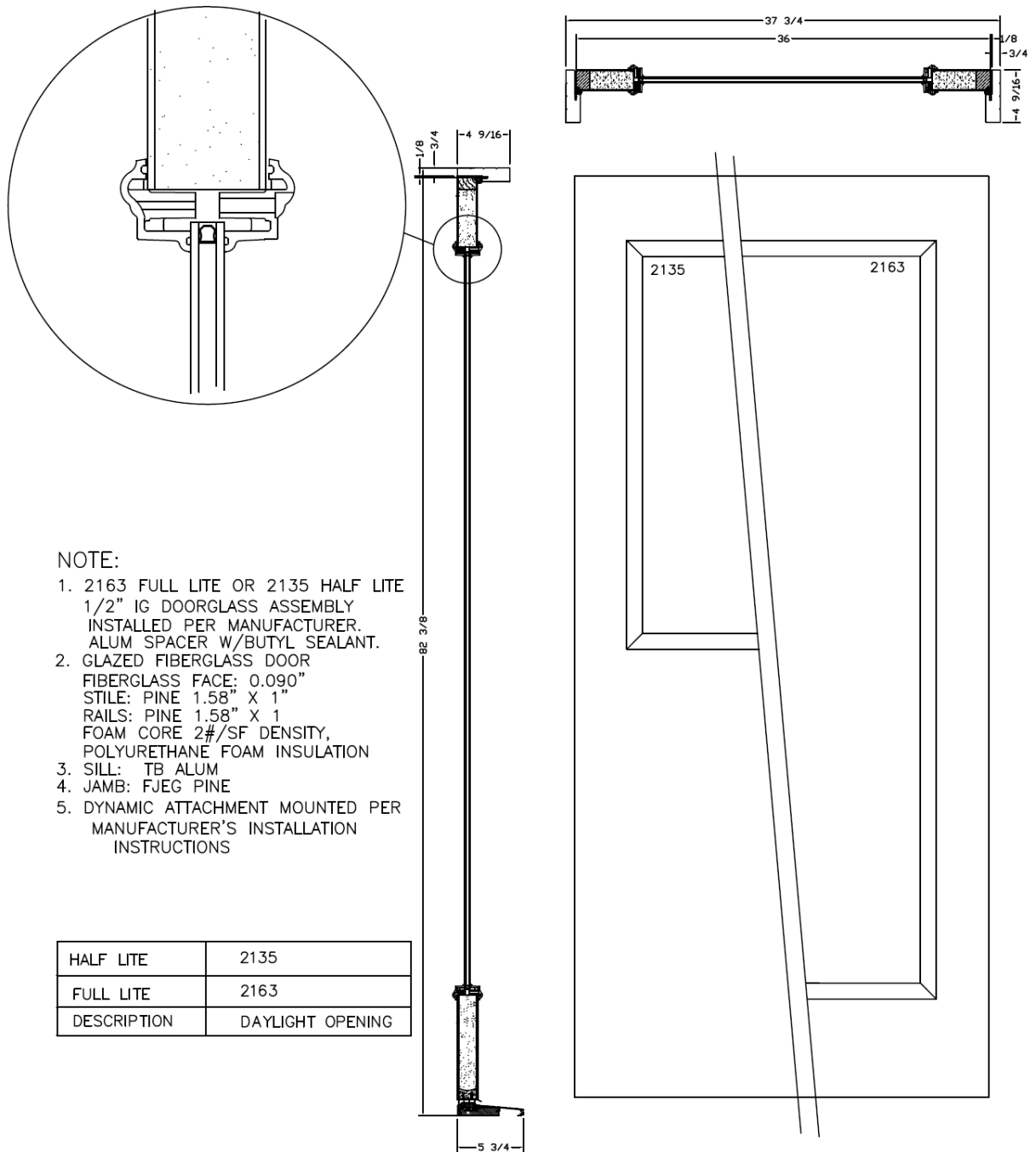
1. 2163 FULL LITE OR 2135 HALF LITE
1/2" IG DOORGLASS ASSEMBLY
INSTALLED PER MANUFACTURER.
ALUM SPACER W/BUTYL SEALANT.
2. GLAZED STEEL DOOR
STEEL FACE: 24 GAUGE (0.022)
STILE: PINE 1.67" X 1"
RAILS: PINE 1.67" X 1"
FOAM CORE 1#/SF DENSITY EPS
3. SILL: TB ALUM
4. JAMB: FJEG PINE
5. DYNAMIC ATTACHMENT MOUNTED PER
MANUFACTURER'S INSTALLATION
INSTRUCTIONS

HALF LITE	2135
FULL LITE	2163
DESCRIPTION	DAYLIGHT OPENING

3068 DASD REFERENCE STEEL DOOR

DRAWING NUMBER	100-001	NFRC 100 REFERENCE DRAWING	REVISIONS	
DRAWN:	ddb	DYNAMIC ATTACHMENT FOR SWINGING DOORS REFERENCE STEEL DOOR FOR SIMULATION AND TEST	1. RELEASE FOR PRODUCTION	06 JAN 08
APPROVED:			2. REVISED SPACER DETAIL	01 MAY 08
DATE:	06 JAN 08		3. ADDED CHART & HALF LITE	08 AUG 09
			4. REVISED GLASS SIZE TO BE DAYLIGHT OPENING	27 AUG 12

Figure 5-15 – Reference Swinging Door Details



NOTE:

1. 2163 FULL LITE OR 2135 HALF LITE
1/2" IG DOORGLASS ASSEMBLY
INSTALLED PER MANUFACTURER.
ALUM SPACER W/BUTYL SEALANT.
2. GLAZED FIBERGLASS DOOR
FIBERGLASS FACE: 0.090"
STILE: PINE 1.58" X 1"
RAILS: PINE 1.58" X 1"
FOAM CORE 2#/SF DENSITY,
POLYURETHANE FOAM INSULATION
3. SILL: TB ALUM
4. JAMB: FJEG PINE
5. DYNAMIC ATTACHMENT MOUNTED PER
MANUFACTURER'S INSTALLATION
INSTRUCTIONS

HALF LITE	2135
FULL LITE	2163
DESCRIPTION	DAYLIGHT OPENING

3068 DASD REFERENCE FIBERGLASS DOOR

DRAWING NUMBER 100-002	NFRC 100 REFERENCE DRAWING	REVISIONS	
DRAWN: ddb	DYNAMIC ATTACHMENT FOR SWINGING DOORS REFERENCE FIBERGLASS DOOR FOR SIMULATION AND TEST	1. RELEASE FOR PRODUCTION	06 JAN 08
APPROVED:		2. REVISED SPACER DETAIL	01 MAY 08
DATE: 06 JAN 08		3. ADDED CHART & HALF LITE	08 AUG 09
		4. REVISED GLASS SIZE TO BE DAYLIGHT OPENING	27 AUG 12

5.8 Rolling Doors

5.8.1 Scope

This section presents and references methods for determining specific rolling door system heat transfer properties or quantities used in the determination of these properties. At this time, the scope of these properties is limited to total rolling door system U-factor. For additional simulation parameters see Reference 2.

5.8.2 Variations from Standard Product Lines

A given series of rolling door systems defined by skin material, core material, and edge of rolling door construction that differ only in:

- A. Size,
- B. Slat changes where one component of the same physical shape has a thermal conductivity that differs by more than a factor of 10,
- C. Jamb guide components,
- D. Variations in slat ends and guide configurations,
- E. Variations in slat interior/exterior finish that changes the surface emittance by more than 0.10, and
- F. Variations in top slat and bottom slat/bottom bar designs.

5.8.3 Variations from Standard Individual Products

An individual product, in a product line, shall be those products that comply with the requirements per Section 5.8.2.

5.8.4 Variations from Standard Simulation and Test Conditions

- A. In accordance with validation testing for simulated rolling door products, rolling doors shall have the U-factor determined using a specimen to fill a 2.13 m (7 ft) wide by 2.13 m (7 ft) tall opening (the aperture is smaller than the test specimen);
- B. Slat height shall be per the manufacturer's drawing (the bottom slat, the top slat, and the intermediate slats shall be modeled per manufacturer drawings);
- C. Slat ends and guide configurations shall be per the manufacturer's drawing;
- D. Rolling door simulations shall not include components and hardware above the top of the opening, e.g. hood, barrel, operator, etc.; and
- E. Door opening framing and sill shall be included in simulation calculations. The framing (nominal 2 in x 4 in) and the sill (nominal 2 in x 6 in) shall consist of 38 mm (1.5 in) thick wood surrounding the perimeter of the door (See Figures 5-16 through 5-18).

5.8.5 Total Product Rating

The total rolling door system U-factor shall be calculated as outlined below:

A. Determine all of the following, as applicable:

- i. Top rail (i.e., top edge of door) U-factor using the approved 2-D computational program, including the wood framing in the surround panel,
- ii. Bottom rail (i.e., bottom edge of door) U-factor using the approved 2-D computational program, including the wood sill in the surround panel,
- iii. End stile (i.e., side edge of door) U-factor using the approved 2-D computational program, including the wood framing in the surround panel,
- iv. Door core U-factor using the approved 2-D computational program, and
- v. The component areas in square feet, to the nearest 0.001 m² (0.010 ft²) of:
 - a) Top rail area, which includes the greater of 63 mm (2.5 in) or 25 mm (1 in) into a homogeneous area of the door core, measured from the top edge of the wood opening framing,
 - b) Bottom rail area, which includes the greater of 63 mm (2.5 in) or 25 mm (1 in) into a homogeneous area of the door core, measured from the bottom edge of the wood opening sill,
 - c) End stile area, which includes the greater of 63 mm (2.5 in) or 25 mm (1 inch) into a homogeneous area of the door core, measured from the outside edge of the wood opening framing,
 - d) Door core area, using three slats as the basis for computation, and
 - e) Projected total exterior door system area (including framing and sill);

B. Perform the following calculations as shown in Equation 5-4:

- i. Multiply the top rail, bottom rail, end stile, and door core U-factors by their corresponding areas,
- ii. Total these four quantities, and
- iii. Divide this total by the projected total exterior rolling door system area to produce computed total rolling door system product U-factors for all the door systems in the matrix of required U-factors.

$$U_t = [(U_{tr}A_{tr}) + (U_{br}A_{br}) + (U_{es}A_{es}) + (U_{dc}A_{dc})]/A_{pt}$$

Equation 5-4

Where

- U_t = Total door system U-factor
- U_{tr} = Top rail U-factor
- A_{tr} = Top rail area
- U_{br} = Bottom rail U-factor
- A_{br} = Bottom rail area
- U_{es} = End stile U-factor
- A_{es} = End stile area
- U_{dc} = Door core U-factor
- A_{dc} = Door core area
- A_{pt} = Projected total door system area

5.8.6 Figures

Figure 5-16 – Rolling Door U-factor Area Weighting - Sectional View

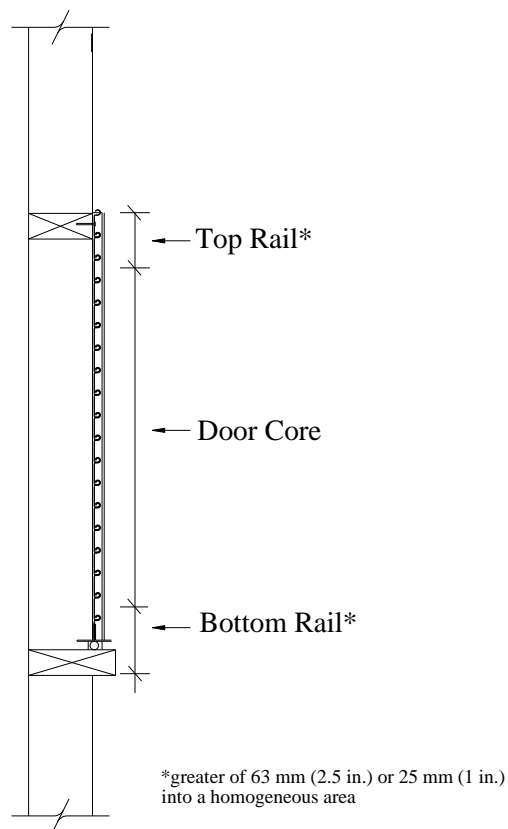
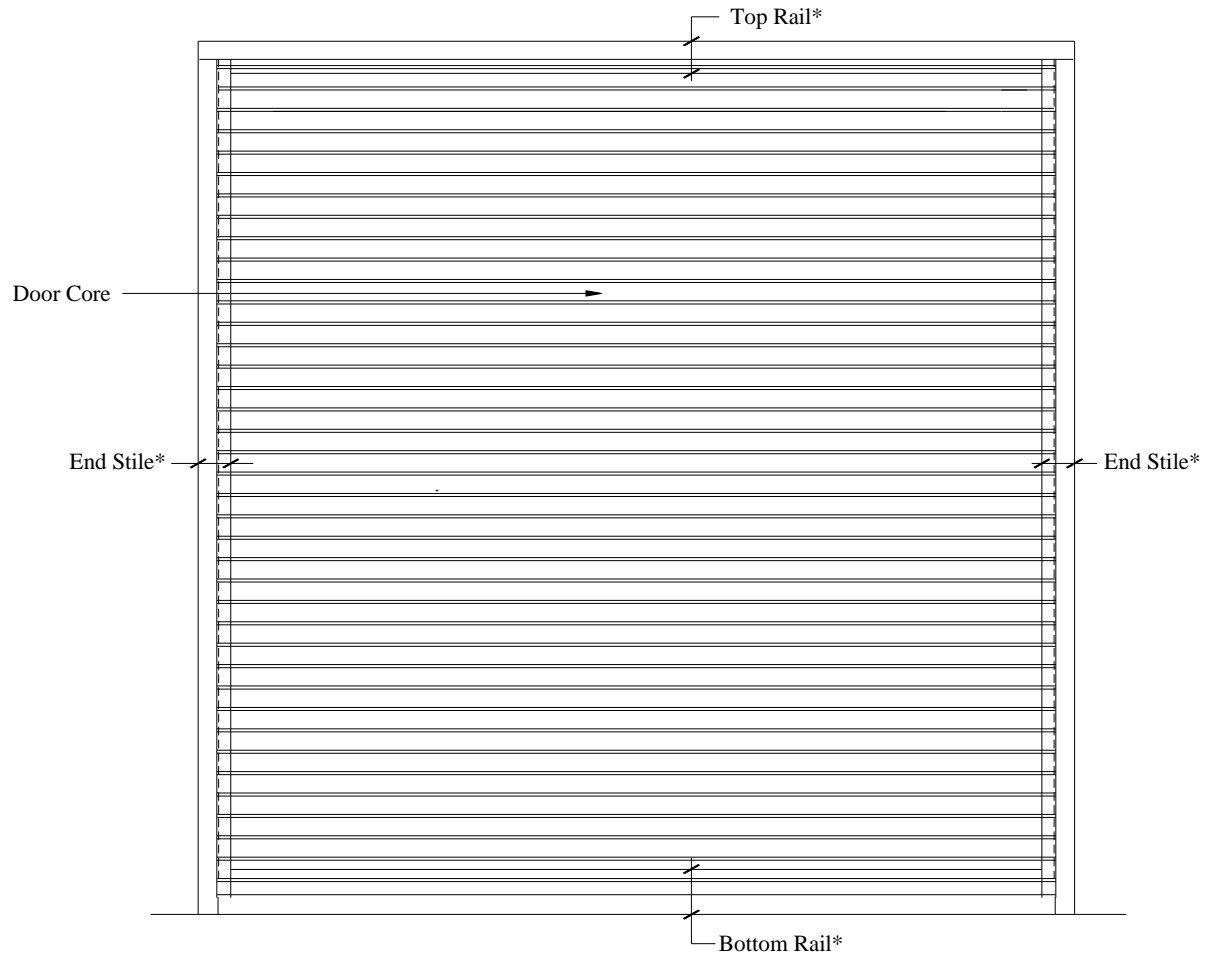
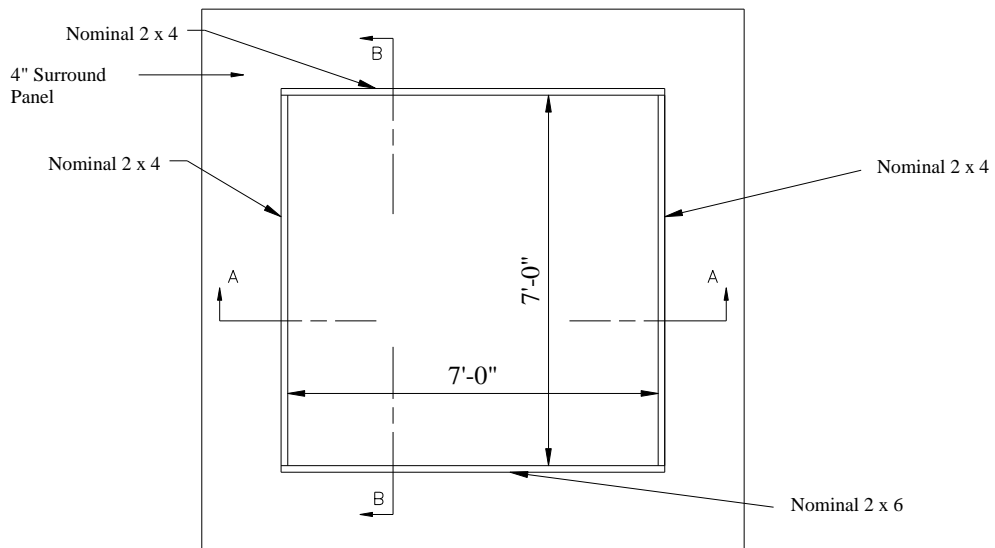


Figure 5-17 – Rolling Door U-factor Area Weighting – Front Elevation View



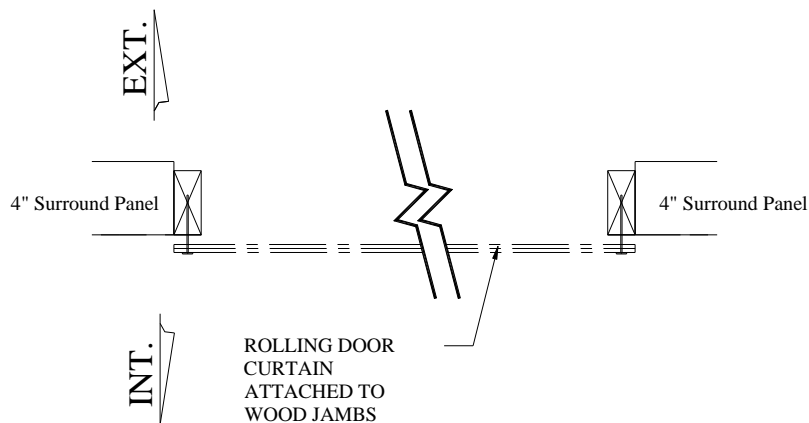
* greater of 63 mm (2.5 in.) or 25 mm (1 in.) into a homogeneous area

Figure 5-18 – Rolling Door Front Elevation View and Perimeter Details



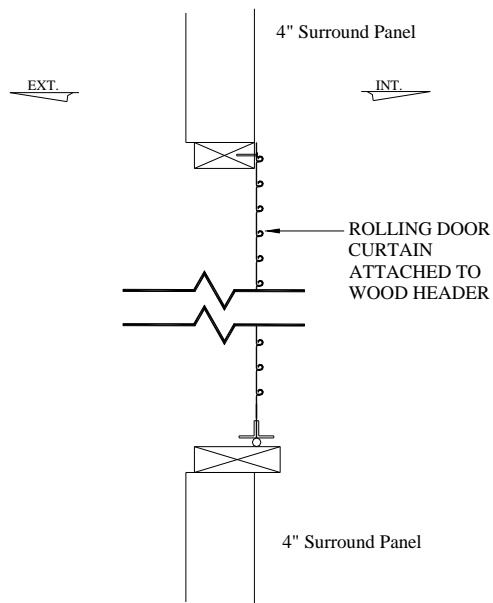
EXTERIOR ELEVATION

Door not shown N.T.S.



SECTION A-A

N.T.S.



SECTION B-B

N.T.S.

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

5.9.1 Scope

This section covers methods for determining fenestration product U-factor (thermal transmittance) for fenestration products using Component Modeling Approach (CMA).

5.9.2 Products and Systems Covered

- A. All products listed in Table 4-3 except;
 - 1. Garage Doors;
 - 2. Greenhouse/garden;
 - 3. Hybrid tubular;
 - 4. Jal/jal awning;
 - 5. Tubular daylighting devices
 - 6. Tropical awning

- B. Combination products;
- C. Composite products;

5.9.3 Standard Simulation and Testing

5.9.3.1 Simulation

All simulations shall be based on computer simulations that comply with Section 4.3.1 and are further based on the CMA modeling procedure (Reference 10).

The CMA procedure is based on modeling frame cross-sections with generic low and high (L/H) conductance center-of-glazing assemblies (L/H COGA) and low and high conductance spacer edge seal assemblies (L/H SESA), collectively known as L/H options. The following are definitions of L/H options.

5.9.3.1.1 Definition of the Low and High (L/H) Options

A total of four configurations are used in the definition of L/H options for insulated glazing. For products without SESA, only two center of glazing assembly configurations are defined for two L/H options. These configurations are assembled from the extreme ends of thermal performance for both COGA and SESA.

- A. Insulating glazing: The following thermal performance is used for insulating glazing options:
 - Low glazing – Double glazed, low-E, with the invented gas fill properties that produces R12.5 insulation value – $U_{cog} = 0.45 \text{ W/m}^2\text{-K}$ (0.08 Btu/hr-ft²-F)
 - High glazing – Double glazed clear air
 - $U_{cog} = 2.684 \text{ W/m}^2\text{-K}$ (0.473 Btu/hr-ft²-F)
- B. Single glazing: The following thermal performance is used for single glazing options:
 - Low glazing – Low-E single glass, with low-E facing indoor side – $U_{cog} = 3.24 \text{ W/m}^2\text{-K}$ (0.57 Btu/hr-ft²-F)
 - High glazing $U_{cog} = 5.82 \text{ W/m}^2\text{-K}$ (1.03 Btu/hr-ft²-F)

- C. Glazing for dual window or door and glazing for products with secondary sash or panel, energy panel, or storm panel:
 - Low glazing – Use a combination of low-E coated glass and inerted gas fill from above
 - High glazing – Use clear glass (non-coated) for all panes with all glazing cavity with air
- D. If the original configuration has any combination of insulated glazings and/or single glazings, low and high glazing configuration should duplicate that;
- E. If a product includes SESA, the following low and high spacer details should be used:
 - Low spacer – generic low conductivity spacer – $K_{eff} = 0.01 \text{ W/m-K}$ (0.006 Btu/hr-ft-F)
 - High spacer – generic high conductivity spacer – $K_{eff} = 10.0 \text{ W/(m-K)}$ (5.8 Btu/hr-ft-F)
- F. SESA height is standardized to 12.7 mm (0.5 in), spacer width is variable in order to match the gap width of L/H COGA;
- G. SESA is not applicable to single glazing systems; and
- H. Glass thickness is standardized to 3 mm (1/8 in) for residential products and 6 mm (1/4 in) for commercial products. Overall (nominal) thickness of L/H glazing systems should match nominal thickness (\pm tolerance) of the real glazing systems (i.e. 19.1 mm (3/4 in); 22.2 mm (7/8 in); 25 mm (1 in), etc.) that the simulated product is designed for.

5.9.3.1.2 Reporting Simulation Results

See NFRC 701.03 – Reporting Requirements, Section 1.2.

5.9.3.1.3 Total Product U-factor Calculation

- A. Total product U-factor calculation requires the U-factors for frame components frame U-factor (U_f) and edge-of-glass U-factor (U_e), for their representative Low and High options. In addition, projected frame depth (pfd) is required;

- B. The following additional calculation results are required for total product U-Factor calculation and these shall be reported for the whole product:

$$\text{COGA: } U_c = \quad \text{W/m}^2\text{-K (Btu/hr-ft}^2\text{-}^\circ\text{F)}$$

$$\text{SESA: } K_{\text{eff}} = \quad \text{W/m-K (Btu/hr-ft-}^\circ\text{F)}$$

- C. The calculation of total product U-factor for products with a SESA is done using the procedure detailed in Reference 10. For products without a SESA, total product U-factor is calculated by excluding the equations that involve the SESA; and
- D. The NFRC-approved CMA Software Tool (CMAST) shall be used to determine total product U-factor for standard model size.. U-factor ratings for sizes other than standard model size can be calculated for informational purposes when applicable.

5.9.3.2 Testing

There is no separate CMA testing procedure for frame components. Testing is done for the whole product, which is the baseline product for the purposes of validation testing, and is done to validate a Framing Product Line (FPL).

5.9.4 Validation Testing

Each FPL will require validation testing on a standard baseline product representing the framing product line, using NFRC 102. The following conditions apply:

- A. Test specimen size and configuration shall be as defined in Table 4-3 and Section 5.9.6
- B. All test specimens shall be tested without removable screens, removable grilles and trims, or any other applied devices;
- C. All test specimens shall be tested in the vertical position. For determining validation of the baseline product only, skylights, and other sloped glazing products shall be simulated in a vertical position;
- D. The test specimen shall not be modified by the testing laboratory, except as allowed in Reference 1 for sealing against air leakage and as required by this section;
- E. The product selected as the baseline product shall have an insulating glass unit(s) with a maximum center-of-glazing U-factor of 0.35, unless the product is not designed for use with insulating glass (i.e. domes, glass block, translucent panels, single glazing, etc.); and

- F. The framing product line is validated if the baseline product has a tested U-factor which meets the equivalence criteria in Table 4-4 when simulated in accordance with Section 5.9.3.

5.9.5 Simplifications

5.9.5.1 Simplifications to Spacer Components

- A. For the purpose of the CMA methodology, each SESA performance shall be provided in terms of its effective conductivity, K_{eff} ;
- B. The SESA consists of the spacer component, desiccant, and any applicable sealants. Three different paths are provided for the definition of the spacer component and corresponding SESA; and
- C. Each spacer component can be submitted by the spacer manufacturer and later made available for SESA under only one path.

Path I – Generic Spacer: (Default Spacer, Default Sealant, Default Geometry)

The K_{eff} is defined based on simple review of spacer drawings.

Group 1 – Spacer containing aluminum

If the spacer uses any aluminum in the design it shall be assigned a spacer system kK_{eff} of 8.0 W/mC (4.622 Btu/hr-ft-F).

Group 2 – Spacer containing mild steel (i.e. galvanized steel, tin-plated steel)

If the spacer uses any mild steel in the design it shall be assigned a spacer system K_{eff} of 3.0 W/mC (1.733 Btu/hr-ft-F).

Group 3 – Spacer containing stainless steel

If the spacer uses any stainless steel in the design it shall be assigned a spacer system kK_{eff} of 1.0 W/mC (0.578 Btu/hr-ft-F).

Group 4 – Spacer containing all non-metallic materials

If the spacer uses only non-metallic materials in the design it shall be assigned a spacer system K_{eff} of 0.5 W/mC (0.289 Btu/hr-ft-F). If the spacer design incorporates any metal, it shall fall into either Group 1, 2, or 3.

In the event a spacer contains two metals, the higher conductivity metal shall be used in specifying the spacer group, regardless of the amount of that metal present in the spacer.

Path II – Specific Spacer, Default Sealants (Specific Spacer, Default Sealants, Limited Geometry):

The Keff of the spacer edge-seal assembly is defined based on simulation from spacer bar drawings.

- A. The spacer manufacturer shall submit drawings to an NFRC-accredited simulator to be evaluated and modeled;
- B. The spacer component shall be evaluated by the certified simulator working for an accredited lab and shall be based on the drawings and the bill of materials supplied by the spacer manufacturer;
- C. The spacer component is evaluated for each width available for the spacer series, to which spacer component belongs, based on the drawings supplied by the spacer manufacturer at the maximum spacer height available for the spacer series;
- D. Modeling of desiccant is applicable to only those spacer systems which separately add desiccant to the spacer bar;
- E. The spacer edge seal assembly that is generated from this spacer component shall be evaluated using generic sealant and desiccant materials to cover all sealant and desiccant materials (see table below); and
- F. The spacer edge seal assembly with the highest Keff value shall be used to represent all spacer components for this spacer series. Only one Keff for the spacer edge-seal assembly is submitted for inclusion in the CMA database to represent all spacer components for the spacer series.

Table 5-4 – Generic Sealant and Desiccant Material Values

Generic Materials	k (W/m-K)	k(Btu/hr-ft-F)
Generic Primary Sealant	0.25	0.144
Generic Secondary Sealant	0.40	0.231
Generic Desiccated Matrix	0.29	0.168
Generic Desiccant Bead	0.03	0.017

Path III – Specific Spacer, Specific Sealants: (Specific Spacer, Specific Sealant, Detailed Spacer Edge-Seal Assembly Geometry)

The Keff of the spacer edge-seal assembly is defined based on simulation from spacer drawings, any applicable desiccant, and any applicable sealants.

- A. The spacer manufacturer shall submit drawings to an NFRC-accredited simulator to be evaluated and modeled;
- B. The spacer component shall be evaluated by the certified simulator working for an accredited lab and shall be based on the drawings and the bill of materials supplied by the spacer manufacturer;
- C. Each spacer component has a unique width and height;
- D. The spacer edge-seal assembly, consisting of the spacer component, desiccant, and any sealants, as appropriate, is generated when the spacer edge-seal assembly composition and geometry is known;
- E. The effective conductivity of such spacer edge-seal assembly is calculated on demand using the specific spacer component, generic values for desiccant from the Table 5.6.2 and specific values for the primary and secondary sealants, as appropriate, and shall be used in the whole fenestration product calculation; and
- F. As an option, the product may be evaluated and modeled with the generic sealant materials defined under Path II to limit the number of system configurations. However, specific sealant geometry shall be used.

5.9.5.2 Simplifications to Frame Component

FPL are not grouped; grouping is done on the basis of frame components (i.e., head cross-sections are compared to head cross-sections, etc.). All applicable frame components shall be members of the same FPL. Membership in the FPL is based on the comparison with the approved framing components used in the standard framing system product.

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

- A. Frame Grouping
 - i. All grouping rules contained in Section 4 shall be permitted to be utilized with the calculation procedures of Section 5.9,
 - ii. In addition, this section presents additional frame grouping rules that shall be permitted to reduce the number of simulations by grouping individual frame components. If this approach is used, the frame U-

factors (U_f) calculated in accordance with Section 5.9.5 for the frame group leader shall be used to represent the frame U-factors (U_f) for all individual frame components within that group,

- iii. Individual frame components may be grouped based upon the variations listed below; when more than one of these variations is being used for grouping, the priority for determining the frame group leader shall be in the order listed below:
 - 1. Change in frame length in the direction perpendicular to the fenestration plane,
 - 2. Emissivity of external and internal frame surfaces,
 - 3. Glazing inset relative to the exterior,
 - 4. Projected frame depth (PFD),
 - 5. Material wall thickness, or
 - 6. Addition of internal frame web(s) to create additional frame cavities.
- iv. The frame group leader shall be determined in accordance with Tables 5-5 to 5-7 based upon the dominant frame material.

Table 5-5 – Frame Group Leader for all Metallic, Aluminum, Thermally-Improved Aluminum, and Thermally-Broken Aluminum Frames

Variation	Group Leader
Change in frame length in the direction perpendicular to the fenestration plane	Maximum length
Surface emissivity	Highest emissivity
Glazing inset relative to the exterior	Glazing location closest to the outside
Change in PFD	Highest PFD
Material wall thickness	Highest wall thickness
Addition of internal frame web(s) to create additional frame cavities	Maximum number of webs

Table 5-6 – Frame Group Leader for Vinyl, Fiberglass, and Composite Frames

Variation	Group Leader
Change in frame length in the direction perpendicular to the fenestration plane	Maximum length
Glazing inset relative to the exterior	Glazing location closest to the outside
Change in PFD	Highest PFD
Material wall thickness	Highest/thickest wall
Addition of internal frame web(s) to create additional frame cavities	Minimum number of webs

Table 5-7 – Frame Group Leader for Wood Frames (either with or without Cladding)

Variation	Group Leader
Change in frame length in the direction perpendicular to the fenestration plane	Minimum length
Glazing inset relative to the exterior	Glazing location closest to the outside
Change in PFD	Highest PFD

5.9.5.3 Modification of Approved Framing Components and Addition of New Framing Components

- A. If a framing component within an approved FPL is modified, the modified component becomes a new member of the approved FPL without additional validation testing if the modification is consistent with the definition of framing product line.
- B. A new framing component may be added to an approved FPL without additional validation testing if the new framing component is consistent with the definition of FPL.

5.9.6 Total Product Rating

The U-factor of a fenestration product may vary by size. In order to provide a uniform rating procedure for the comparison of fenestration systems, total product U-factor rating is calculated for the model (standard) size per Table 4-3 and Table 5-9.

A U-factor rating for sizes other than standard model size can be calculated for informational purposes.

5.9.6.1 Reporting of Ratings

The U-factor shall be reported to 0.05 W/(m²-K) (0.01 Btu/h•ft²•°F). All variables used in the formula shall be expressed to at least three significant decimal places.

5.9.6.2 Determining Thermal Transmittance (U-factor) for Sloped Glazing Systems

- A. All sloped glazing systems shall be rated for thermal performance characteristics at a slope of 20° or above the horizontal (See Section 5.3 [Skylights] for more information); and
- B. Sloped glazing systems are validated at vertical position.

5.9.6.3 Complex Product Rating

This section provides the details of additional non-residential product types and their model (standard) sizes for rating purposes.

5.9.6.3.1 Spandrel Panel

Spandrel panels shall be rated for U-factor at the size specified in Table 4-3 if the spandrel infill can be represented solely as a glazing assembly.

A. Validation of Spandrel Panel Products

If the frame components of the spandrel panel have been validated for any framing product line, no additional validation is required. It is treated as an additional glazing option.

5.9.6.3.2 Combination Products

Individual fenestration products forming the combination product, which can be identified as a product/operator type listed in Table 4-3, will get separate NFRC rating for their individual model (standard) sizes.

A. Validation of Combination Products

No separate validation is required for combination products. Frame components of individual units forming the combination product shall be part of a validated Framing Product Line (FPL).

5.9.6.3.3 Composite Products

Individual units forming the composite product, which can be identified as a product/operator type listed in Table 4-3, will be rated at their NFRC standard size. Centerline of integral mullion will be used to determine the actual sizes of these individual units.

A. Validation of Composite Products

No separate validation required for composite products. Frame components of individual units forming the composite product shall be part of a validated Framing Product Line (FPL).

5.10 Applied Films

[Note: Applied films factory-applied to glazing prior to fenestration product fabrication and installation are already covered as glazing options by ANSI/NFRC 100 and shall not be rated according to the procedure of Section 5.10 below.]

5.10.1 Scope

This section presents additional details specific to applied films. This section presents and references methods for determining specific applied films U-factor rating.

5.10.2 Variations from Standard Product Lines

None

5.10.3 Variations from Standard Individual Products

None

5.10.4 Variations from Standard Simulation and Test Conditions

5.10.4.1 Approved Center-of-Glazing Computational Program

Approved center-of-glazing software shall be used to determine U-factor. Applied films shall be from the approved NFRC spectral data files with the International Glazing Database (IGDB). Glazing/applied film assembly shall be constructed in accordance with NFRC 304 procedure.

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 (1/4 in) air gap;
- E. Double 6mm (1/4 in) Clear/ 6 mm (1/4 in) Clear: 12.7 mm (1/2 in) air gap; and
- F. Double 6 mm (1/4 in) Grey/ 6mm (1/4 in) Clear: 12.7 mm (1/2 in) 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 matrix in Table 5-8 for each applied film and applied film position.

5.10.5 Calculation of Total Product Rating

The reference fenestration product with applied film U-factor shall be calculated as outlined below.

5.10.5.1 Reference Fenestration Products

Calculate the total fenestration product U-factor for each reference fenestration product with the corresponding applied film according to Section 5.10.5.2. U-factor for reference products are pre-calculated based on the illustrations in Figures 5-19 and 5-20. This will result in the matrix in Table 5-9 for each film product.

Figure 5-19 – Residential Fixed Window Reference Product

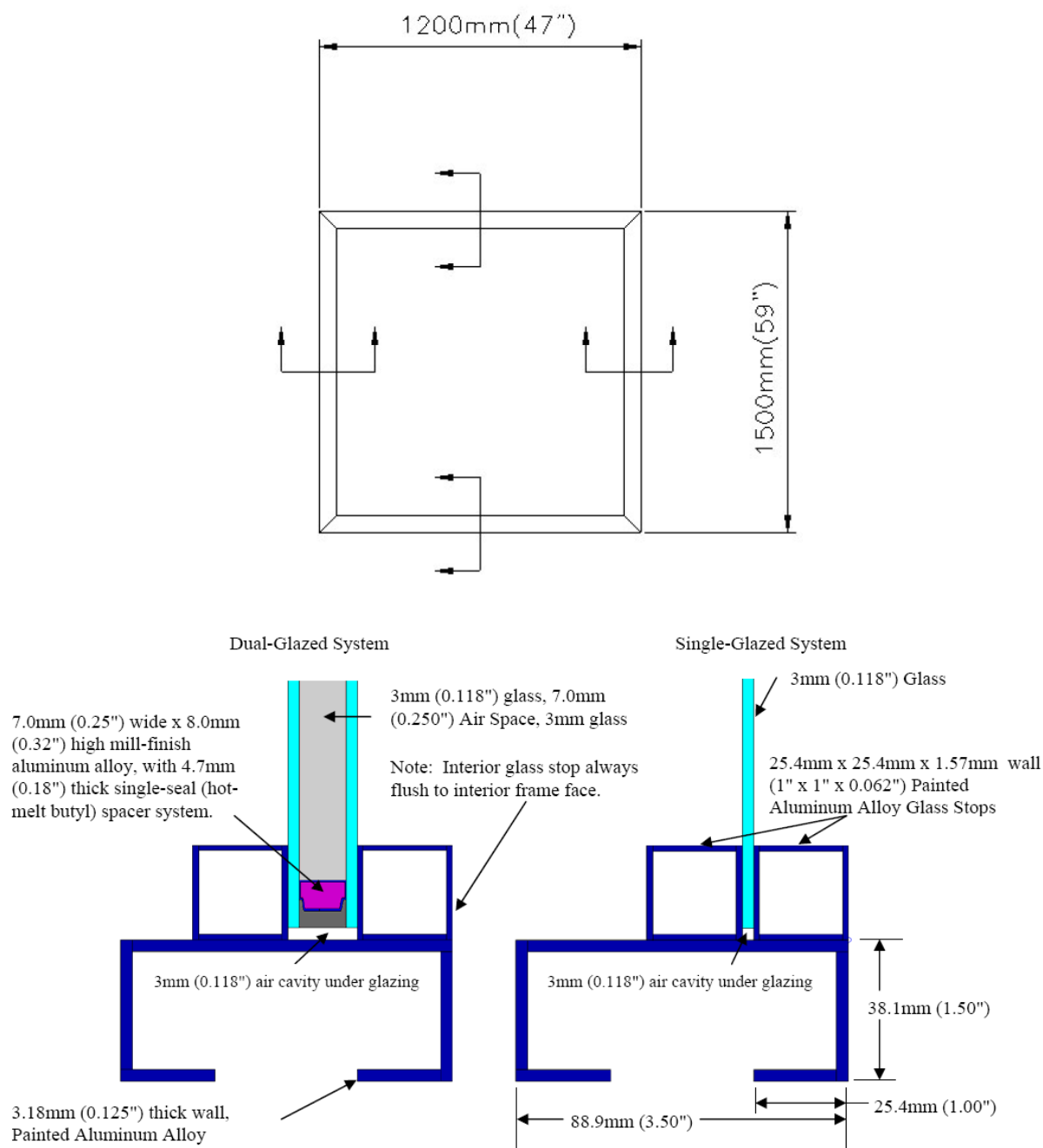
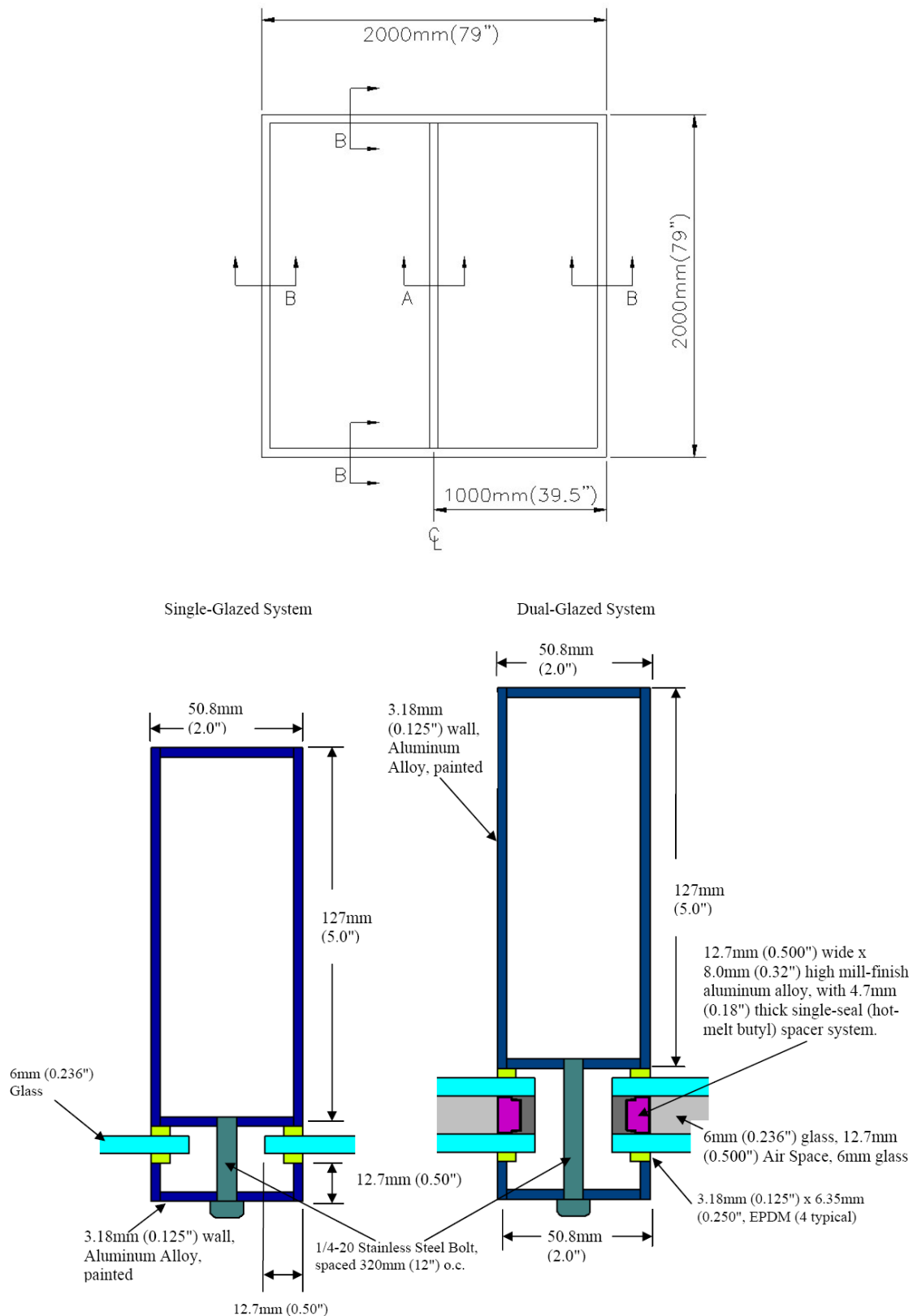
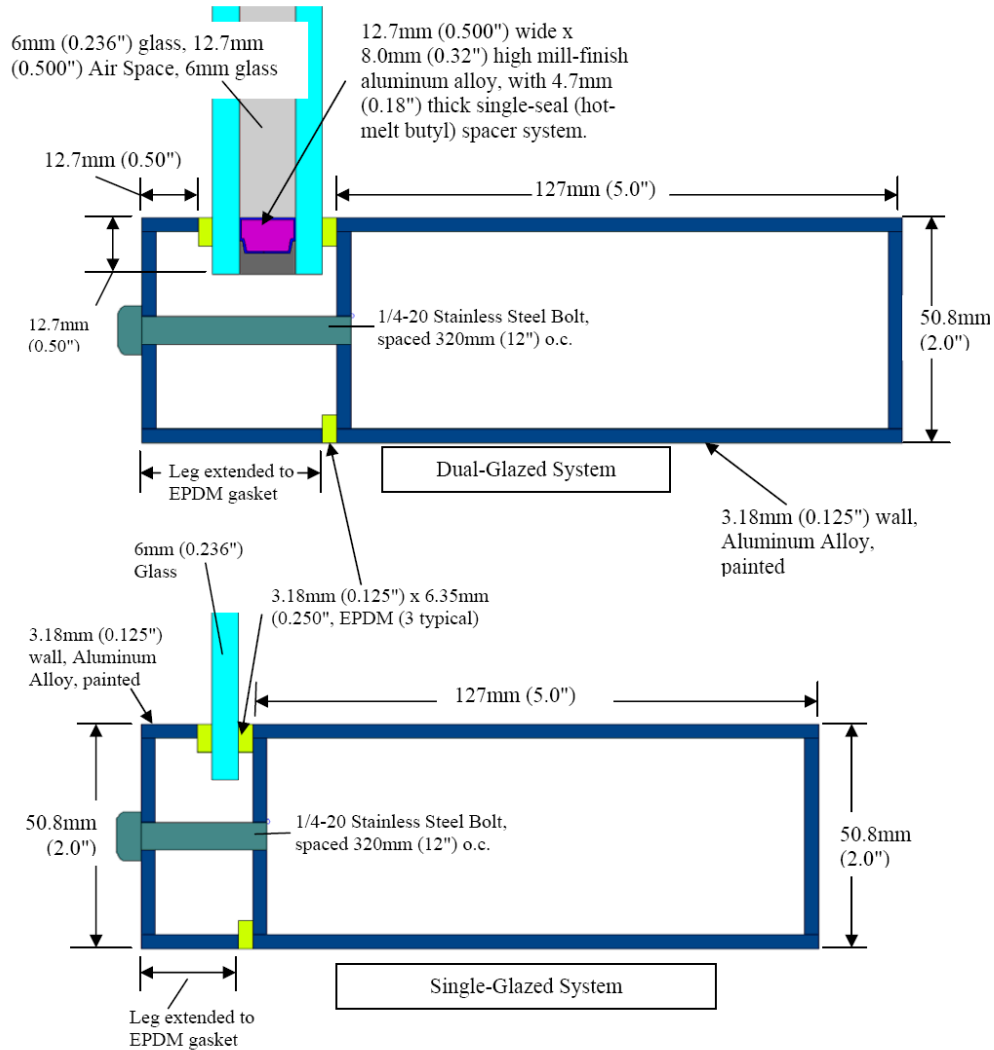


Figure 5-20 – Non-Residential Window-Wall Reference Product





5.10.5.2 Total Fenestration Product U-factor

Calculate the total fenestration product U-factor for each reference fenestration product and corresponding reference product with applied film using the following equation:

$$U_t = [\Sigma(U_f A_f) + \Sigma(U_e A_e) + \Sigma(U_c A_c)] / A_{pf}$$

Equation 5-5

Where:

U_t = Total product U-factor, W/m^2K , (Btu/hr-ft²-°F)

A_{pf} = Projected fenestration product area, m² (ft²)

U_f = Frame U-factor, W/m^2K , (Btu/hr-ft²-°F)

A_f = Frame area, m² (ft²)

U_e = Edge-of-glazing U-factor, W/m^2K , (Btu/hr-ft²-°F)

A_e = Edge-of-glazing area, m² (ft²)

U_c = Center-of-glazing U-factor, W/m^2K , (Btu/hr-ft²-°F)

A_c = Center-of-glazing area in ft² (m²)

To three significant digits

Table 5-8 – Center-of-Glazing Values U_c

Reference Glazing System	Without Film	With Film	
	U_c Btu/h·ft ² ·°F	Film Position	U_c^* Btu/h·ft ² ·°F
3 mm (1/8 in) clear	1.04	Interior	
6 mm (1/4 in) clear	1.02	Interior	
6 mm (1/4 in) grey	1.02	Interior	
3 mm (1/8 in) clear 3 mm (1/8 in) clear 7mm (1/4 in) gap	0.55	Interior	
6 mm (1/4 in) clear 6 mm (1/4 in) clear 12.7mm (1/2 in) gap	0.47	Interior	
6mm (1/4 in) grey 6 mm (1/4 in) clear 12.7mm (1/2 in) gap	0.47	Interior	

* U_c 'with Film' shall be calculated using reference glazing with film to be rated.

Table 5-9 – Values of U-factor for Reference and Applied Films

Reference Product			U-factor Btu/h·ft ² ·°F	
Operator Type	Reference Frame	Reference Glazing	no film	with film*
Residential Fixed	Aluminum	3mm (1/8 in) clear	1.081	
Non-Residential Window-wall	Aluminum	6mm (1/4 in) clear	1.021	
		6mm (1/4 in) grey	1.021	
Residential Fixed	Aluminum	3mm (1/8 in) clear 3mm (1/8 in) clear 7mm (9/32 in) gap	0.700	
Non-Residential Window-wall	Aluminum	6mm (1/4 in) clear 6mm (1/4 in) clear 12.7mm (1/2 in) gap	0.588	
		6mm (1/4 in) grey 6mm (1/4 in) clear 12.7mm (1/2 in) gap	0.588	

* 'with film' shall be calculated using reference glazing with film to be rated.

5.10.6 Testing

If a reference product with applied film cannot be simulated in accordance with Section 5.10.5, the center-of-glazing test procedure in Section 5.10.6.1 shall be used to determine the U-factor of the applied film glazing system.

5.10.6.1 Center-of-Glazing Component Test Procedure

The center-of-glazing U-factor (U_c) for corresponding reference product glazing system with applied film shall be tested in accordance with Section 4.6.2.1.

5.10.6.2 Total Fenestration Product Test Procedure

Using center-of-glazing U-factor (U_c) determined in accordance with Section 5.10.6.1 with applicable reference product framing system shall be simulated to calculate total fenestration product U-factor.

6. REFERENCES

- 1) *NFRC 102-2014: Procedure for Measuring the Steady-State Thermal Transmittance of Fenestration Systems*. National Fenestration Rating Council: Greenbelt, MD; 2014. www.nfrc.org.
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APPENDIX A (NON-MANDATORY INFORMATION)

A.1 Determination of Project-Specific U-factors

The system U-factor ratings for project-specific U-factors shall be determined by an NFRC-accredited simulation laboratory using NFRC-approved software tools which utilizes components of the NFRC-certified system, specifically with the frame, edge-of-glazing, and center-of-glazing U-factors. Each component of the total system shall be assigned percentages of the total product and the total system U-factor shall be calculated using the procedures outlined in Section 4.6.3.

[**Note:** Reference the contents of Section 5 of this document.]

A.2 Determination of U-factors at Non-Standard Sizes

A U-factor-rating matrix that is size specific may be developed in accordance with ANSI/NFRC 100 procedures and requirements. A matrix shall only be developed for those product lines and individual products of a product line that have been submitted to an NFRC-licensed independent certification and Inspection Agency (IA) for certification authorization purposes at the product size as defined in Table 4-3. Products that have previously received certification authorization may also have a matrix developed. Each matrix shall be specific to an individual product within a product line.

The matrix shall include the standard rating size and sizes that are defined by the manufacturer.

The fenestration thermal performance parameter ratings (i.e., U-factor,) shall be determined by an NFRC-accredited simulation laboratory, using NFRC-approved software tools, which utilizes components of the NFRC-certified system, specifically with the frame, edge-of-glazing and center-of-glazing thermal performance ratings, where applicable. Each component of the total system shall be assigned percentages of the total product and the total system thermal performance parameter shall be calculated using the procedures outlined in Section 4.6.3.

[**Note:** Until such time that a certification change is made in the NFRC 700: Product Certification Program, the thermal performance parameters that are determined at sizes other than the product size in Table 4-3 are for informational purposes only.]

Table A-1 – Example U-factor Size Matrix

Example Only – Widths, Heights, and U-factors

		Width (in.)								
		36	48	60	72	80	84	96	108	120
Height (in.)	36	0.55	0.52	0.49	0.48	0.47	0.47	0.46	0.45	0.45
	48	0.53	0.49	0.47	0.46	0.45	0.44	0.44	0.43	0.42
	60	0.52	0.48	0.46	0.44	0.43	0.43	0.42	0.41	0.41
	72	0.51	0.47	0.45	0.43	0.42	0.42	0.41	0.40	0.40
	80	0.51	0.47	0.44	0.43	0.42	0.41	0.41	0.40	0.39
	84	0.51	0.47	0.44	0.42	0.42	0.41	0.40	0.40	0.39
	96	0.50	0.46	0.44	0.42	0.41	0.41	0.40	0.39	0.38
	108	0.50	0.46	0.43	0.42	0.41	0.40	0.39	0.39	0.38
	120	0.50	0.46	0.43	0.41	0.40	0.40	0.39	0.38	0.38

U-factor units in matrix above are Btu/hr-ft²-°F

Shaded area indicates ANSI/NFRC 100 Standard Size for Certification and Rating Purposes.

The values stated (other than the identified standard size) in the matrix above are for informational purposes only and have not been authorize for certification. The standard size rating is also shown on the label certificate to which this matrix is attached. For additional information, contact the IA stated on the label certificate.

A.3 Determination of Skylight U-factors at Non-Standard Slopes

A U-factor-rating matrix that is slope-specific may be developed in accordance with ANSI/NFRC 100 procedures and requirements. A matrix shall only be developed for those product lines and individual products of a product line that have been submitted to an NFRC-licensed independent certification and Inspection Agency (IA) for certification authorization purposes at the standard 20° slope from horizontal. Products that have previously received certification authorization may also have a matrix developed. Each matrix shall be specific to an individual product and glazing type within a product line.

The matrix shall include the standard slope rating and ratings at other slopes that are defined by the manufacturer.

Calculation shall use the following Convective Surface Heat Transfer Coefficients, for any of the listed slopes:

Table A-2: Convective Surface Heat Transfer Coefficients, $h_{c,in}$ for Skylights at Different Incidence Angles ($W/m^2 \cdot ^\circ C$)

Frame Type	Angle of Incidence from Horizontal (degrees)									
	0	10	15	20	30	45	60	70	85	90
Wood/Vinyl	3.147	3.147	3.095	3.090	3.042	2.798	2.357	2.405	2.441	2.443
T/B AI	4.147	4.147	4.096	4.091	4.043	3.801	3.088	2.953	2.997	2.999
TI AI	4.373	4.373	4.322	4.317	4.270	4.029	3.316	3.071	3.117	3.120
AI	4.710	4.710	4.659	4.654	4.606	4.366	3.657	3.244	3.292	3.295

Table A-3: Convective Surface Heat Transfer Coefficients, $h_{c,in}$ for Skylights at Different Incidence Angles ($Btu/hr^2 \cdot ft^{20} \cdot F$)

Frame Type	Angle of Incidence from Horizontal (degrees)									
	0	10	15	20	30	45	60	70	85	90
Wood/Vinyl	0.554	0.554	0.545	0.544	0.536	0.493	0.415	0.424	0.430	0.430
T/B AI	0.730	0.730	0.721	0.720	0.712	0.670	0.544	0.520	0.528	0.528
TI AI	0.770	0.770	0.761	0.760	0.752	0.710	0.584	0.541	0.549	0.549
AI	0.829	0.829	0.821	0.820	0.811	0.769	0.644	0.571	0.580	0.580

Coefficients for any slopes not listed can be calculated using linear interpolation between the two closest angles.

Skylights that are approved for use at slopes within 15° of vertical under the manufacturer's standard instructions may be entitled to dual U-factor ratings. Consult with the NFRC-licensed independent certification and Inspection Agency (IA) for further determination.

[Note: Until such time that a certification change is made in the NFRC 700: Product Certification Program, the thermal performance parameters that are determined at slopes other than the standard slope are for informational purposes only.]

Table A-4: Skylight U-factors Slope Table (Example Only)

	Roof Slope (degrees above horizontal)						
	0	15	20	40	60	75	85
U-Factor	0.52	0.50	0.49	0.47	0.45	0.43	0.42

Shaded column indicates ANSI/NFRC 100 standard slope ratings for certification purposes.

The values stated (other than the identified standard ratings) in the matrix above are for informational purposes only and have not been authorized for certification. The standard slope ratings are also shown on the label or certificate to which this matrix is attached. For additional information, contact the IA stated on the label certificate.

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