NFRC 100-2009, Section 5.6 (Non-residential Fenestration)

Revised 11.08

Definitions (Referred to Glossary and Terminology for inclusion in NFRC 600)

Non-residential Building – All buildings over three stories in height above grade or buildings, other than residential buildings, that are three stories or less in height above grade.

Non-residential Fenestration Systems – Common types of Non-Residential fenestration systems installed in Non-residential buildings include windows, curtain wall, window wall, storefront and doors.

Double-sash product- Fenestration product that has two or more independent sashes or glazing pockets. Each sash or glazing pocket may contain single glazing or IGU or combination of the two.

Fenestration - The placement of openings in a building wall, such as windows, doors, skylights, curtain walls, etc., designed to permit the passage of air, light, or people; one of the important elements in controlling the exterior appearance of a building. Also, associated interior or exterior elements, such as shades or blinds. From the Latin word, "fenestra", meaning window.

Framing Product Line **–** A collection of framing sections whose cross-sections can be grouped using the applicable grouping rules for non-residential products. This may include standard sections (head, jamb, sill, etc.) as well as non-standard sections (inside corner, outside corners, etc.) which are used in conjunction with the primary systems to build a complete system on a building.

Spacer: The linear object that separates and maintains the space between the glass surfaces of insulating glass.

Standard Framing System Product **–** The framing sections (head, jamb, sill, etc.) within a Framing Product Line which are required to fabricate a standard size and configuration fenestration product per NFRC 100, Table 4-3.

Storefront**:** A non-residential system of doors and windows mulled as a composite structure; typically designed for high use/abuse and strength. The storefront system is usually installed between the floor and ceiling of the building.

Structurally glazed framing**:** A method of glazing where framing members are generally not exposed to the exterior (i.e., 2-sided or 4-sided structural glazed).

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

Spandrel Area: The area of the spandrel infill between the primary sash or frame members.

Non-thermally broken members**:** System members with less than 1.6 mm (1/16 in.) or no separation between metal or system members to provide a resistance heat transfer path from exterior to interior.

OWL (Outdoor wetted length): measured from the interface between frame and glazing to the first adiabatic boundary on the outdoor side

PFD (Projected frame depth): representing projection in the plane of glazing measured from the sightline to the end of the frame

5.6 Non-residential building fenestration products:

This section covers methods for determining fenestration product U-factor (thermal transmittance), for fenestration products installed in Non-residential buildings, including, but not limited to, fenestration products that are site assembled (built). This section also covers methods for determining fenestration product U-factor (thermal transmittance), for solarium/sunroom systems.

5.6.1 Scope

To specify a method for determining the thermal transmittance (U-factor) of Non-residential fenestration systems, including site-built fenestration systems for Non-residential buildings.

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

5.6.2 Variations from Standard Product Lines

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

A. Framing Product Lines where grouping for Framing Product Lines is applied on a per cross-section basis, i.e. heads are compared to heads for grouping purposes. Multi-purpose cross-sections (e.g., heads, which can also serve as jambs, etc.) are also included in the Framing Product Line. All applicable sections are members of the same Framing Product Line. Membership in the Framing Product Line is judged based on comparison with the approved framing components used in the Standard Framing System Product.

B. 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;

C. Glazed wall support and framing systems;

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

E. Products with single or multiple glazing layers;

F. Products with spacer systems between glazings;

G. Horizontal, vertical, and sloped systems;

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

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

J. Spandrel Panels;

K. Non-residential products or systems not covered by Section 4.4, Table 4 of this standard;

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

5.6.3 Variations from Standard Individual Products

The following products and product configurations have special provisions:

A. Single glazed products

B. Double-sash products

5.6.4 Variations from Standard Simulation and Test Conditions

5.6.4.1 Simulation

All ratings shall be based on computer simulations that comply with ISO 15099 except for the following provisions:

A. Partially debridged thermal bridges, like poured-and-debridged thermal breaks, which are not fully debridged (i.e., skip and de-bridged frame sections), thermally slotted sections, etc. These situations shall be simulated following the procedure in Section 6.3.1 of ISO15099. For additional details see Reference [2].

B. For single glazed products, framing members shall be modeled using single glazing best and worst options, as detailed in section 5.6.5.3.

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

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

5.6.4.2 Simplifications to a Product Line

This section presents additional product line simplification rules specific to non-residential fenestration systems and site-built products.

5.6.4.2.1 Spacer

For the purpose of the CMA methodology, each spacer system assembly performance shall be provided in terms of its effective conductivity, k_{eff}.

The spacer system assembly consists of the spacer component, desiccant, and any applicable sealants. Three different paths are provided for the definition of the spacer component and corresponding spacer system assembly.

Each spacer component can be submitted by the spacer manufacturer and later made available for spacer system assembly under only one path. The Path selected for a specific spacer model may be revised by the spacer manufacturer at any given time. The spacer model values shall be removed from the original Path and be made available in the new Path in accordance with the acceptance procedures established for that specific Path.

Path I – Generic Spacer - Spacer System k_{eff}: (Default Spacer, Default Sealant, Default Geometry)

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

<u>Group 1 – Spacer containing aluminum</u>
If the spacer uses any aluminum in the design it shall be assigned a spacer system K_{eff} of 8.0 W/mC (0.096 Btu/hr-ft-F).

<u>Group 2 – Spacer containing mild steel (i.e. galvanized steel, tin-plated steel)</u>
If the spacer uses any mild steel in the design it shall be assigned a spacer system K_{eff} of 3.0 W/mC (0.036 Btu/hr-ft-F).

<u>Group 3 – Spacer containing stainless steel</u>
If the spacer uses any stainless steel in the design it shall be assigned a spacer system K_{eff} of 1.0 W/mC (0.012 Btu/hr-ft-F) .

<u>Group 4 – Spacer containing all non-metallic materials</u>
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 (0.006 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 - Spacer System k_{eff} : (Specific Spacer, Default Sealant, Limited Geometry)

The k_{eff} 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. The spacer shall be evaluated using generic sealant and desiccant materials to cover all sealant and desiccant materials (see table below).

B. Modeling of desiccant is applicable to only those spacer systems which separately add desiccant to the spacer bar.

C. The spacer is evaluated for each width available based on the drawings supplied by the spacer bar manufacturer at the maximum spacer height available from the manufacturer. If the spacer system does not incorporate secondary sealant, then the spacer system height is equal to spacer height.

D. The spacer system with the highest k_{eff} value shall be used to represent all spacer system geometries for this spacer bar. Only one k_{eff} is submitted for inclusion in the CMA database to represent a spacer system under this path.

Table 5.6.1

Generic Sealant and Desiccant Material Values

Generic Materials	**k (W/m-K)**	**k(Btu/hr-ft-F)**
Generic Sealant 1	0.25	0.144
Generic Sealant 2	0.40	0.231
Generic Desiccated matrix	0.29	0.168
Generic Desiccant bead	0.03	0.017

Path III – Detailed Spacer - Detailed Spacer System Calculation: (Specific Spacer, Specific Sealant, Detailed Spacer System Geometry)

The k_{eff} 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 under this path consists of spacer bar only. 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. The spacer system, consisting of the spacer component, desiccant, and any sealants, as appropriate, is generated when the spacer system composition and geometry is known.

D. The effective conductivity of such spacer system is calculated on demand using the values of 0.29 W/m-K for desiccated matrix and 0.03 W/m-K for desiccant bead, and shall be used in the whole fenestration product calculation.

E. As an option, the product may be evaluated and modeled with the generic sealant and (or) generic desiccant materials defined under Path II to limit the number of system configurations.

F. For the purpose of calculating the overall product rating at the standard NFRC size, the spacer system assemblies may be grouped with the spacer system assembly with the higher effective conductivity, which then becomes the group leader.

5.6.4.2.2 Frame

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

A. Frame Grouping

i. All grouping rules contained in Chapter 4 shall be permitted to be utilized with the calculation procedures of Section 5.6.

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 5.6.5 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.
6. Addition of internal frame web(s) to create additional frame cavities.

iv. The frame group leader shall be determined in accordance with Tables 5.6.2 to 5.6.4 based upon the dominant frame material.

Table 5.6.2

Frame Group Leader for 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
Change in PFD	Highest PFD
Surface Emissivity	Highest emissivity
Glazing inset relative to the exterior	Glazing location closest to the outside
Material wall thickness	Highest wall thickness
Addition of internal frame web(s) to create additional frame cavities	Maximum number of webs

Table 5.6.3

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
Change in PFD	Highest PFD
Glazing inset relative to the exterior	Glazing location closest to the outside
Material wall thickness	Highest/thickest wall
Addition of internal frame web(s) to create additional frame cavities	Minimum number of webs

Table 5.6.4

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
Change in PFD	Highest PFD
Glazing inset relative to the exterior	Glazing location closest to the outside

5.6.5 Calculation of Total Product Rating

5.6.5.1 Component Modeling Procedure

The U-factor of a fenestration product may vary by size. In order to provide a uniform rating procedure, as well as size specific information, the component modeling procedure, as described in this section, shall be used [as the primary method]. For the comparison rating of non-residential systems, the U-factor rating for model (standard) size per Table 1 is calculated. A U-factor rating for sizes other than standard size can be calculated for informational purposes when applicable.

5.6.5.2 Basic Product Line Model and Component information for calculation and Reporting of U-factors

U-factors shall be reported on a component basis for each frame assembly (i.e., sill, jambs, head, etc.), each spacer configuration, and each glazing system (center-of-glass). The U-factors for frame components shall be reported as U_f (i.e. frame U-factor) and U_e (i.e., edge-of-glass U-factor), using the four representative options (Low and High), as defined in Table 5.6.1, and which gives a template for reported U-factors.

5.6.5.3 Definition of the Low and High configurations

A total of four Low/High or L/H configurations are defined. These configurations are assembled from two different glazing options at the extreme of thermal performance and two spacer configurations at the extreme of thermal performance.

The glazing and spacers used in L/H configurations are defined as follows:

Low/High Glazing Systems

Single Glazing

- Low Glazing –Low-e -– U_{cog} = 3.24 W/m^2-K (0.57 Btu/hr-ft^2-F).
- High glazing –clear

Glass thickness standardized to 3mm (1/8”) for residential products and 6mm (1/4”) for commercial.

Insulating

- Low Glazing – Double glazed, dual Low-e -– U_{cog} = 0.45 W/m^2-K (0.08 Btu/hr-ft^2-F).
- High glazing – Double glazed clear Air.

Glass thickness standardized to 3mm (1/8”) for residential products and 6mm (1/4”) for commercial. Overall (nominal) thickness of Low/High glazing systems should match nominal thickness (± tolerance) of the real glazing systems (i.e. 19.1mm (3/4”); 22.2mm (7/8”); 25mm (1”); etc.) that the simulated product is designed for.

Low/High Spacer Systems (Not applicable to monolithic applications)

- Best Spacer – generic low conductivity spacer – k_{eff} = 0.01 W/m-K (0.006 Btu/hr-ft-F).
- High Spacer – generic high conductivity spacer – k_{eff} = 10.0 W/(m-K) (5.8 Btu/hr-ft-F).

- Spacer height standardized to 12.7 mm (1/2”).
- Spacer width variable in order to match gap width of Low/High glazing systems.

(a) b1 in Table 5.6.5: Low glazing with Low spacer

(b) b2 in Table 5.6.5: Low glazing with High spacer

(c) w1 in Table 5.6.5: High glazing with Low Spacer

(d) w2 in Table 5.6.5: High glazing with High Spacer

Table 5.6.5 - Template for Reporting Component U-factors

	Frame			
	w1	w2	b1	b2
U_f [W/m^{2}K] (Btu/hr-ft^2-ºF)				
U_e [W/m^{2}K] (Btu/hr-ft^2-ºF)				
PFD [mm] (inch)				

Center of Glass: U_c = W/m^2-K (Btu/hr-ft^2-ºF)

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

The quantities w1, w2, b1, and b2 are defined in Reference [15].

For each individual product, total fenestration product U-factors shall be reported for the specified configuration at the model size, as shown in Table 1 of NFRC 100. The calculation of this total product U-factor is done using procedure detailed in Reference [15].

5.6.5.4 Approved Total Fenestration Product U-factor Calculation Procedure

The total fenestration product U-factor calculation procedure shall be calculated as per procedure detailed in Reference [15].

Approved software shall be used for calculating the total fenestration product U-factor. NFRC approved software is listed in Reference [5].

Follow NFRC approved procedure for rounding the final result. The U-factor shall be reported to 0.05 W/(m^2-K) (0.01 Btu/h•ft^2•˚F). All variables used in the formula shall be expressed to at least three (3) significant decimal places.

5.6.5.5 Determining thermal transmittance (U-factor) for sloped glazing systems

All sloped glazing systems shall be rated for thermal performance characteristics at a slope of 20 degrees above the horizontal (See Skylights for more information).

5.6.5.6 Test Procedures

Framing components shall be tested as a whole product using an insulating glass package as selected by the manufacturer, according to NFRC 102 and according to all frame and validation grouping rules. Validation shall be determined by the equivalence criteria of section 4.7.1 of this document.

5.6.5.6.1 Validation Testing

Each Framing Product Line will require validation testing on a Standard Framing System Product using NFRC 102. The following conditions apply:

A. Test specimen size and configuration shall be as defined in Table 4-3.

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.

5.6.5.6.2 Validation of Framing Product Line

A. The product selected as the Standard Framing System Product shall have 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, monolithic, etc.)

B. The Framing Product Line is validated if the Standard Framing System Product has a tested U-Factor which meets the equivalence criteria in Table 4-4 when simulated in accordance with Section 5.6.5.

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

A. If a Framing Component within an Approved Framing Product Line is modified, the modified component becomes a new member of the Approved Framing Product line 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 Framing Product Line without additional validation testing if the new Framing Component is consistent with the definition of Framing Product Line.

5.6.5.7 Approved Total Fenestration Product U-factors for Non-Model Sizes

The procedure in Reference [15] and NFRC-approved software as defined in Section 5.6.5.2 shall be used to determine size-specific product indices.

References:

[15] **Curcija, D.C. 2003.** "*Component Model Approach In Modeling Non-Residential Fenestration Products*"