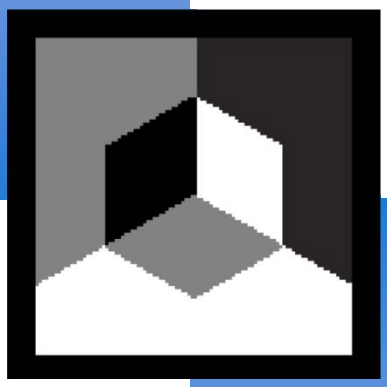
AMERICAN ARCHITECTURAL

AAMA 507-15

# Standard Practice for Determining the Thermal Performance Characteristics of Fenestration Systems in Commercial Buildings





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# TABLE OF CONTENTS


1.0 PURPOSE ..... 1
2.0 SCOPE ..... 1
3.0 REFERENCE DOCUMENTS.. ..... 2
4.0 TERMINOLOGY ..... 3
5.0 DETERMINATION OF PRODUCT LINES ..... 3
6.0 DETERMINATION OF SYSTEM SPECIFIC THERMAL PERFORMANCE CHARACTERISTICS.. ..... 3
7.0 DETERMINATION OF BUILDING SPECIFIC THERMAL PERFORMANCE CHARACTERISTICS ..... 8
8.0 EXAMPLES ..... 10
9.0 FENESTRATION PRODUCT RATING CERTIFICATE (IP).. ..... 17
10.0 FENESTRATION PRODUCT RATING CERTIFICATE (SI) ..... 18
APPENDIX A: CONSERVATIVE REPRESENTATIVE VALUES FOR GENERIC PRODUCTS ..... 19
APPENDIX B: RELATED FENESTRATION PERFORMANCE INDICES ..... 44


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# 1.0 PURPOSE

This document provides a uniform standard method for determining the thermal performance of building specific fenestration systems that are installed in commercial buildings. The following thermal performance characteristics are included in this document:

- Thermal Transmittance (U-factor)
- Solar Heat Gain Coefficient (SHGC)
- Visible Transmittance (VT)
- Air Leakage
- Condensation Resistance Factor (CRF)

# 2.0 SCOPE

**2.1** Fenestration affects building energy use through four basic mechanisms: thermal heat transfer, solar heat gain, visible transmittance and air leakage. Condensation resistance is considered not to affect energy use and is therefore not a concern of the building codes. However, CRF is an important thermal performance characteristic and is therefore included in this document.

***NOTE 1**: A CRF tool is available for public use on the AAMA website.*

(*http://www.aamanet.org/crfcalculator/1/334/crf-tool*)

**2.2** This document covers glazed fenestration systems such as windows, curtain walls, window walls, sloped glazing, storefronts, doors and other glazed products that are installed in commercial buildings (buildings other than low-rise residential buildings). For projecting elements that do not increase usable floor space, refer to the generalized equation in Section 7.1 and the specific building application.

**2.3** Products not covered by this standard include fenestration systems (windows, doors, skylights) intended for use in low-rise residential applications. Please see AAMA 1503 or NFRC 100 for determining the thermal performance ratings for these products.

**2.4** This document provides manufacturers, architects, builders and code authorities with a means to verify product thermal performance. National energy codes and standards relating to commercial buildings include:

- ASHRAE/IES Energy Code for Commercial and High-Rise Residential Buildings
- ASHRAE/IESNA 90.1 Energy Standard for Buildings Except Low-Rise Residential buildings
- IBC International Building Code
- IECC International Energy Conservation Code

**2.5** This document provides manufacturers, architects and builders with information on the energy performance of fenestration systems installed in commercial buildings. This information can be useful in determining overall building performance, occupant comfort and HVAC sizing. However, care must be taken when extrapolating such information from the product ratings developed in accordance with this standard. Product performance ratings are determined under standardized conditions, which may not represent the environmental conditions into which the product is installed.

**2.6** Energy use in commercial buildings is usually dominated by cooling loads. For this case, lower SHGC ratings for fenestration products are desirable. In recognition of this phenomenon, there are two rating methodologies presented herein for determining the solar heat gain coefficient of fenestration systems: a generic framing determination and a specimen specific determination. The generic rating provides a simple, conservative methodology that is very helpful in determining system design. The product specific rating utilizes the actual fenestration product framing system simulated and tested for U-factor determination.

**2.7** This document contains the following:

Section 3.0 provides a list of reference documents.

Section 4.0 provides definitions pertinent to this document.

Section 5.0 provides the methodology to determine and validate product lines.

Section 6.0 provides a method to determine U-factors, Solar Heat Gain Coefficients (SHGC), visible transmittance (VT) and Condensation Resistance Factors of specific fenestration systems

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Section 7.0 provides instruction on how to determine an overall building specific U-factor, SHGC and VT.

Section 8.0 provides examples for determining overall U-factors.

Section 9.0 provides the Fenestration Product Rating Certificate (IP format) that shall be used to demonstrate compliance with code requirements for U-factor, SHGC and VT.

Section 10.0 provides the same Fenestration Product Rating Certificate provided in Section 9, except in SI format.

Appendix A provides non-mandatory information for determining pre-calculated thermal performance values for four types of generic framing systems. The pre-calculated U-factors are conservative and may be used as an estimating tool in the early phases of design. It also defines and illustrates the four types of framing systems typically used in commercial fenestration systems and provides SHGC and Visible Transmittance (VT) of generic fenestration systems.

Appendix B provides test method references for air leakage and condensation resistance.

**2.8** The values stated in Inch-Pound (IP) units are to be regarded as the standard. Metric (SI) conversions are given in parenthesis. The SI values were rounded off to the significant digits. Therefore, the user of this document may find slight disagreement in values when converting from SI to IP units. For simplification and ease of reference, the examples given in Section 8.0 have been prepared using only the inch-pound convention.

**2.9** This document was developed in an open and consensus process and is maintained by representative members of AAMA as advisory information.

## 3.0 REFERENCE DOCUMENTS

**3.1** References to the standards listed below shall be to the edition indicated. Any undated reference to a code or standard appearing in the requirements of this standard practice shall be interpreted as referring to the latest edition of that code or standard.

**3.2 American Architectural Manufacturers Association (AAMA)**

**AAMA 1503-09**, Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections

**AAMA AG-13**, AAMA Glossary

**AAMA/WDMA/CSA 101/I.S.2/A440-11**, North American Fenestration Standard/Specification for windows, doors, and skylights

**3.3 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)**

**2013 ASHRAE Handbook** - Fundamentals

**1997 ASHRAE Handbook** - Fundamentals

**ANSI/ASHRAE/IES 90.1-2013**, Energy Standard for Buildings Except Low-Rise Residential buildings

**3.4 ASTM International (ASTM)**

**ASTM E283-04(2012)**, Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

**3.5 International Code Council (ICC)**

**IBC**, International Building Code, 2012

**IBC**, International Building Code, 2015

**IECC**, International Energy Conservation Code, 2012

**IECC**, International Energy Conservation Code, 2015

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**WINDOW/THERM**, NFRC Simulation

**3.7 National Fenestration Rating Council (NFRC)**

**ANSI/NFRC 100-2014**, Procedure for Determining Fenestration U-Factors

**NFRC 102-2010**, Procedure for Measuring the Steady-State Thermal Transmittance of Fenestration Systems

**ANSI/NFRC 200-2014**, Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Light Transmittance at Normal Incidence

**ANSI/NFRC 400-2014**, Procedure for Determining Fenestration Product Air Leakage

**NFRC Simulation Manual** (latest edition)

# 4.0 TERMINOLOGY

**4.1** Please refer to AAMA Glossary (AG-13) for all definitions except for those appearing below (which apply only to this voluntary standard).

**SPACER:** Insulating glass units generally have continuous spacers around the glass perimeter to separate the glazing and provide an edge seal. Two types of spacers are defined in this document: aluminum without a thermal barrier (hereafter referred to as aluminum) and insulating. Edge-of-glass U-factor is based on the type of spacer used in the insulating glass unit and the center-of-glass U-factor. The 1997 ASHRAE Handbook -Fundamentals defines the edge-of-glass U-factors for aluminum and insulating spacers by the following formulas:

Aluminum Spacer:
$U_{EOG} = 0.223 + 0.842U_{COG} - 0.153\ U_{COG}^2$

Insulating Spacer:
$U_{EOG} = 0.120 + 0.682U_{COG} + 0.244\ U_{COG}^2$

# 5.0 DETERMINATION OF PRODUCT LINES

A Product Line shall be tested for U-factor in accordance with NFRC 102 and simulated in accordance with NFRC 100. Typical product lines are differentiated by operator type, frame type and a set of basic frame/sash profiles (see Section A1.0). If a product line consists of several systems with different interior profiles that vary only in depth, the system with the highest U-factor (typically the unit with the greatest exposed interior surface area) shall be simulated and tested. If the fenestration system consists of several product lines in combination (mulled together), the system shall be simulated and tested as separate product lines. The baseline product shall be tested and simulated at the size(s) shown in NFRC 100. Simulated and tested U-factors for a given fenestration system shall be considered equivalent if the agreement between the two numbers is within the ranges given in NFRC 100.

***NOTE 2:*** *When Condensation Resistance Factor (CRF) is desired, users of this Standard Practice are advised to also consider testing in accordance with AAMA 1503 when testing to NFRC 102.*

# 6.0 DETERMINATION OF SYSTEM SPECIFIC THERMAL PERFORMANCE CHARACTERISTICS

### 6.1 THERMAL TRANSMITTANCE (U-FACTOR)

#### 6.1.1 Vision Area

The U-factor for the vision area of each framing system tested per Section 5.0 shall be modeled in accordance with the NFRC Simulation Manual including all applicable NFRC Technical Interpretations. If the simulation and test results are determined to be equivalent as prescribed in Section 5.0, a graph is constructed that gives the thermal performance for this specific framing with variations in glazing type and size. This is accomplished by computer simulations using any combination of low-e coatings and/or gas fills to establish center-of-glass U-factors ranging from:

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0.48 Btu/(ft$^2$·h·°F) [2.70 W/(m$^2$·°C)]
to
0.10 Btu/(ft$^2$·h·°F) [0.61 W/(m$^2$·°C)]

in increments of 0.02 Btu/(ft$^2$·h·°F) [0.11 W/(m$^2$·°C)]

***NOTE 3:*** *Center-of-glass U-factors below 0.20 Btu/(ft$^2$·h·°F) [1.14 W/(m$^2$·°C)] may require the addition of a suspended film within the IG unit, Vacuum Insulating Glass (VIG), or multiple low-e coatings in multi-cavity gas-filled insulating glass units.*

For systems that accommodate 1 in (25 mm) glazing, the frame shall be modeled with edge-of-glass conditions based on two panes of nominal 0.25 in (6 mm) glass with 0.5 in (12 mm) gap and standard aluminum spacer. Alternative spacers may be modeled in addition to the standard aluminum spacer. For systems that accommodate glazing other than 1 in (25 mm) infill, the glass shall be modeled accordingly with the center-of-glass U-factors ranging from the highest to the lowest in increments of 0.02 Btu/(ft$^2$·h·°F) [0.11 W/(m$^2$·°C)].

Simulations to generate the chart are based on the tested unit and shall be modeled in accordance with the NFRC Simulation Manual including all applicable technical interpretations.

For a given framing system and center-of-glass configuration, the relationship between U-factor and percent of vision area is linear. Therefore, it is only necessary to determine the U-factor for each glazing at two percentages of vision area. Using NFRC approved simulation tools, the system U-factor is determined at 70% vision area and 95% vision area utilizing the same glass aspect ratios as in the test.

If the product vision area falls outside these bounds, vision area ratios shall be expanded or shifted to account for the appropriate frame/glass ratio. Once these two points have been established the straight line is calculated using the equation:

*U-factor = Intercept + Slope x (percentage of vision area)*

This equation is established for each center-of-glass U-factor and a graph is constructed for percentage of vision to frame areas between 70% and 95% (or other percentages if more appropriate for the product). It is important to note that NFRC defines vision area as the total center-of-glass area plus the edge-of-glass area which extends to the gasket edge or framing sightline. This document defines vision area as the area of glass extending to the primary frame or sash members; therefore it is not necessary for the user of this document to know how much the gasket extends over the glass. The vision area U-factor charts are to be prepared in a manner that follows the NFRC simulation rules while accounting for vision area as defined in this document.

For product comparison and for generating the Fenestration Product Rating Certificate given in Section 9.0, a matrix shall be provided utilizing the same center-of-glass increments to obtain various system U-factors. This matrix shall be based on the test unit size utilizing NFRC simulations including applicable Technical Interpretations. This matrix shall be generated by an NFRC accredited simulation laboratory. As an alternative, this matrix shall be generated by an NFRC Independent Approved Calculation Entity (ACE) organization utilizing approved frame, glass and spacer components within the NFRC CMAST program. See Section 8.4 for example matrix. For informational purposes, the vision area to total area ratio used in the matrix shall be noted on the chart.

### 6.1.2 Spandrel Area

The U-factor for the spandrel area of each framing system tested per Section 5.0 shall be modeled in accordance with the NFRC Simulation Manual including all applicable NFRC Technical Interpretations. A graph is constructed that gives the thermal performance for this specific framing system with variations in the spandrel insulation and in percentage of spandrel. This is accomplished by simulating the edge and center of spandrel with insulation. It is assumed that the spandrel insulation does not cover the framing members, is flush with the 0.25 in (6 mm) glass and has a foil facing exposed to the interior. At a minimum, the spandrel insulation shall be based on the following R-values and (thicknesses):

| (ft2·h·°F)/Btu | (m2·°C)/W |
|---|---|
| 2 (0.62 in) | 0.35 (16 mm) |
| 3 (1 in) | 0.53 (25 mm) |
| 4 (1.25 in) | 0.70 (32 mm) |
| 5 (1.5 in) | 0.88 (38 mm) |
| 11 (3.5 in) | 1.94 (89 mm) |
| 15 (4.5 in) | 2.64 (114 mm) |
| 19 (6 in) | 3.34 (152 mm) |
| 30 (9.5 in) | 5.28 (241 mm) |

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For systems that accommodate glazing other than 0.25 in (6 mm) monolithic spandrel infill, the frame shall be modeled accordingly.

Simulations to generate the chart are based on the tested unit and shall be modeled in accordance with the NFRC Simulation Manual including all applicable Technical Interpretations.

For a given framing system and spandrel insulation, the relationship between U-factor and percent of spandrel area is linear. Therefore, it is only necessary to determine the U-factor for each insulation option at two percentages of spandrel area. Using NFRC approved simulation tools, the system U-factor is determined at 70% spandrel area and 95% spandrel area utilizing the same infill aspect ratio as in the test.

If the product spandrel area falls outside these bounds, the spandrel area shall be expanded or shifted to account for the appropriate frame/spandrel ratio. Once these two points have been established, the straight line is calculated using the equation:

*U-factor = Intercept + Slope x (percentage of spandrel area).*

This equation is established for each center-of-glass R-value and a graph is constructed for percentage of spandrel to frame areas between 70% and 95% (or other percentages if more appropriate for the product). It is important to note that this document defines spandrel area as the area of spandrel extending to the primary frame or sash members; therefore it is not necessary for the user of this document to know how much the gasket extends over the spandrel. The spandrel area R-value charts are to be prepared in a manner that follows the NFRC simulation rules while accounting for spandrel area as defined in this document.

### 6.2 SYSTEM SPECIFIC SOLAR HEAT GAIN COEFFICIENT (SHGC)

If the system specific SHGC ratings for a fenestration system are specified, they shall be determined in accordance with NFRC 200. For a given glass type, the relationship between SHGC and percent of vision area is linear. A graph shall be constructed utilizing center-of-glass SHGC ranging from 0.05 to 0.75 in 0.05 increments. The SHGC for each glazing option is determined at 70% vision area and 95% vision area utilizing the same infill aspect ratio as in the test.

If the product vision area falls outside these bounds, vision area ratios shall be expanded or shifted to account for the appropriate frame/glass ratio. Once these two points have been established, the straight line is calculated using the equation:

*SHGC = Intercept + Slope x (percentage of vision area).*

This equation is established for each center-of-glass SHGC and a graph is constructed for percentage of vision to frame areas between 70% and 95% (or other percentages if more appropriate for the product). It is important to note that NFRC defines vision area as the total center-of-glass area plus the edge-of-glass area which extends to the gasket edge or framing siteline. This document defines vision area as the area of glass extending to the primary frame or sash members; therefore it is not necessary for the user of this document to know how much the gasket extends over the glass. The SHGC charts are to be prepared in a manner that follows the NFRC simulation rules while accounting for vision area as defined in this document.

For product comparison and for generating the Fenestration Product Rating Certificate given in Section 9.0, a matrix shall be provided utilizing the same center-of-glass SHGC increments to obtain various system SHGC. This matrix will be based on the test unit size, utilizing NFRC simulations including all applicable Technical Interpretations. This matrix shall be generated by an NFRC accredited simulation laboratory. As an alternative, this matrix shall be generated by an NFRC Independent Approved Calculation Entity (ACE) Organization utilizing approved frame, glass and spacer components within the NFRC CMAST program. This matrix will be based on the test unit size utilizing NFRC simulations including applicable technical interpretations. See Section 8.5 for an example matrix.

If system specific ratings are not required for SHGC, see Section A3.0 (Determination of Solar Heat Gain Coefficient (SHGC) and Visible Transmittance (VT)).

### 6.3 SYSTEM SPECIFIC VISIBLE TRANSMITTANCE (VT)

If the system specific VT ratings for a fenestration system are specified, they shall be determined in accordance with NFRC 200. For a given glass type, the relationship between VT and percent of vision area is linear. A graph shall be constructed utilizing center-of-glass VT ranging from 0.05 to 0.75 in 0.05 increments. The VT for each glazing option is determined at 70% vision area and 95% vision area utilizing the same infill aspect ratio as in the test.
If the product vision area falls outside these bounds, vision area ratios shall be expanded or shifted to account for the appropriate frame/glass ratio. Once these two points have been established, the straight line is calculated using the equation:

*VT = Intercept + Slope x (percentage of vision area).*

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This equation is established for each center-of-glass VT and a graph is constructed for percentage of vision to frame areas between 70% and 95% (or other percentages if more appropriate for the product). It is important to note that NFRC defines vision area as the total center-of-glass area plus the edge-of-glass area which extends to the gasket edge or framing siteline. This document defines vision area as the area of glass extending to the primary frame or sash members; therefore it is not necessary for the user of this document to know how much the gasket extends over the glass. The VT charts are to be prepared in a manner that follows the NFRC simulation rules while accounting for vision area as defined in this document.

For product comparison and for generating the Fenestration Product Rating Certificate given in Section 9.0, a matrix shall be provided utilizing the same center-of-glass VT increments to obtain various system VT. This matrix will be based on the test unit size, utilizing NFRC simulations including all applicable Technical Interpretations. This matrix shall be generated by an NFRC accredited simulation laboratory. As an alternative, this matrix shall be generated by an NFRC Independent Approved Calculation Entity (ACE) Organization utilizing approved frame, glass and spacer components within the NFRC CMAST program. This matrix will be based on the test unit size utilizing NFRC simulations including applicable technical interpretations. See Section 8.6 for an example matrix.

If system specific ratings are not required for VT, see Section A3.0 (Determination of Solar Heat Gain Coefficient (SHGC) and Visible Transmittance (VT)).

### 6.4 SYSTEM SPECIFIC CONDENSATION RESISTANCE FACTOR (CRF)

If the system specific Condensation Resistance Factor (CRF) ratings are specified they shall be provided by physical testing per AAMA 1503 or alternately a graphical projection of the system specific Condensation Resistance Factor (CRF) shall be provided as follows:

The CRF graph will consist of three lines: CRF-glass, CRF-frame (low conductivity spacer), CRF-frame (high conductivity spacer). In order to generate the CRF graphs the CRF-frame and CRF-glass results from two AAMA 1503 tests shall be required. The two test units shall be representative of the full range of expected insulating glass unit performance, excluding products with interior surface Low-E coatings.

Test Unit #1 – IGU with lowest expected center-of-glass U-Factor and lowest expected effective conductivity spacer.

Test Unit #2 - IGU with highest expected center-of-glass U-Factor and highest expected effective conductivity spacer.

The range tested shall represent actual spacers which may be used in the product and do not need to cover the entire possible range of options. However, extrapolation of frame CRF shall not exceed 10% of the conductivity of the best or worst performing spacer.

The center-of-glass U-Factor and spacer effective conductivity shall be determined using methods prescribed in the NFRC Simulation Manual and NFRC 100.

The CRF-glass line shall be plotted using the center-of-glass U-Factors and the CRF-glass for each of the two test units.

The CRF-frame (low conductivity spacer and high conductivity spacer) lines are straight lines at the CRF-frame values for the test unit with the corresponding spacer.

Since System CRF is represented by the lower of the two CRF values (frame and glass) for a given unit, the intersection of the frame and glass lines shall be determined. For any given center-of-glass U-Factor, the higher of the CRF-frame or CRF-glass lines should be shown as a dotted line (unachievable result for the system at that COG U-Factor). The lower of the two lines shall be shown as a solid line (controlling CRF component). The spacer effective conductivity shall be included on the chart.

For spacers that are not on either extreme represented on the graph, the effective conductivity of the third spacer shall be determined via simulation. A CRF-frame line can be linearly interpolated between the two lines on the chart using the effective conductivity of the three spacers.

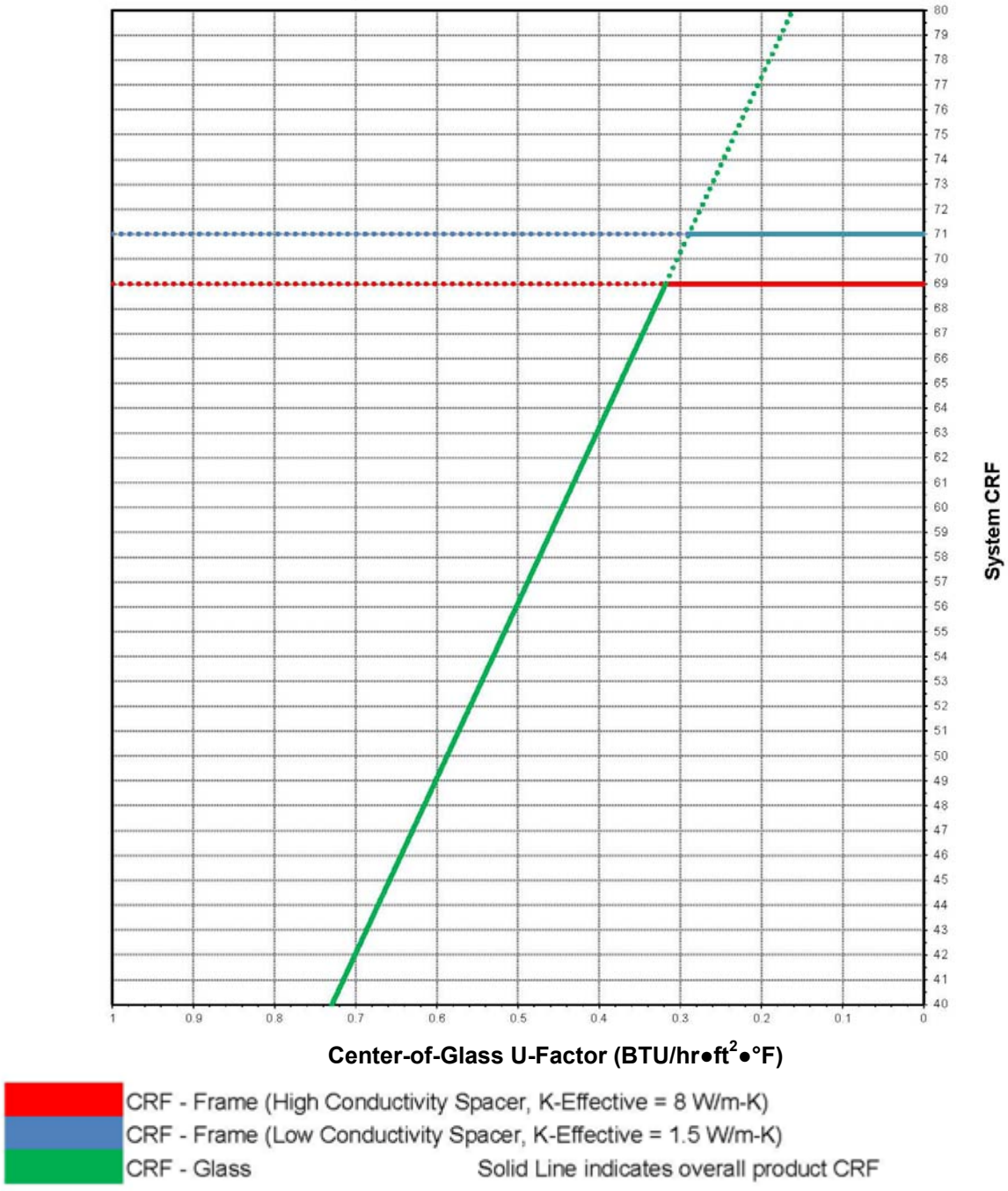
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**Company ABC**

**Storefront, Front IG (Clear-Al Spacer & Low-e Argon Warm Edge)**

**System CRF vs. Center-of-Glass U-Factor**




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# 7.0 DETERMINATION OF BUILDING SPECIFIC THERMAL PERFORMANCE CHARACTERISTICS

## 7.1 THERMAL TRANSMITTANCE (U-FACTOR)

An estimate of the overall U-factors for a specific building is determined by the area-weighted U-factor from each component. This is accomplished by utilizing Sections 7.1.1, 7.1.2 and 7.1.3, which define actual U-factors depicted in a chart format developed from the generalized area-weighted equation given below.

$$U_O = (U_{COG}A_{COG} + U_{EOG}A_{EOG} + U_FA_F)/A_{PF}$$

*Where:*

$U_O$ = *U-factor (overall)*
$U_{COG}$ = *U-factor (center-of-glass)*
$A_{COG}$ = *Area (center-of-glass)*
$U_{EOG}$ = *U-factor (edge-of-glass)*
$A_{EOG}$ = *Area (edge-of-glass)*
$U_F$ = *U-factor (frame)*
$A_F$ = *Area (frame)*
$A_{PF}$ = *Total area (The area of the rough opening in the building envelope, for the fenestration product, less installation clearances)*

### 7.1.1 Vision Area

In order to determine the U-factor for the vision area of a specific building, it is first necessary to know the center-of-glass U-factor and the percent of vision area to total vision area. Enter the chart on the horizontal axis at the appropriate percentage of vision area to total area. Project a line vertically until it intersects with the center-of-glass U-factor for the building. Project a line horizontally until it intersects with the vertical axis. This intersection will indicate the system U-factor for the vision area. Interpolation or extrapolation is permitted within the chart. Center-of-glass U-factor is determined using the latest Optical Data Library for WINDOW and is typically given in the glass manufacturer's data as winter time (night) U-factor.

### 7.1.2 Spandrel Area

In order to determine the U-factor for the spandrel area of a specific building, it is first necessary to know the R-value of the spandrel insulation and the percent of spandrel area to total area. Enter the chart on the horizontal axis at the appropriate percentage of spandrel area to total area. Project a line vertically until it intersects with the R-value of the spandrel insulation for the building. Project a line horizontally until it intersects with the vertical axis. This intersection will indicate the system U-factor for the spandrel area. Interpolation or extrapolation is permitted within the chart. For the case where the spandrel insulation covers the framing members, the full R-value for the insulation shall be applied to the entire spandrel area.

### 7.1.3 Combined Vision and Spandrel

For fenestration systems that have a combination of vision and spandrel areas in a single elevation, such as in a curtain wall, the vision and spandrel portions must be determined separately. In this case, the total area for both the vision and spandrel portions must be calculated based on the centerline of those framing members that are common to both the vision and spandrel areas. If a single U-factor is required for an elevation that contains both vision and spandrel, it shall be determined by area weighting the respective U-factors to the total area of the entire assembly. See Figure 5 for an illustration of combined vision and spandrel.

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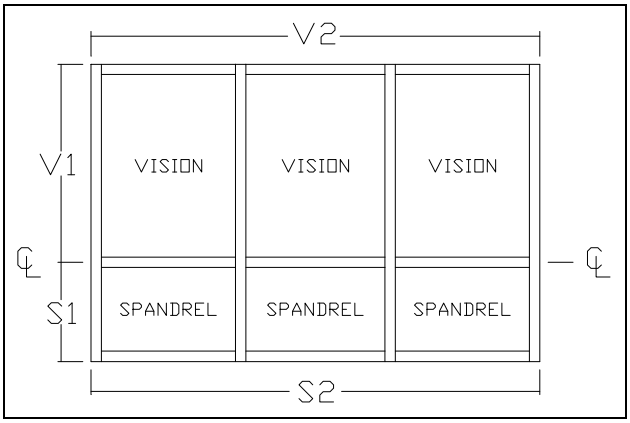



**FIGURE 5**

Total Area (Vision Glazing + Frame) = (V1 X V2)
Total Area (Spandrel + Frame) = (S1 X S2)
Total Area (Assembly) = (V1 + S1) V2 or S2

**7.2** For the SHGC for a specific building, it is first necessary to determine the center-of-glass SHGC based on the latest edition of the Optical Data Library for WINDOW and percent vision area. The SHGC for the fenestration system is determined from the graph in Section A3.1 or from system specific graphs as determined in accordance with Section 6.2.

**7.3** For the VT for a specific building, it is first necessary to determine the center-of-glass VT based on the latest edition of the Optical Data Library for WINDOW and percent vision area. The VT for the fenestration system is determined from the graph in Section A3.2 or from system specific graphs as determined in accordance with Section 6.3.

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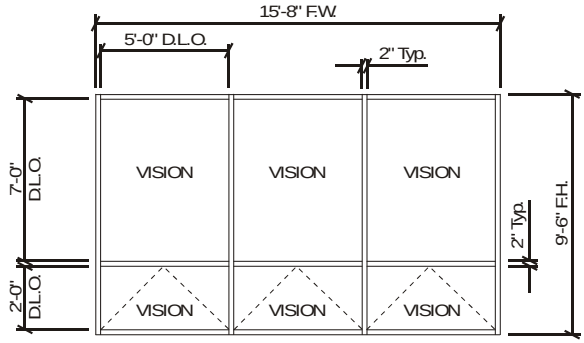
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# 8.0 EXAMPLES

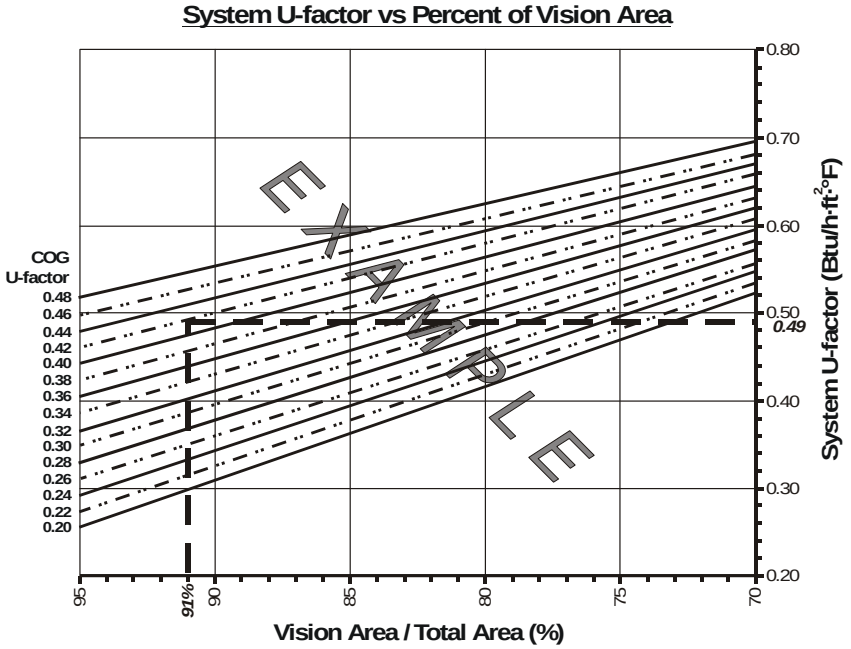
Examples are based on specific systems and fenestration configurations.

### 8.1 VISION AREA

Project Specified U-Factor - Example Calculation
(Based on entire elevation)




| | |
|---|---|
| Example Glass U-factor | = 0.42 Btu/ft$^2$· h ·°F |
| Vision Area | = 3(5' x 7') + 3(5' x 2') = 135.0 ft$^2$ |
| Total Area | =15'-8" x 9'-6" = 148.8 ft$^2$ |
| Percent of Vision Glass | = (Vision Area ÷ Total Area)100<br>= (135.0 ÷ 148.8)100 = 91% |




Based on an elevation comprised of 91% vision glass and center-of-glass U-factor of 0.42, system U-factor is equal to 0.49 Btu/h•ft$^2$•°F.

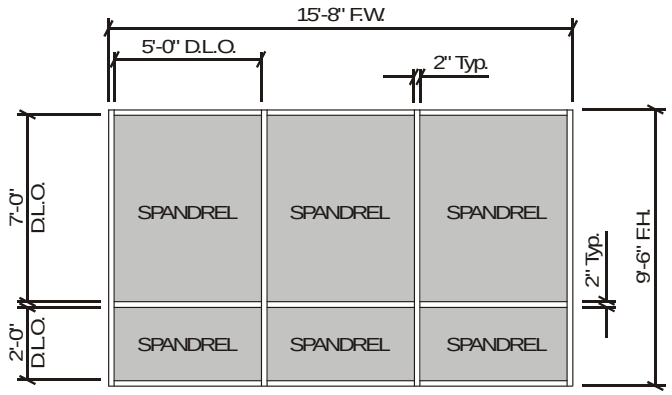
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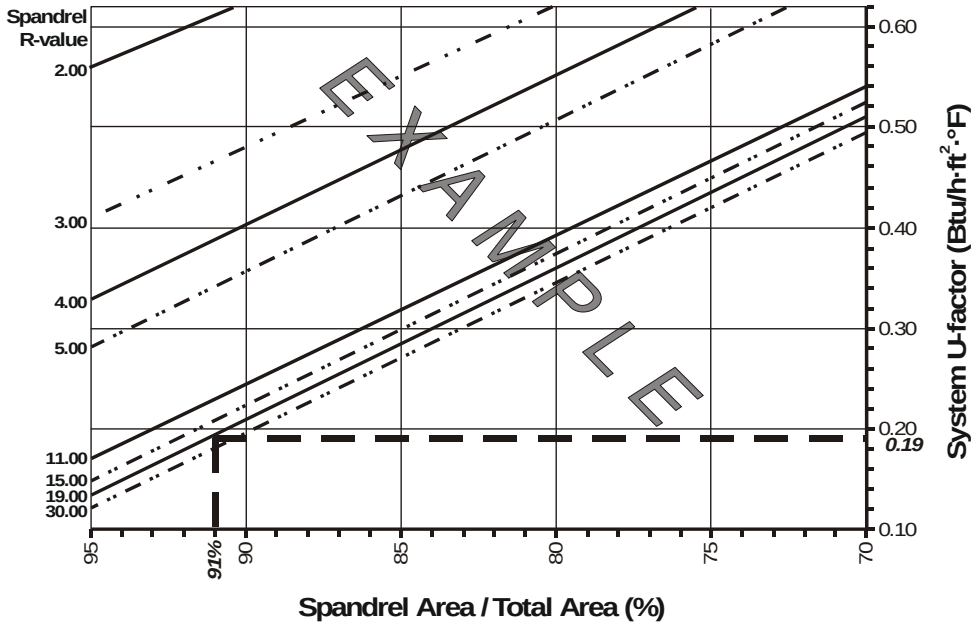
**8.2 SPANDREL AREA**

Project Specified U-Factor - Example Calculation
(Based on entire elevation)




| | |
|---|---|
| Example Spandrel R-value | = 19 $ft^2 \cdot h \cdot °F/Btu$ |
| Spandrel Area | = 3(5' x 7') + 3(5' x 2') = 135.0 $ft^2$ |
| Total Area | = 15'-8" x 9'-6" = 148.8 $ft^2$ |
| Percent of Spandrel | = (Spandrel Area ÷ Total Area)100<br>= (135.0 ÷ 148.8)100 = 91% |

**System U-factor vs Percent of Spandrel Area**




Based on an elevation comprised of 91% vision glass and center of spandrel R-value of 19, system U-factor is equal to 0.19 Btu/h•$ft^2$•°F.

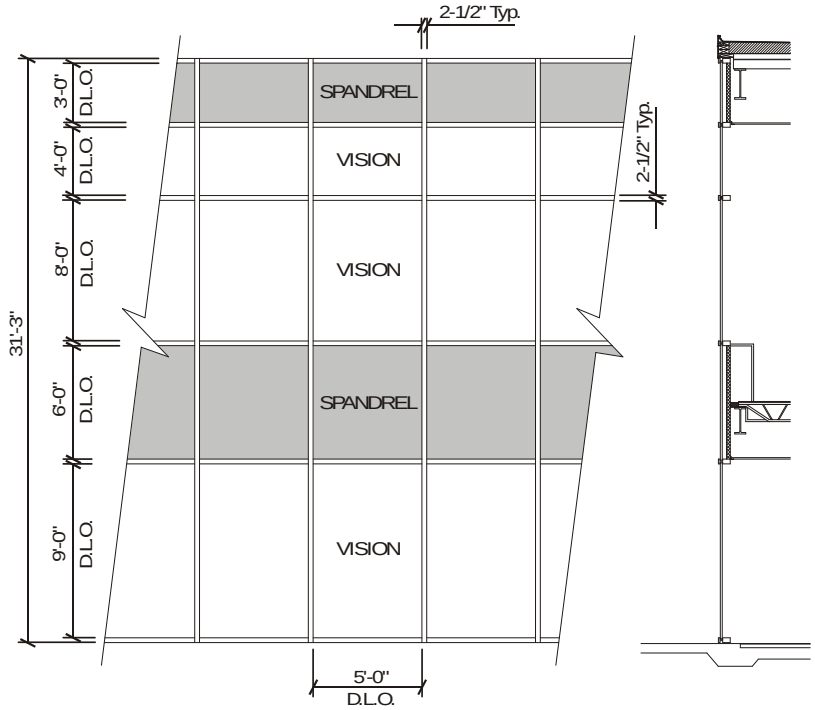
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## 8.3 COMBINED VISION & SPANDREL

Project Specified U-Factor - Example Calculation
(Based on entire elevation)




**8.3.1** Vision Area

| | |
|---|---|
| Example Glass U-factor | = 0.28 Btu/h•ft$^2$•°F |
| Vision Area | = 5 (9+8+4) = 105 ft$^2$ |
| Total Area (Vision) | = 5’ 2½” (9’ 3¾” + 8’ 2½” + 4’ 2½”) = 113.2 ft$^2$ |
| Percent of Vision Glass | = (Vision Area + Total Area) 100 |
| | = (105 / 113.2) 100 = 93% |

8.3.2 Spandrel Area

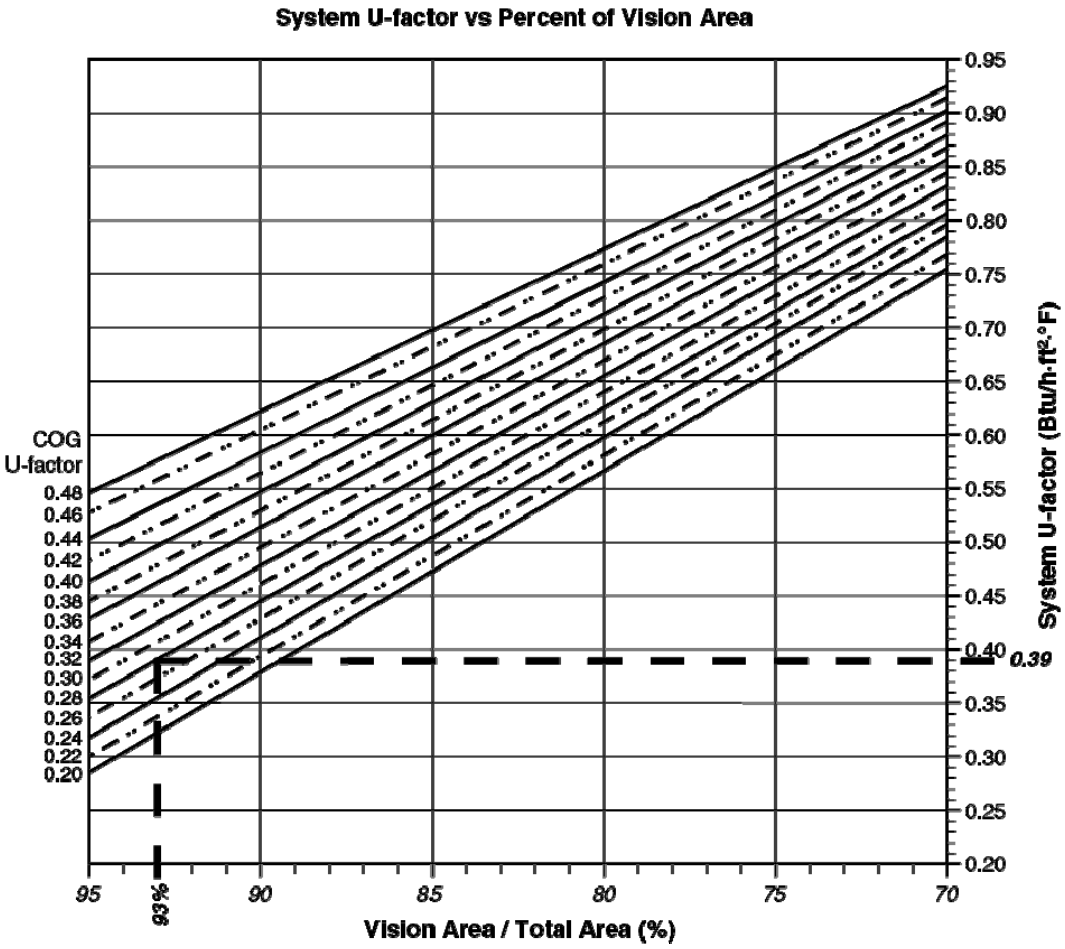
| | |
|---|---|
| Example Spandrel R-value | = 0.15ft$^2$•h•°F |
| Spandrel Area | = 5 (6 + 3) = 45 ft$^2$ |
| Total Area (Vision) | = 5’ 2½” (6’ 2½” + 3’ 3¾”) = 49.6 ft$^2$ |
| Percent of Vision Glass | = (Spandrel Area + Total Area) 100 |
| | = (45 /49.6) 100 = 91% |

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Vision Area Chart




Based on a single curtain wall bay of 93% vision glass and center-of-glass U-factor of 0.28, system U-factor is equal to 0.39 Btu/h•ft$^2$•°F

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