PART II

11.0 *[DCC Note: This should probably start from section 1, since it is Part II. Also, the first part should be labeled Part I]* Non Residential and High rise residential building fenestration products:

To specify methods for determining fenestration product U-factor (thermal transmittance), for fenestration product installed in non-residential and high-rise residential buildings, including fenestration products that are site assembled, or so called site-built products.

11.1 Purpose

To specify appropriate methods for determining the thermal transmittance (U-factor) and thermal performance characteristic of non-residential, high rise residential buildings, including site-built fenestration systems, commonly referred here as Commercial products.

Note: Reference Part 1 for additional terminology and procedures for determining thermal performance properties.

The ratings derived from this procedure may be used to compare thermal performance characteristics of commercial fenestration products 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 commercial fenestration product.

11.2 Scope

11.2.1 Commercial fenestration systems covered by this method include products that are listed in Table 1, including but not limited to:

11.2.1.1 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;

11.2.1.2 Glazed wall support and framing systems;

11.2.1.3 Products of any size and design;

11.2.1.4 Products with single or multiple glazing layers;

11.2.1.5 Products with spacer systems between glazings;

11.2.1.6 Horizontal, vertical and sloped systems;

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

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

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11.2.2 Systems not covered include totally opaque walls and products covered by part 1 of this standard.

11.3 Product Lines

This section presents additional product line details specific to commercial building fenestration products.

Composite window treatment: Composite window assembly shall be treated as a combination window assembly, consisting of individual products, unless the heat flow through the common frame members is different by more than 20% than the heat flow through the frame assemblies of individual products;

11.4 Individual Products

As defined in section 1.4.2

11.5 Baseline Products General

As defined in section 1.4.3

11.6 Simplifications to a Product Line

This section presents additional product line simplification rules specific to non-residential high rise commercial building fenestration products and site built products.

11.6.1 Center-of-glazing:

For the purpose of calculating overall product rating at the standard NFRC size, center of glass groupings may be done as per section 1.4.4.1

11.6.2 Spacer:

Each individual spacer shall be modeled to determine its effective conductivity. Two generic spacers, representing low and high end in thermal conductance are identified by their effective conductivity in section 6.0.

For the purpose of calculating overall product rating at the standard NFRC size, the spacers may be grouped with the spacer with the highest effective conductivity, which becomes the group leader.

For the purpose of component performance, each spacer assembly performance shall be provided in terms of its effective conductivity.

11.6.3 Divider:

For the purpose of calculating overall product rating at the standard NFRC size, divider groupings may be done as per section 1.4.4.1

11.6.4 Frame:

See section 1.4.4.1?? **This needs further work!**

11.6.5 Additions to a Product Line

See section 1.4.5? **Do we need anything else here??**

11.7 Standard Conditions and Requirements

This section presents standard simulations, tests, and calculations for determining total or component fenestration product U-factors. Read and follow Section 4 **(DCC remark: Section 4 are skylights!)**, Fenestration Product Thermal Properties, before performing any of the tests, simulations, or calculations identified in this section. **This is not clear. Need to be improved.**

11.7.1 Simulation Procedures

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

a) For calculating the overall U-factor, ISO 15099 offers a choice between the linear thermal transmittance (4.1.2) and the area weighted method (4.1.3). The area-weighted method (4.1.3) shall be used.

b) Frame and divider SHGC's shall be calculated in accordance with Section 4.2.2 of ISO15099. The alternate approach in section 8.6 shall not be used. [Note: current research is aimed at assessing which method is more accurate; at some point in the future, this recommendation may be revised.]

c) Material conductivities and emissivities shall be determined in accordance with the NFRC 101.

d) Section 7 on Shading Systems in ISO15099 is currently excluded from NFRC procedures.

e) The following environmental conditions shall be used:

For U-factor calculations:

T_{in} = 21 °C
T_{out} = -18 °C
V = 5.5 m/s
$T_{rm,out}=T_{out}$
$T_{rm,in}=T_{in}$
I_s=0 W/m^2

For SHGC calculations:

T_{in} = 24 °C

T_{out} = 32 °C
V = 2.75 m/s
$T_{rm,out}=T_{out}$
$T_{rm,in}=T_{in}$
I_s=783 W/m^2

f) On the indoor side of a fenestration product, detailed radiation model, based on grey body radiation model as described in section 8.4.2.1 (Two-Dimensional Element To Element View Factor Based Radiation Heat Transfer Calculation) in ISO15099, shall be used. Furthermore, in the interests of consistency and accuracy, this method shall be used for all products, including planar products, for U-factor calculations as well as CR calculations.

g) On the outdoor side of a fenestration product, black body radiation model, as defined in ISO15099 shall be used. This model applies to both glass and frame surfaces;

h) 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 shall be determined using the algorithms in ISO15099 and using representative frame surface temperatures for each frame material type;

i) The outdoor side convective heat transfer coefficient shall be calculated based on wind speed as defined under the sub clause e) and shall be applied to all of outdoor surface, glass and frame;

j) The use of detailed radiation model on indoor fenestration surfaces makes the use of Slightly or Partially Ventilated cavities (see section 6.7.1 of ISO 15099) on the indoor frame surfaces redundant. The standard frame convective film coefficients (hc) referenced in h) above and detailed radiation model referenced in f) above shall thus be applied to all interior frame surfaces.

k) The size glazing system that is modeled with each frame cross section will be 150 mm (6 in.) long. The size of the edge-of-glass region remains 63.5 mm (2.5 in.). Therefore, there will be region of 86.5 mm (3.5 in.), which will be included in a model, but the heat transfer in that region on indoor side would not be included in edge-of-glass U-factor calculation.

The U-factor of a fenestration product may vary by size. To provide uniform rating procedure, while still providing size specific information, component-rating procedure shall be used for commercial fenestration products. For information purposes and for the comparison of different products, the fixed size rating is also provided, when applicable. The fixed model sizes are provided in Table 1 of NFRC 100. Also refer to section 1.5.3 for more details about fixed size ratings.

For gas fills other than air, the gas fill percentages used in the simulations shall not exceed the values in Reference 3 for a given filling technique.

Non-continuous elements, including but not limited to screws and bolts in sloped glazing and poured-and-debridged thermal breaks which are not fully debridged, shall be simulated as indicated in section 6.3.1 in ISO15099. For additional details see also Reference 3.

Material conductivities shall be determined according to NFRC 101.

Revolving doors shall be simulated with the width dimension equal to the diameter of the revolving door. Rating to include the heat flow through the A_{pf} (i.e. the rough opening in the wall) from all components of the revolving door assembly (including door wings, walls and roof of the revolving door enclosure). Revolving doors are to be rated in the closed position (i.e. with the maximum number of enclosed cavities). The frame profiles required to model a revolving door are: head, sill, hub, and one jamb for even number of wings or two jambs for odd number of wings. Glazing shall be modeled with the distance between the glazings set to the average distance between them (for 4-wing door, [3.142 x (diameter/8)]). Separate ratings are required for various configurations (e.g. two, three and four wings).

11.7.2 Approved Center-of-Glazing Simulation Programs

Approved center-of-glazing software shall be used. NFRC approved software is listed in Reference 7.

11.7.3 Approved 2-D Heat Transfer Simulation Programs

Approved 2-D heat-transfer software shall be used. NFRC approved software is listed in Reference 7.

11.7.4 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]. The computer program for this procedure is in development stage and needs to be approved by NFRC.

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.

11.8 Test Procedures

NFRC 102 shall be used for determining the thermal performance of the total fenestration products and glazings. The total fenestration product test procedure shall be used to validate the product line simulations (see section 4.3) and shall be used under the testing alternative (see section 4.4), which shall be used only if U-factor for the product cannot be simulated in accordance with section 3.1. Section 3.2.2 defines a center-of-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 3.1

11.8.1 Total Fenestration Product Test Procedure

The NFRC 102 *Test Procedure for Measuring the Steady State Thermal Transmittance of Fenestration Systems* [Reference 2], shall be used to determine tested total fenestration product U-factors. The conditions from the section 1.5.2.1 of NFRC 100 also apply

11.8.2 Each Product Line shall have one baseline product be validated in accordance with Part 1, Section1 and 2, with the following exception:

11.8.3 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 by 2000 mm (a nominal 79 in. width and an 79 in. height), 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 1.6.1.1 .

11.8.4 **??**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.

11.8.5 For simulating and testing 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 1of this standard..

11.8.6 Center-of-Glazing Component Test Procedure

The procedure given in section 1.5.2.2 shall be used for this purpose.

11.9 Product Line Model Sizes and Configurations for Reporting of U-factors, SHGC and VT.

U-factors shall be reported for the total product at standard NFRC size and 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 as defined in section 11.16 Table 2 gives a template for reported U-factors.

Table 2. Template for Reporting Component U-factors, SHGC and VT.

	Frame			
	w1	w2	b1	b2
U_f [W/m^{2}K]				
U_e [W/m^{2}K]				
SHGC [-]				
VT [-]				
Pdf [m]				

Center of Glass: U_c =

Spacer: k_{eff} =

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, SHGC and VT is done using procedure detailed in Reference [15].

11.10 Representative Product Size for Testing of Production Line Fenestration Products

Representative sizes shall be determined as per section 1.5.4

11.11 Equivalent

Equivalence shall be determined as per section 1.5.5

11.12 Product Line Validated Simulation Procedure

(a) Determine representative size for validating U-factors from Table 1 and/or section 1.5.4.

(b) **Validation of simulation procedure**. If the simulated and tested U-factors for the baseline product are equivalent, as defined in Section 1.5.5, then the computational procedure presented in Section 11.7.1 shall be considered validated for all the products in the product line. The approved fenestration U-factor calculation procedure presented in Section 11.7.1 shall then be used to determine U-factors for all of the components and total products as defined in section 11.9. 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 1.5.5 then the alternative test procedure presented in Section 11.13 may be used for all products within the product line with written permission from NFRC. [***DCC Note: Alternative possible here; Instead of testing everything (nobody wants to do that), perhaps some correction factor for simulation could be proposed.]***

11.14 Total Fenestration Product U-factors for Non-Model Sizes

Procedure in Reference [15] and approved NFRC software as defined in section 11.7.4 shall be used to determine size specific product indices.

11.15 Custom Product Rating

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

A custom product shall be composed of unique frame/sash components not covered within an existing standard product line's U-factor matrix.

The specific configuration of a custom product shall not be offered publicly in a manufacturer's catalog or similar literature. Less than 500 units, or less than 10,000 ft^2 shall be produced annually, or if more than 500 units or 10,000 ft^2 are produced annually, they shall be produced as part of one purchase order. U-factors for custom products, which meet all three 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 their designated representative.

11.16 Definition of the Best/Worst (B/W) configurations

Total of four best/worst or B/W configurations is defined. These configurations are assembled from two different glazing options at the extreme of the thermal

performance and two spacer configurations at the extreme of thermal performance. The following are four B/W configurations:

(a) B/B (or b1 in Table 2): Best glazing with Best spacer
(b) B/W (or b2 in Table 2): Best glazing with Worst spacer
(c) W/B (or w1 in Table 2): Worst glazing with Best Spacer
(d) W/W (or w2 in Table 2): Worst glazing with Worst Spacer

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

11.17.1 All sloped glazing systems shall be rated for thermal performance characteristics at a slope of 20 degrees above the horizontal (See Part 1, Section 4 Skylights for more information).

11.18. Determining the thermal transmittance for solarium/sunroom systems

11.18.1 The thermal transmittance of solarium/sunroom systems shall be determined in accordance with Part II, Section 11.7.1. of this standard.

11.18.2 For simulating and testing site-built vertical glazed wall sections of solarium/sunroom systems, each Product Line shall have one baseline product be validated in accordance with Part II, Section 11.12, 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 by 2000 mm (a nominal 79 in. width and an 79 in. height), 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. There shall be no insulation of any type applied to the test specimen during validation testing. Validation will be achieved per Part II, Section 11.12.

11.18.3 Sloped glazing systems shall be rated in accordance with Section 11.17 utilizing sample construction as described in paragraph 11.18.2.

11.18.4 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 1, Part 1 of this standard, with glazing in accordance with Section 11.18.2

11.19. Determination of System Solar Heat Gain Coefficients and, Visible Light Transmittance Ratings

11.19.1 The system Solar Heat Gain Coefficient (SHGC) and Visible Light Transmittance (VT) ratings shall be determined in accordance with Section 11.9.

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INDEX