

# Pre-Read document

## Window Labelling and Certification program

**Bureau of Energy Efficiency**

Government of India



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**INTRODUCTION:** The windows and fenestrations are considered the crucial parts of building envelope concerning of the energy efficiency and the indoor comfort conditions. Considering the ever increasing demand on low energy consumption, more and more attention is to be paid to enhance the thermal insulation of the critical component of buildings, which are the windows, doors skylight – in generic term Fenestration. The requirement of efficient fenestration has brought about both a wide variety of energy conserving window design and the need to analyze window heat transfer under diverse environmental conditions.

The energy performance of a fenestration product can be described by three parameters: the total thermal transmittance (U-value), the total solar energy transmittance and the total light transmittance. The thermal transmittance of the fenestration is based on the thermal transmittance of the frame the glazing and the linear transmission co-efficient in the assembly between the framing and glazing. To collectively portray the overall energy performance of window, the following energy performance parameters of windows are used.

- i) Window U-value or U-factor ( the insulating value )
- ii) Solar heat gain coefficient ( the heat gain from solar radiation )
- iii) Visible light transmittance ( light transmitted through the glass )
- iv) Air infiltration ( air leakage through window )

The U-factor is the standard way to quantify insulating value. It indicates the rate of heat flow through the fenestration product. The U-factor is the total heat transfer coefficient of the fenestration system, in  $W/m^2\text{-}^\circ C$  ( $Btu/hr\text{-}ft^2\text{-}^\circ F$ ), which includes conductive, convective, and radiative heat transfer for a given set of environmental conditions. It therefore represents the heat flow per hour, in Watts (Btu per hour) through each square meter (square foot) of fenestration product for a  $1^\circ C$  ( $1^\circ F$ ) temperature difference between the indoor and outdoor air temperature. The smaller the U-factor of a material, the lower the rate of heat flow. The total R-value, which measures thermal resistance, is the reciprocal of the total U-factor ( $R=1/U$ ).The U-factor depends on the thermal properties of the materials in the fenestration product assembly, as well as the weather conditions, such as the temperature differential between indoors and outside, and wind speed.

The second major energy performance characteristic of fenestration products is the ability to control solar heat gain through the glazing. Solar heat gain through fenestration products tends to be the single most significant factor in determining the air-conditioning load of a residential building. The intensity of heat gain from solar radiation can greatly surpass heat gain from other sources, such as outdoor air temperature or humidity. There are two means of indicating the amount of solar radiation that passes through a fenestration product. These are solar heat gain coefficient (SHGC) and shading coefficient (SC). In both cases, the solar heat gain is the combination of directly transmitted radiation and the inward-flowing portion of absorbed radiation. However, SHGC and SC have a different basis for comparison or reference. The SHGC value is Calculated for NFRC rating and certification.

The third and the major energy performance characteristic of fenestration is Visible transmittance is the amount of light in the visible portion of the spectrum that passes through a glazing material. This property does not directly affect heating and cooling loads in a building, but it is an important factor in evaluating energy-efficient fenestration products. Transmittance is influenced by the glazing type, the number of layers, and any coatings that might be applied to the glazings. Visible transmittance is an important factor in providing daylight, views, and privacy, as well as in controlling glare and fading of interior furnishings. These are often contradictory effects: a high light transmittance is desired for view out at night, but this may create glare at time.

The fourth factor of heat loss and gain occur by infiltration through cracks in the window assembly. It is indicated by an air leakage rating (AL) expressed as the equivalent cubic feet of air passing through a square foot of window area. The lower the AL, the less air will pass through cracks in the window assembly. At this time, the AL is optional among NFRC ratings. For code compliance purposes, however, air infiltration is often tested in accordance with the North American Fenestration Standard (NAFS), which produces similar results to the NFRC air leakage rating.

### **Window Energy Ratings systems – Global trends:**

Windows being the major area of energy losses in any building, improving their performance would have a substantial impact on energy use and comfort. Considering the energy losses in 2001 eight countries joined a SAVE project in order to develop a window energy rating system for all of Europe, European Window Energy Rating System (EWERS). The window energy rating system and the associated labeling system is not simply a British idea. It is place in the USA, Canada and Australia & New Zealand as well as other countries. Energy rating system was promoted to recognizes energy efficient products, it provides a clear and unambiguous choice between good products and poor products and acts as a driving force for improved energy efficiency by clearly stating the relative efficiency of each product and will help consumers, dealers, architects and other decision makers in the building sector to choose the most energy efficient windows.

### **Existing regulatory structures for window rating systems:**

The first systems to be developed were those in Canada (ER or Energy Rating) and the USA (National Fenestration Rating Council). The original aim of those schemes was, and remains, to quantify the amount of heat loss or heat gain through fenestration products. Rating procedures include the effect of frames and air infiltration. This enables comparison with other elements of the building such as walls, roofs, floors and insulation products and is driven largely by the desire to reduce the heating and cooling energy used by conditioned buildings. Products are rated under fixed, reference environmental conditions.

## AUSTRALIAN RATING



**Heating Band:**  
Where windows are required to keep heat in

**Cooling Band:**  
Where windows are required to keep heat out

## NEW ZEALAND RATING

### Windows To Keep You Cool

Number Of Stars	Indicative Improvement*
NIL	0
★	12%
★★	24%
★★★	36%
★★★★	48%
★★★★★	60%

**New Zealand winter rating**

### Windows To Keep You Warm

Number Of Stars	Indicative Improvement*
NIL	0
★	9%
★★	18%
★★★	27%
★★★★	36%
★★★★★	45%

**New Zealand summer rating**

## Window Energy Rating Scheme (WERS) – Australia & New Zealand

The Australasian Window Council Inc (AWC) was formed for the window products industry in Australian and New Zealand for the introduction of new technology, new standards and programs across the industry. The Window Energy Rating Scheme, WERS, enables residential windows to be rated and labeled for their annual energy impact on a whole house, in any climate of Australia. A New Zealand variant of WERS, is the 'Window Efficiency Rating Scheme. To participate in WERS, window makers must obtain energy ratings for their products from a rating organization that is accredited by the Australasian Window Council (AWC). The AWC is the peak body for the window products and components industry in Australia and New Zealand.

The Window Energy Rating Scheme (WERS) is a 10-star rating system that ranks windows in terms of their annual energy performance and provides certified data. It is developed by the Australian window and glass industries with assistance from the Australian Greenhouse Office, WERS enables whole residential windows to be energy-rated and labeled a manufactured products. Data is produced for U-value, SHGC, visible transmittance, fading transmittance and air infiltration. Generally, all but the last can be simulated with computer software. However, air infiltration must be measured in a test laboratory using a procedure that complies with AS 2047.

WERS also rated windows for their typical, annual energy impact on a whole house, in any climate of Australia. The annual energy ratings are expressed in the form of two star ratings on a five-star scale – one for heating (winter) performance and one for cooling (summer) performance. The energy properties of a window are an area weighted average of the corresponding properties of its component parts or regions. These parts are the:

- Centre-of-glass
- Edge-of-glass
- Frame

## NFRC label, USA




 <b>World's Best Window Co.</b> Millennium 2000+ Vinyl-Clad Wood Frame Double Glazing • Argon Fill • Low E Product Type: Vertical Slider	
ENERGY PERFORMANCE RATINGS	
U-Factor (U.S./I-P)	Solar Heat Gain Coefficient
<b>0.35</b>	<b>0.32</b>
ADDITIONAL PERFORMANCE RATINGS	
Visible Transmittance	Air Leakage (U.S./I-P)
<b>0.51</b>	<b>0.2</b>
Condensation Resistance	
<b>51</b>	<b>—</b>
<small>Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information. www.nfrc.org</small>	

## National Fenestration Rating Council NFRC :United States of America

NFRC has successfully developed a rating system and certification program for the thermal performance of residential fenestration products, including windows, patio doors and skylights. This Rating System is a procedure for determining the thermal transmittance ("U-factor") of a product. The U-factor rating procedure is supplemented by procedures for rating products for solar heat gain coefficient ("solar heat gain" or "SHGC"), visible transmittance ("VT"), air leakage ("AL"), and condensation resistance ("CR"). Together, these rating procedures, are known as the NFRC Rating System. The Rating System employs computer simulation and physical testing by NFRC-accredited laboratories to establish performance ratings for fenestration products. NFRC algorithms and calculations follow the ISO 15099 Standard and use the Window, Optics and Therm software tools. Those tools are in a state of continuous development and improvement by Lawrence Berkeley National Laboratory, which is part of the University of California at Berkeley. The NFRC is developing a rating for the 'comfort impact' of windows. It will seek to rank windows in terms of their effect on the thermal comfort of people nearby. It will take account of glass surface temperature, solar heat gain and tendency to generate draughts.

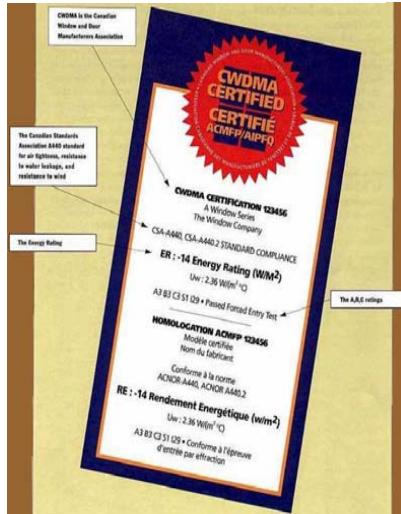
## British Fenestration Rating Council (BFRC) : European Countries

### European Union Window labeling

<b>Energy Window</b> Energy Windows Ltd XYZ 68/abc	
	
Energy Index (kWh/m <sup>2</sup> /year) <small>(Energy Index certified by BFRC and based on UK standard window. The actual energy consumption for a specific application will depend on the building, the local climate and the indoor temperature)</small>	<b>- 14</b>
The climate zone is:	<b>UK</b>
Thermal Transmittance (U <sub>trans</sub> ) Solar Factor (g <sub>trans</sub> ) Effective Air Leakage (L <sub>trans</sub> )	1.7 W/m <sup>2</sup> .K 0.50 0.10 W/m <sup>3</sup> .K
 <a href="http://www.bfrc.org">www.bfrc.org</a>	
<small>This label is not a statutory requirement. It is a voluntary label provided as a customer service to allow consumers to make informed decisions on the energy performance of competing products.</small>	

A window's Rating is determined by a formula which takes into account its total solar heat transmittance (usually referred to as g value), U value and air infiltration. The resulting value is then placed into a band on an A-G scale. BFRC Rating and label is applied to a whole window (i.e. frame and glass). They do not apply to either the frame or the system or the glass individually. Therefore it is at the point at which all these components come together to produce a whole window that the Rating and label are obtained. D-rated windows provide a lower cost alternative although still above the minimum for regulatory compliance. B-rated windows allow companies to differentiate products with superior thermal properties. The Certified Simulator's report gives an assessment of the BFRC Rating, which takes into account U value, g value and L value (air leakage). The U value would normally be produced by the Simulator using approved software, the g value comes from the glass manufacturer and the L value from testing to BS 6375.

## CWDMA label, Canada



## Canadian Window and Door Manufacturers' Association, : CANADA

In the late 80's, Natural Resources Canada, through its Canada Centre for Mineral and Energy Technology (CANMET), initiated a project that supported research and development of testing and simulation methods for fenestration products. At the same time, the Canadian Standards Association (CSA) was encouraged to develop an appropriate window thermal performance measure through its usual consensus process. The net result was an energy rating (ER) standard for windows. A window's ER rating is a measure of its *overall* performance, based on three factors: 1) solar heat gains; 2) heat loss through frames, spacer and glass; and 3) air leakage heat loss. A number is established in watts per square meter, which is either positive or negative, depending on heat gain or loss during the heating season. A negative ER means a window loses more energy than it gains, making the heating system work harder. The lower the number, the more heat is lost and the harder the heating system has to work in colder weather.

## Windows Energy Labeling Program : CHINA

### CHINA : Window labeling

RISN	
标签编号	
企业名称	
产品名称	
框 材	
玻 璃	
适宜地区	
传热系数(K)	W/(m²·K)
空气渗透率(q <sub>a</sub> )	正压 m³/(m²·h) 负压 m³/(m²·h)
遮阳系数(Sc)	
可见光透射比(Tv)	%
<small>声明: 企业保证本标签是严格按照中华人民共和国住房和城乡建设部规定的程序取得的, 其中的性能指标是采用标准规格产品在特定边界条件下确定的, 如需了解产品的详细性能, 请查阅相关资料, 查询网址: <a href="http://www.ccsn.gov.cn">www.ccsn.gov.cn</a></small>	

The program is overseen by the Research Institute of Standards and Norms (RISN), which has developed more than one thousand standards for construction industry products under supervision of the Ministry of Housing and Urban/Rural Development (MOHURD). The ratings for the RISN label are determined through a combination of computer simulations and physical tests by accredited laboratories that follow a protocol of standardized procedures. RISN label template as of 2009. Shows the certified ratings of the window's *thermal transmittance*, *air leakage*, *shading coefficient*, and *visible transmittance*. RISN decided to focus the label on technical ratings without an assessment of energy performance for several reasons: a) the label's main purpose is to allow comparison of the ratings with building design specifications and requirements in the building standards; b) the energy performance of different windows relative to each other depends on the climate where they are used and building conditions such as orientation, building type, and shading conditions; c) RISN does not currently have the authority to endorse any products based on their ratings. The only exception is a slot on the label that identifies "suitable regions" where the window would likely meet the building energy standard.

## **SIMULATION TOOLS IMPORTANT TO EVALUATE FENESTRATION PERFORMANCE**

Following text elaborate on required input parameters to simulate window performance and output one receive.

### **THERM 6 : Overview**

THERM is a fully integrated simulation environment, developed by Lawrence Berkeley National Laboratory, USA, that includes the following features:

- Graphic user interface: The user draws or imports a cross section of the product or component ( using DXF file or a dimensioned drawing . For which thermal calculations are to be performed. The user can assign material , cavity and boundary condition properties form customizable libraries .
- Heat-transfer analysis: This includes an automatic mesh generator to create the elements for the finite-element analysis, a radiation view-factor model, a finite-element solver, and an error estimator.
- Graphic results: Results can be visualized using isotherms, flux vectors, or color infra-red images.

THERM is capable of modelling conduction an radiation heat transfer explicitly. It models natural convection within cavities using correlations, and convection boundary conditions using standard or custom heat transfer coefficients. It is also capable of modelling absorbed solar radiation or other heat flux sources.

#### **The different typical inputs required to undertake the analysis are :**

- Material of Frame
- Frame Cross-sectional Drawing
- Glazing System Configuration

#### **THERM Capabilities :**

THERM has powerful drawing capabilities aimed at minimizing the effort required to define the geometry, materials, and boundary conditions for a given problem. A cross section can be drawn based on an imported computer-aided drawing (using a DXF file) or a dimensioned drawing. The user can assign material, cavity, and boundary condition properties from customizable libraries.

#### **Output Results**

When THERM has finished a heat-transfer calculation for a cross section, the program calculates total product

The typical outputs generated from the analysis will be the graphical and tabular representations of:

- U - value
- Solar Heat Gain Coefficient
- Visible Transmittance

The results are obtained in following different format

**U- factors as well as graphic results in the form of :**

- Isotherms
- Colour-flooded isotherms
- Heat-flux vector plots
- Colour-flooded lines of constant flux
- Temperatures (local and average, maximum and minimum)

The most commonly used of these are the isotherm plots, flux vector plots, and calculated U-values.

Isotherms are useful for identifying large temperature gradients (isotherms very close together) that may lead to thermal stress or structural problems. Isotherms are also useful for identifying hot or cold areas in the cross section in order to predict thermal degradation or condensation. Flux vectors indicate the amount and direction of heat flow through the cross section. U-factors are important for showing the overall heat transfer rate and thus quantifying the total degradation resulting from a two-dimensional heat-transfer effect.

THERM generates a report (rtf format) that contains a summary of the U-factor results as well as a description of the elements in the cross section

## **WINDOW 6 : Overview**

WINDOW (Arasteh, Finlayson & Huizenga 1994) is the cornerstone of developed by Lawrence Berkeley National Laboratory, USA's fenestration software series; it calculates total window U-factors, SHGC, visible transmittance, and other related optical properties. WINDOW 6 uses a heat-transfer analysis method that is consistent with the National Fenestration Rating Council (NFRC) rating procedure.

**WINDOW 's Capabilities** can be used to analyze products to vary the following parameters :

- Combination of glazing layers,
- Gas layers,
- Frames,
- Spacers,
- Dividers

Environmental conditions and at any tilt. (outdoor and sky temperature , incident solar radiation ,wind speed ) As input, WINDOW requires information on the optical performance properties of a window's glazing materials and the results of a detailed two-dimensional heat-transfer model on the window's frame and edge thermal performance.

### **Input Parameters: ( Required for THERM 5.2/ WINDOWS 5.2)**

#### **Defined environmental conditions**

**Frame material :** Type of material with its following parameters :

- i) Emissivity
- ii) Conductivity

**Frame cross sectional drawing** :Importing ' DXF or Bitmap file ' format ' as underlay and Redrawing and Assigning the material to the frame .

### **Glazing System Configuration :**

a. Importing glazing type to frame ( with its following values to THERM from WINDOW )

$T_o$  : Outside temperature

$T_i$  : Inside temperature

$T_g$  : glazing temperature

$h_o$  : exterior film convection co-efficient

$h_i$  : interior film convection coefficient

$h_g$  : gap space convection co-efficient

$t$  : transmittance for a single glazing

$r$  : reflectance for a single glazing layer

$a$  : absorptance for a single layer

$t'$  : Transmittance for a single glazing layer in a system of multiple glazing layer .

$a'$  : Absorptance for a single glazing layer in a system of multiple glazing layer.

### **Optics 5 : Overview**

Developing suitable material description for glazing system that include coating , adding applied film , interlayer and multi-layer makeup's . Developed by Lawrence Berkeley National Laboratory, USA

Optics 5 can be used for the limited purpose of constructing laminates for NFRC certified simulations using the following criteria :

- Laminates cannot have embedded coating , where embedded coating are defined as a coating on a substrate that touches an interlayer .
- The glass layers can be tinted or coated as long as the coating do not face the interlayer .

As a output result optics give an accurate calculation for Transmission , differing front and back side reflectance and angular dependencies for a particular material description . The application utilizes the International Glazing Database (IGDB ) which is comprise of measured spectral optical data and thermal data .

## **List and Description of Applicable Standards**

(List not exclusive for ECBC but inclusive of other needed standards)

### **ISO 15099:2003\_ Thermal performance of windows, doors and shading devices -- Detailed calculations**

ISO 15099:2003 specifies detailed calculation procedures for determining the thermal and optical transmission properties (e.g., thermal transmittance, total solar energy transmittance) of window and door systems based on the most up-to-date algorithms and methods, and the relevant solar and thermal properties of all components.

Products covered by ISO 15099:2003 include windows and doors incorporating:

1. single and multiple glazed fenestration products with or without solar reflective, low-emissivity coatings and suspended plastic films;
2. glazing systems with pane spacing of any width containing gases or mixtures of gases;
3. metallic or non-metallic spacers;
4. frames of any material and design;
5. fenestration products tilted at any angle;
6. shading devices;
7. projecting products.

### **ISO 12567-1:2000 Thermal performance of windows and doors -- Determination of thermal transmittance by hot box method -- Part 1: Complete windows and doors**

Specifies a method to measure the thermal transmittance of a door or window system. It is applicable to all effects of frames, sashes, shutters, blinds, screens, panels, door leaves and fittings.

It is not applicable to edge effects occurring outside the perimeter of the specimen, energy transfer due to solar radiation on the specimen, effects of air leakage through the specimen, and roof windows and projecting products, where the external face projects beyond the cold side roof surface

### **ISO 9050:2003\_ Glass in building -- Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors**

ISO 9050:2003 specifies methods of determining light and energy transmittance of solar radiation for glazing in buildings. These characteristic data can serve as a basis for light, heating and ventilation calculations of rooms and can permit comparison between different types of glazing.

ISO 9050:2003 is applicable both to conventional glazing units and to absorbing or reflecting solar-control glazing, used as glazed apertures. The appropriate formulae for single, double and triple glazing are given. Furthermore, the general calculation procedures for units consisting of more than components are established.

ISO 9050:2003 is applicable to all transparent materials. One exception is the treatment of the secondary heat transfer factor and the total solar energy factor for those materials that show significant transmittance in the wavelength region of ambient temperature radiation (5 microns to 50 microns), such as certain plastic sheets.

### **NFRC 100: Procedure for Determining Fenestration Product U-factors**

Products of all frame materials, glazing materials, Products with any or no gap width between glazing layers, any spacer or spacer systems between glazings, glazing dividers, any gas-fill between glazing layers & shading systems between glazing layers, currently limited to those that are an integral, i.e., non-removable, part of the product.

### **NFRC 101:2001 Procedure for Determining Thermo-Physical Properties of Materials For Use in NFRC-Approved Software Programs.**

The NFRC rating systems (*NFRC 100*, *NFRC 200*) rely on NFRC approved computer simulation programs for calculating total fenestration thermal performance indices. Manufacturers and suppliers of materials that are used in the design and construction of fenestration products have relied upon a variety of standards for determining the thermophysical properties of specific materials, including ASTM, ISO, ASHRAE and other proprietary methods. This standardized procedure provides a uniform method for determining the thermo-physical properties, long wave surface emissivity and solar surface absorptivity of framing and other opaque materials used in the construction and manufacture of fenestration products.

### **NFRC 200-2010[E0A1] : Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence**

This standard specifies a method for calculating the solar heat gain and visible transmittance from direct solar radiation through most fenestration products at normal incidence only. This procedure is limited to normal incidence calculations because solar optical data needed for such calculations is typically only available at normal incidence. While solar radiation rarely enters a fenestration product at normal incidence, SHGC and VT at near normal angles of incidence (less than 30° off normal) are typically very similar to those at normal incidence; for other angles, the SHGC and VT at normal can be used, to first order, as an indicator of the relative magnitude of solar heat gain (SHG) and VT.

### **NFRC 201:2001 Interim Standard Test Method for Measuring the Solar Heat Gain Coefficient of Fenestration Systems Using Calorimetry Hot Box Methods**

This test method provides requirements, and guidelines, and specifies calibration procedures required for the measurement of the Solar Heat Gain Coefficient, SHGC, of fenestration systems installed in a solar calorimeter (hot box). This test method applies to all fenestration systems, glazed apertures in buildings intended for the controlled admission of solar radiation. This includes windows, glazed doors, translucent panels, skylights, and glazing systems incorporating integral

### **NFRC 300-2010 Test Method for Determining the Solar Optical Properties of Glazing Materials and Systems**

This test method includes the experimental procedure for measuring the transmittance and reflectance over the solar spectral range of flat specular glazing materials at normal incidence only. Under certain conditions these same techniques may also be used for nonspecular glazing, but significant errors are possible. This method is generally suitable for measuring the transmittance and reflectance of architectural glazing materials such as glass and plastic layers (coated and uncoated, monolithic or laminated).

### **NFRC 301-2004 Standard Test Method for Emittance of Specular Surfaces Using Spectrometric Measurements**

This test method determines the normal and hemispherical emittance of a specular surface. This test method describes the spectrometric measurement of the near-normal specular reflectance in the mid-infrared range from 5  $\mu\text{m}$  to at least 25  $\mu\text{m}$ . It includes the calculation procedures required to determine the normal and hemispherical emittance of said object. This test method includes calibration instructions for the spectrometer and procedures for selecting reflectance-reference standards. This test method is generally suitable for any flat, specular-reflecting specimen. It is recommended for measuring emittance of architectural glazing materials such as glass (coated and uncoated), etc. This test method is not suitable for determining the emittance of an object, which is transparent in the specified range of infrared radiation.

This test method is suitable for determining the emittance of an object based on blackbody weighing at a specified temperature, typically 23°C (75°F), as would be needed to determine the thermal performance (i.e., U-Factor or Solar Heat Gain Coefficient) of a fenestration product.

### **NFRC 400-2004[E1A0] Procedure for Determining Fenestration Product Air Leakage**

This procedure defines the criteria for testing fenestration air leakage rates to the requirements and guidelines as established by the NFRC. The air leakage rates obtained from this procedure are intended primarily for product comparison purposes.

### **NFRC 500-2004[E1A0] Procedure for Determining Fenestration Product Condensation Resistance Values.**

This procedure provides a Condensation Resistance rating form windows, fully glazed doors, curtain wall systems, site-built products, sloped glazing system, skylights and other fenestration products. This procedure refers to the Condensation Resistance rating of a fenestration system installed vertically in the absence of solar and air leakage effects. The Condensation Resistance rating is determined for a single set of environmental conditions. The Condensation Resistance value is a comparative rating that indicates a product's ability to resist the formation of condensation. Since the Condensation Resistance rating is a comparative rating, it may not be appropriate for the determination of the actual occurrence of condensation under a given set of environmental conditions.

### ***ASTM E331 - 00(2009) Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference***

*This test method is a standard procedure for determining the resistance to water penetration under uniform static air pressure differences. The air-pressure differences acting across a building envelope vary greatly. These factors should be fully considered prior to specifying the test pressure difference to be used*

## **ASTM C518-02**

### **Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus**

This test method covers the measurement of steady state thermal transmission through flat slab specimens using a heat flow meter apparatus. The heat flow meter apparatus is used widely because it is relatively simple in concept, rapid, and applicable to a wide range of test specimens. The precision and bias of the heat flow meter apparatus can be excellent provided calibration is carried out within the range of heat flows expected. This means calibration shall be carried out with similar types of materials, of similar thermal conductance's, at similar thicknesses, mean temperatures, and temperature gradients, as expected for the test specimens.

## **ASTM C177 - 10 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus**

This test method covers the measurement of heat flux and associated test conditions for flat specimens. The guarded-hot-plate apparatus is generally used to measure steady-state heat flux through materials having a "low" thermal conductivity and commonly denoted as "thermal insulators." Acceptable measurement accuracy requires a specimen geometry with a large ratio of area to thickness.

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