Energy-Saving Windows:

Survey of Policies and Programs to Promote Advanced Window and Glazing Technologies in APEC Economies

Deliverable 4- Final Report

APEC Energy Working Group

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Asia-Pacific
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Prepared by the
National Fenestration Rating Council
and WinBuild

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Executive Summary

Energy saving windows may spread in an APEC economy when the necessary infrastructure is in place. A window energy rating and testing method can enable manufacturers to rate products, compete fairly in the market, and enable established energy policies and programs to make direct reference to these ratings. A few APEC economies have well-established testing and rating systems for windows:

- AUS: Australia
- CDA: Canada
- PRC: China
- CT: Chinese Taipei
- JPN: Japan
- PNG: Papua New Guinea
- US: United States

Several other APEC economies may be able to increase the potential application of energy saving windows by adopting a rating and testing method. Some of these economies may have a building energy policy or program in place, but without a specific, referenced window testing and rating method, the policy or program cannot guarantee good window performance.

- SIN: Singapore
- HKC: Hong Kong, China
- NZ: New Zealand
- RUS: Russian Federation
- CHL: Chile
- MAS: Malaysia
- MEX: Mexico
- THA: Thailand
- INA: Indonesia
- VN: Viet Nam

A third group of APEC economies has significant challenges ahead of them. Without a rating and testing method, building energy program or policy, the chance for widespread adoption of energy saving windows is poor. These economies need to consider the adoption of existing energy ratings in other APEC economies as well as building energy policies and programs appropriate for their needs. These economies may also consider developing their own ratings, policies, and programs, but this would likely further delay their adoption of energy saving windows. Without the necessary infrastructure of software and equipment to test and rate windows, poorly performing products are likely to dominate the market place. The third group of APEC economies includes:

- BD: Brunei Darussalam
- PE: Peru
- RP: Philippines

In APEC economies where the infrastructure for testing and rating windows needs to be improved, the following recommendations are provided:

- Work with other APEC economies toward adoption of existing testing and rating methods. Many APEC economies have successfully pursued this path and have more quickly achieved a functioning energy saving window environment. The National Fenestration Rating Council (NFRC) has worked with Australia, Canada, China, Japan, Korea, the Russian Federation, and Thailand to help implement a window energy rating system.

- Work with other APEC economies to develop or adopt existing policies or programs to facilitate energy saving windows in the marketplace. Frequently, programs and policies are written by third parties such as trade associations. These groups are eager to work with national, state, or local governments to help them adopt their documents. Examples of this include the US Green Building Councils Leadership in Energy Efficient Design (LEED), American Society of Heating, Refrigerating, and Air conditioning Engineers (ASHRAE) Standard 90.1 and 90.2, the Building Codes of Australia (BCA), and ENERGY STAR, a US Government voluntary program with international presence.

Abundant information is available right now for any APEC economy to move toward full implementation of energy saving window infrastructure. APEC economies interested in pursuing these goals may begin working with other APEC economies or some of the mentioned trade associations immediately.

Next Steps

This Energy Saving Windows report outlines information necessary for increased energy efficiency in APEC economies. A new initiative launched in November 2010 by U.S. President Obama and Japanese Prime Minister Kan titled the *Energy Smart Community Initiatives or ESCI*, may enable some of the notions introduced here to be implemented in APEC economies. The ESCI will demonstrate the practicality of clean energy technologies, like energy saving windows, to reduce energy intensity both through research, development and demonstration of new technologies and through establishment of best practices for deploying the technologies already available. Research and development efforts will focus on research, testing, scaling, and development of building energy technologies including windows. The ESCI will include small scale pilot projects and project demonstrations of the building energy technologies. Best practice efforts will focus on codes, standards, testing methods, regulatory frameworks, and public awareness policies. As discussed in this report, Energy Saving Window standards, building energy codes, and energy rating methods and practices may be immediately implemented as a part of the ESCI.

In the ESCI Smart Building component of the initiative, Low Energy Window demonstration projects (SB-4) and Materials Testing and Rating Centers (SB-2) are two identified elements ideal for implementation of many of the recommendations made by this report. APEC economies are encouraged to seek out opportunities presented by the ESCI and integrate information collected and recommendations made in this report.

Finally, recent efforts in Thailand, in which the United States Department of Energy and NFRC collaborated with Thailand's Department of Alternative Energy Development and Efficiency (DEDE), have introduced the necessary sortware and equipment to develop energy saving windows to several APEC economy building energy experts. Details on the required software and equipment are provided in appendix B of this document. Potential exists to begin developing a building component energy efficiency testing center in Thailand deploying much of the energy saving software and equipment described. APEC economies may benefit from participation in this testing center.

Fenestration Testing and Rating Comparison in APEC Economies

APEC economies are in various state of fenestration testing and rating. Most mature economies have some form of testing and rating programs. Developing economies have minimal activity. The testing and rating of window products will lead to a fair and competitive market, enable new technologies to emerge, ensure building energy codes have a standard to reference, and enable professional and layman consumers to make an informed purchasing decision.

Window energy ratings include three primary energy measures: U-factor, SHGC and air leakage. U-factor is the thermal transmission from the inside of a building to outside. The lower the U-factor, the better the window performs during heating periods. The SHGC or solar heat gain coefficient (g-value in many energy codes and window standards) is the amount of infrared heat allowed into a building from the sun. The lower the SHGC, the better the window performs during a cooling season. Air leakage (uncontrolled) through cracks and openings of fenestration system increases heating or cooling loads when outdoor air entering the building needs to be heated or cooled. Air leakage is typically expressed as an air flow rate. Several standards exist throughout the APEC economies to measure these values. Some are common to several economies, but none is common to all. Ideally, one set of harmonized standards among APEC economies would eliminate the barrier and promulgate trade of energy efficient windows.

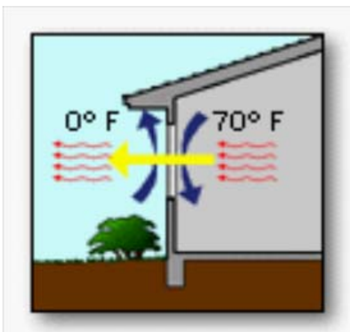


Figure 1-Heat Loss measured by Window's U-factor

The most effective window rating systems involve both computer simulations and physical testing of window products to determine the energy indices. This provides a cost effective solution for manufactures to rate their products. Computer simulations are widespread in several APEC economies and many are validated by physical testing of the indices as a major quality control step. A physical test involves putting the entire window product into a testing laboratory to measure the heat flows and calculate the U-factor and SHGC. These validated window energy indices enable the most competitive markets and lead to ever increasing efficiencies as manufacturers compete to improve their products.

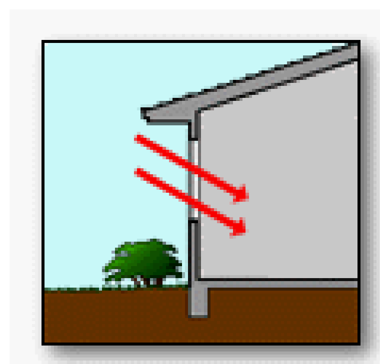


Figure 2-Heat Gain measured by Window's SHGC or g-value

In most APEC economies, these energy rating indices are simply calculated manually using common thermal and optical properties. Many building energy codes allow this simple calculation and do not reference any available standard or measurement document. This practice does not lead to accurate ratings, good building energy performance, or induce competition. Energy savings windows will not typically become widespread in these economies without more accurate and independent ratings and testing methods.

Building energy code presence and enforcement are necessary to make reference to a window rating and testing method. In many APEC Economies, a policy or building energy code makes reference to specific, common window ratings methods. This fundamental step underpins any window energy rating and testing program an APEC economy might consider.

Below is a summary of the testing and rating of window in APEC economies. The table notes if the economy employs any testing or rating and comments on the enforcement within the economy. Enforcement of any energy code, either advanced or minimal, is crucial to fomenting energy savings windows in any economy. Even advanced APEC economies, with widespread use of testing and simulation methods, may suffer from poor enforcement. In addition, poor enforcement eliminates the motive for manufacturers to pursue ratings, develop better products, and reduce national energy consumption from buildings.

APEC Economy	**Testing and Rating Method**		**Enforcement**
	Physical test	Computer Simulation	
AUS: Australia	No	Yes	Simulation required by building energy code
BD: Brunei Darussalam	No	No	NA
CDA: Canada	Yes	Yes	Limited enforcement, provincial authorities do not require with one exception, British Columbia
CHL: Chile	No	No	NA
PRC: China	Yes	Yes	Limited enforcement
HKC: Hong Kong, China	No	No	Generic U-factors and SHGC used for wall OTTV calculation in energy code
INA: Indonesia	No	No	Generic U-factors and SHGC used for wall OTTV calculation in energy code
JPN: Japan	Yes	Yes*	Limited enforcement of window energy performance measurements. Performance rating limited to U-Value only. New calculation standard developed, JIS A 2102-1
ROK: Korea	Yes	No	Limited enforcement
MAS: Malaysia	No	No	Generic U-factors and SHGC used for wall OTTV calculation in energy code
MEX: Mexico	No	No	Generic U-factors and SHGC used for wall OTTV calculation in energy code
NZ: New Zealand	No	No	NA

APEC Economy	Testing and Rating Method		Enforcement
PNG: Papua New Guinea	No	Yes	Follow Australian Building energy code practices
PE: Peru	No	No	NA
RP: Philippines	No	No	NA
RUS: Russian Federation	Yes	No	limited
SIN: Singapore	No	No	Generic U-factors and SHGC used for wall Envelope Thermal Transfer Value ETTV calculation in energy code.
CT: Chinese Taipei	Yes	Yes	Limited enforcement
THA: Thailand	No	No	Generic window U-factors and SHGC entered into a combines wall heat and air leakage rate
US: United States	Yes	Yes	Residential program nearly 100% effective, commercial program available, but limited enforcement restricting full implementation
VN: Viet Nam	No	No	Generic U-factors and SHGC used for wall OTTV calculation in energy code

In the table above, only the US, Canada, Australia, China, Chinese Taipei, and Papua New Guinea use window simulation methods. In addition, only the United States and Canada require the rating be validated by physical testing. These simulations enable manufacturers to showcase advance window technologies and local and state government to enforce building energy codes making references to these simulation methods. Simulation methods consistently rate window products also.

Figure 3-NFRC Window Energy Rating Label (used in US, Canada, Australia)

Computer simulation of U-factor and SHGC may be based on internationally recognized standards such as *ISO 15099-Thermal Performance of Windows, Doors and Shading Devices — Detailed Calculations* or other standards. Some window ratings are based on similar standards such as ISO 10077-*Thermal performance of windows, doors and shutters — Calculation of thermal transmittance*. These standards, however, are not compatible and lead to differing ratings. A new effort is underway to integrate these two standards. . An ISO meeting scheduled in September 2011 will address this concern. APEC economies are encouraged to monitor or participate in this effort.

Canada, China, Chinese Taipei, Korea, Japan, Russian Federation, and the United States are the only APEC economies deploying a physical test method as part of a

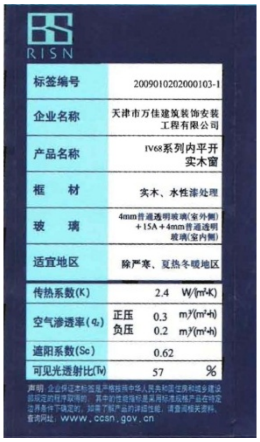


Figure 4-Chinese Window Energy Label

rating. Physical testing is expensive, time consuming, and only rates one version of a window product. Simulations on a computer enable numerous ratings since components (glazing, spacers, and frames) may easily be modified. Physical testing is usually done on a small portion of window products to demonstrate congruence with a simulation or become the representative performance of a group of window products. Physical testing is not a practical method for widespread implementation of an energy saving window program.

Finally, the remaining APEC economies simply make a manual calculation of the window rating as instructed by the relevant energy code, if present. This calculation relies on common material properties and may use look up tables for some window configurations. The window rating calculated is then put into a larger building envelope performance calculation to enable energy code compliance. This method is frequently referred to as the overall thermal transmittance value or OTTV. Some economies break it down further using both envelope thermal transmittance value, ETTV, and roof thermal transmittance value, RTTV, calculations in their codes. This simplified building envelope energy calculation method is not likely to promote optimized thermal performance of the building envelope as it may lead to poor performing windows with highly insulating walls. OTTV also requires U-Factors, Solar Heat Gain Coefficients for the proper calculation. Currently most economies use default values or only glazing values for the fenestration system. OTTV, RTTV and, ETTV currently do not consider air leakage effect which can be substantial energy loss for some buildings.

OTTV is perhaps a good intermediate step prior to a full window energy rating method since its estimates may be reasonable, but it will not enable manufacturer to compete fairly, allow for consistent calculation among different users, or enable high performance products to be recognized properly. This method will likely limit energy saving windows proliferation. Alternatively, economies should consider the adoption of minimum energy performance criteria for windows in addition to a total OTTV. One key benefit will be to ensure improved comfort near window spaces that can have additional energy savings by avoidance of thermostat adjustments.

Policies and Programs to Promote Energy Savings through Advanced Fenestration Technologies in APEC Economies

APEC economies have a variety of policies or building energy codes to mandate energy saving window use. Beyond those policies, voluntary programs also help to enforce energy saving window use. Voluntary programs may also serve to compel consumers and businesses to consider above minimal energy code window use.

Figure 5-Voluntary Window Energy Label-Korea

Policies may be written by the government, developed by trade associations, written by consultants, or written by third parties and then mandated by local, state, or federal authorities. Any policy developed in an APEC economy must be vigorously enforced by local authorities, typically building code department's within the APEC economy government. Enforcement dictates how diligent a window manufacturer may purse the mandated window rating mandated by code. Even where advanced energy saving window policies are present, such as the United States, actual compliance may be nearly absent if enforcement is lacking. In the commercial window market in the United States, this is largely true. Limited enforcement has led to slow development of a competitive commercial window market.

The United States Green Building Council has developed the *Leadership in Environmental and Energy Design* or LEED for new and existing commercial and residential buildings. This program is being used throughout the world and several APEC economies have experience LEED activity. Energy savings windows may be promulgated as a result of this activity. In LEED, the energy and atmosphere section of the program requires compliance with the ASHRAE 90.1-2004. This code requires NFRC rated window products. APEC economies with no viable building energy code or window rating activity may benefit from the presence of this activity to demonstrate better window performance to the local economy. LEED had also been referenced in some APEC economies by local and state governments.

The ideal policy for any APEC economy would be a fully developed building energy code making reference to internationally recognized energy saving window ratings methods with vigorous enforcement. Some APEC economies have evolved this way such as the US, Canada, and Australia. Most other APEC economies have instituted a basic building energy code making reference to simple window energy rating calculation methods.

Figure 6-Voluntary Building Energy Program

The table below compares various policies and programs throughout APEC economies.

APEC Economy	Policy	Program	Enforcement
AUS: Australia	Residential and commercial building energy code	Various Green programs	Widespread adoption of policy and programs.

APEC Economy	Policy	Program	Enforcement
BD: Brunei Darussalam	None	None	NA
CDA: Canada	Residential and commercial building energy code	ENERGY STAR Windows: USGBC LEED activity	Limited, only one province mandates a building energy code
CHL: Chile	Residential Building Energy Code	None	Limited
PRC: China	Residential and Commercial Building energy Code	Limited commercial programs	Limited
HKC: Hong Kong, China	Commercial Building Energy Code	Limited Commercial Building Energy efficiency programs	Limited
INA: Indonesia	Commercial Building Energy Code	None	Limited
JPN: Japan	Commercial and residential building energy code	New high performance Window incentive program	Increasing
ROK: Korea	Residential and Commercial Building Energy Code	Building Component Energy Labeling program	Increasing
MAS: Malaysia	Commercial Building Energy Code	Non	Limited
MEX: Mexico	Commercial Building Energy Code	None	Limited
NZ: New Zealand	Residential and Commercial Building Energy Code	Various commercial and residential programs	Limited
PNG Papua New Guinea	See Australia	See Australia	Using Australian codes (BCA)
PE: Peru	None	None	NA
RP: Philippines	Commercial Building Energy Code	None	Limited
RUS: Russian Federation	Commercial Building Energy Code	None	Limited
SIN: Singapore	Commercial Building Energy code	Commercial Building Energy Efficiency program	Limited
CT: Chinese	Commercial	Limited and	Limited

APEC Economy	Policy	Program	Enforcement
Taipei	Building Energy code	Developing Green Building Programs	
THA: Thailand	Commercial Building Energy Code	None	Limited
US: United States	Residential and Commercial Building Energy Codes	Numerous Voluntary Building Energy efficiency programs	Residential program nearly 100% effective, commercial program still developing and not fully enforced
VN: Viet Nam	Commercial Building Energy Code	None	Limited

Market Assessment of Climate Appropriate Efficient Window Technologies

APEC Economies consume over 60% of the world's energy and constitute $31 trillion in GDP or about half of the world's $58 trillion economy[1]. Within these APEC economies, buildings consume about 70% of all electricity making building energy performance the primary method to achieve good energy conservation. Designing energy efficiency buildings is important to conserve energy in this growing part of the world.

Figure 7-Chinese climate zones

In a typical residential or commercial building, about 25% of the energy passes through the windows. Commercial buildings in cooling only climates, typical in the APEC region, may consume for more energy as a result of the energy load imposed by windows.

Below is a table noting gross domestic product per person in each APEC economies. This common economic indicator reflects the developmental state of an economy. The table lists the presence of a rating or testing method, program or policy, and then estimates the potential for energy efficient window products to promulgate. Energy saving window promulgation will depend upon the energy efficient infrastructure present in an economy. The rating and testing method are fundamental to establishing the window's energy performance. A program, voluntary or mandatory, and a policy such

[1] Asia Pacific Economic Cooperative online database-June 2011 observation

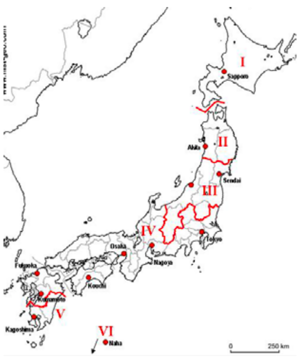


Figure 8-Japanese climate zones

as a building energy code, is to establish a fair, competitive marketplace where energy saving windows will spread.

Climate comments are included as well. The policy or program adopted by an economy will factor in this variable by listing climate zones for large economies crossing several latitudes (hot to cold ranges) and may factor in humidity levels (arid or tropical). Climate zones are declared by grouping heating degree day and cooling degree day values to typify large areas of an economy. For example, the United States ASHRAE 90.1 uses eight climate zones spanning all fifty states. In economies of limited size or existing in uniform national climates, simple energy intensity (energy consumed per unit area per year) may be required since climate will not vary significantly. Considering climate will be essential for the best use of energy savings windows.

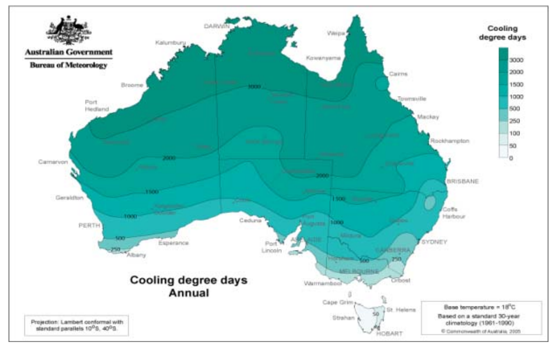


Figure 9-Australian CDD-Cooling Degree Days

If an APEC economy has a rating and testing method and a policy or program in place, it is more likely energy saving window technologies will proliferate. APEC economies lacking these fundamentals are unlikely to experience any widespread application of energy saving windows.

APEC Economy	GDP/person[2]	Rating or Testing Method	Program or Policy present	Climate Considered by Policy or Program?	Potential for Efficient Window Technologies development
AUS: Australia	$41,300	Yes	Yes	yes	High
BD: Brunei Darussalam	$50,300	No	No	No	Low
CDA: Canada	$39,600	Yes	Yes	Yes	High
CHL: Chile	$15,500	No	Yes	Yes	Medium

[2] US CIA World Fact book-June 2011 Observation

APEC Economy	GDP/person[2]	Rating or Testing Method	Program or Policy present	Climate Considered by Policy or Program?	Potential for Efficient Window Technologies development
PRC: China	$7,400	Yes	Yes	Yes	High
HKC: Hong Kong, China	$45,600	No	Yes	Yes	Medium
INA: Indonesia	$4,300	No	Yes	Yes	Medium
JPN: Japan	$34,200	Yes	Yes	Yes	High
ROK: Korea	$30,200	Yes	Yes	Yes	High
MAS: Malaysia	$14,700	No	Yes	Yes	Medium
MEX: Mexico	$13,800	No	Yes	Yes	Medium
NZ: New Zealand	$28,000	No	Yes	Yes	Medium
PNG: Papua New Guinea	$2,500	Yes	Yes	Yes	High
PE: Peru	$9,200	No	No	No	Low
RP: Philippines	$3,500	No	Yes	Developing	Low
RUS: Russian Federation	$15,900	No	Yes	Yes	Medium
SIN: Singapore	$57,200	No	Yes	Yes	Medium
CT: Chinese Taipei	$35,800	Yes	Yes	Yes	High
THA: Thailand	$8,700	No	Yes	Yes	Medium
US: United States	$47,400	Yes	Yes	Yes	High
VN: Viet Nam	$3,100	No	Yes	Yes	Medium

Based on the estimates in the table above, the economies listed here have a high propensity for market application of energy saving windows. Most of these economies have well developed infrastructure and high GDPs.

- AUS: Australia
- CDA: Canada
- PRC: China
- JPN: Japan

- PNG: Papua New Guinea
- CT: Chinese Taipei
- US: United States

The next tier of APEC economies, having moderate potential for adoption of energy saving windows, may be able to increase the energy saving window application potential primarily by adopting a rating and testing method. Many of these economies may have a policy or program in place, but without a specific window testing and rating method, the policy or program cannot guarantee good window performance.

- CHL: Chile
- HKC: Hong Kong, China
- INA: Indonesia
- MAS: Malaysia
- MEX: Mexico
- NZ: New Zealand
- RUS: Russian Federation
- SIN: Singapore
- THA Thailand
- VN Viet Nam

The final tier of APEC economies has significant challenges ahead of them. Without a energy saving window rating and testing method, or building energy programs or policies, the chance for widespread adoption of energy saving windows is poor. These economies need to consider the adoption of existing energy ratings in other economies as well as policies and programs appropriate for their needs. These APEC economies may also consider developing their own ratings, policies, and programs, but this will prolong their adoption of energy saving windows. The pattern in most APEC economies has been to consider widely available rating technology and program or policy documents for adoption with modification. Without the necessary energy saving window infrastructure, poorly performing products are likely to dominate the market place. The final tier of APEC economies includes:

- BD: Brunei Darussalam
- PE: Peru
- RP: Philippines

Conclusion

Energy saving windows may spread in an APEC economy when the necessary infrastructure is in place. A good window energy rating and testing method can enable manufacturers to rate products, help efficient windows compete fairly in the market, and allow energy policies and programs to make direct reference to these ratings. A few APEC economies have established comprehensive window energy rating and testing systems, but most have not. To accelerate the adoption of energy saving window technology, economies may wish to consider the following recommendations:

- Work with other APEC economies toward adoption, with modification, of existing energy saving window testing and rating programs. Many APEC economies have successfully pursued this path and have more quickly achieved a functioning energy saving window environment. The National Fenestration Rating Council (NFRC) has worked with Australia and Canada to help implement a window energy rating system.

- Work with other APEC economies to develop or adopt existing building component energy policies or programs to enable energy saving windows in the marketplace. Frequently, building energy programs and policies are written by third parties such as trade associations. These groups are eager to work with national, state, or local governments to help them adopt their documents. Appendix A lists all potential policies and programs among the APEC economies for consideration.

Abundant information is available right now for any APEC economy to move toward full implementation of energy saving window infrastructure. APEC economies interested in pursuing these goals may begin working with other APEC economies or some of the mentioned trade associations immediately.

Appendix A-Asia Pacific Economic Cooperation Document Summary

Use the table below for a brief description of the available documents. These documents are provided separately in electronic form.

AUS: Australia	
Testing and Rating	American NFRC based certification system for residential and commercial window products dominate the marketplace. The US NFRC has a license agreement with the Australian Fenestration Rating Council (http://www.afrc.org.au/) to operate a rating program based on American NFRC procedures. The AFRC differs by requiring only simulation based on NFRC 100 (U-factor) and NFRC 200 (SHGC and VT).
Policies	Australian Building Codes Board (ABCB) is a government body in charge of the development and administration of building codes in Australia. The ABCB enforces the Building Codes of Australia (BCA-07) that reference NFRC 100 and 200 for energy ratings. The BCA uses whole building energy consumption calculations. Window values derived from NFRC ratings are integrated into the whole building energy calculation.
Programs	In 2006, the Australian Government introduced the Voluntary Building Industry Initiatives Program to persuade the building industry to adopt best practices to reduce greenhouse gas impact Projects developed include the: • Window Energy Rating Scheme (WERS) (uses NFRC ratings) • Green Building Council of Australia-Green Star Program o Green Star Calculation sheet
BD: Brunei Darussalam	
Testing and Rating	None identified
Policies	None identified
Programs	None identified
CDA: Canada	
Testing and Rating	CSA-A440.2 Energy Performance of Windows and Other Fenestration Systems required ISO 15099 compliance software implying NFRC 100 and NFRC 200 (WINDOW 5.2 and THERM 5.2). British Columbia/Vancouver each references ASHRAE 90.1 which also reference NFRC 100 and 200.
Policies	Building energy codes enforced by provincial authorities. Canada has two national codes: Model National Energy Code of Canada for Buildings (MNECB) and the Model National Energy Code for Houses (MNECH), both developed in 1997 and due for update in 2011 by National Resources-Canada. These codes use thermal transmittance for fenestration performance. For fenestration, the code provides regional maximum thermal transmittance values by heating source, with defined exceptions such as automatic sliding glass doors. MNECB varies the regional maximum thermal transmittance values by the ratio of fenestration to wall area for fixed and operable fenestration products. MNECH has similar requirements. British Columbia requires ASHRAE 90.1-04 and the city of Vancouver, BC requires ASHRAE 90.1.07. ASHRAE 90.1 references NFRC 100 and 200 exclusively.

CHL: Chile	
Testing and Rating	Exact window measurement method not referenced by code.
Policy	Chilean Residential Building Code-2007. This code has two compliance paths. One list maximum Window to Wall Ratios (WWR) for a given thermal transmission value (U-factor) for either single or double glazed windows. In colder climates, higher U-factors are required and reduced WWRs. The second path allows an area weighted wall/window U-factor with maximum U-factors specified by climate zones.
Programs	None identified
PRC: China	
Testing and Rating	GB/T8484-2008-*Graduation and Test Method for Thermal Insulating Properties of Doors and Windows.* This is a thermal transmission test for U-factor. *Simulation method: JGJ/T 151-2008*
Policy	GB 50189-2005-Design Standard for Energy Efficiency of Public Buildings is mandatory throughout China, but poorly enforced. Fenestration requirements are given in terms of maximum heat transfer coefficient and shading coefficient (SC) for different orientation. The window-to-wall ratio (WWR) shall not be greater than 0.7. The minimum visual light transmittance (VLT) of glazing for vertical fenestration shall not be less than 0.4 if WWR is less than 0.4. The standard includes fenestration requirements based on window-to-wall ratio and shape coefficient. Thermal transmission (U-factor) reduces as the shape coefficient and WWR rise. GB50189 divides China into three climate zones where U-factor values decrease as the location moves north.
Programs	Significant program efforts include the Green Olympic Building Assessment System (GOBAS) developed in 2004 for evaluating the environmental qualities of buildings for the 2008 Olympics, and the Standard for *Green Building Evaluation (GB/T50378-2006)* developed by the MOHURD in 2006, which represents a preliminary effort by the MOHURD to quantify and rate the environmental quality of both residential and public buildings. MOHURD has shown increasing interest in the establishment of a building energy labeling system. In 2005, the Beijing city government adopted a standard for rating the energy efficiency of public buildings that requires detailed computer modeling of the building (DBJ/T01-100-205).
HKC: Honk Kong, China	
Testing and Rating	Use OTTV method described by Hong Kong, China OTTV-02 Calculation Method-window performance is combined into the OTTV
Policy	Performance based Building Energy Code-2007
Program	Hong Kong-Energy Efficiency Registration Scheme for Buildings-2007
INA: Indonesia	
Testing and Rating	Window testing and rating method not identified, code does not specify measurement technique
Policy	SNI 03-6389-2000-Building Envelope Energy Conservation in Buildings. This document uses the overall heat transfer coefficient value to limit the heat

	transmission of wall/window combinations.
Programs	None identified
JPN: Japan	
Testing and Rating	JIS A 4710-2004-Window and Doors Thermal Resistance Test-thermal transmission test method to determine U-factor
Policy	Commercial: Criteria for Clients of Certain Buildings on the Rationalization Concerning Residential Energy Use-2006 Residential: Design and Construction Guidelines on the Rationalization of Energy Use for Houses Japan-Energy Policy Act
Programs	Japanese Star Rating Program-New program ranking window energy performance using *one to four stars* on the product Measures to Encourage Housing-Business Owners to Improve Energy Efficiency in Housing
ROK: Korea	
Testing and Rating	Overall heat transfer coefficient of window/wall to limit heat loss used in building energy code. For the KEMCO window labeling program, KS F 2278 is used.
Policy	Homeland Ministry 2010-371-HO-Architecture of Energy-Saving Design Criteria
Programs	Ministry of Knowledge Economy (MKE) and Korean Energy Management Corporation (KEMCO) operate three standards and labeling programs: Energy Efficiency Standards & Labeling Program (windows included); e-Standby Program; High-efficiency Appliances Certification Program
MAS: Malaysia	
Testing and Rating	Window energy performance method not referenced by code, use OTTV-overall thermal transfer value where windows are integrated with other wall materials; shading coefficient also used for window calculation; Daylighting provisions in energy code also
Policy	Department of Standards-Malaysia: Code of Practice on Energy Efficiency and Use of Renewable Energy for Non Residential Buildings-2007
Programs	None identified
MEX: Mexico	
Testing and Rating	No testing or rating identified, window values are input into overall thermal transmission value for wall
Policy	Mexico Thermal Insulation Standard, NOM-018-ENER (2005); Building Design Code-CEV001-332 (voluntary, not adopted by government to date)
Programs	None identified
NZ: New Zealand	
Testing and Rating	None identified
Policy	NZS 4218-Thermal Insulation: Housing and Small Buildings Compliance Document for New Zealand Building Code Clause H1 Energy

	Efficiency – Third Edition-2006, references WERS rated windows
Programs	WERS (Window Efficiency Rating System) is the official New Zealand window & door rating system which is coordinated by Window Association of New Zealand (WANZ) and supported by the New Zealand Government agencies: Energy Efficiency Conservation Authority and the Foundation for Research, Science and Technology
PNG: Papua New Guinea	
Testing and Rating	See Australia
Policies	Adopted Australian BCA codes (see Australia)
Programs	None identified
PE: Peru	
Testing and Rating	None identified
Policies	None identified
Programs	None identified
RP: Philippines	
Testing and Rating	None identified
Policy	Green Building Act 2009-Philippines; Beginning in the late 1980's the Philippines passed an energy conservation law that encouraged consumers to save energy and informed them of best practices, as well as promoted energy efficient technologies and appliances and rewarded projects that conserved energy. In 1994, voluntary energy efficiency standards were incorporated into the National Building Code, which was last updated in 2005. These standards applied to commercial buildings and covered building envelope, lighting, HVAC, and water heating systems.
Programs	No national programs. Limited USGBC LEED building activity has resulted in some window with energy labels per the NFRC 100 and 200.
RUS: The Russian Federation	
Testing and Rating	Specific method not defined in code
Policy	Russia Thermal Performance of Buildings (SNiP 23-02-2003); Russia Multifamily Residential Buildings Code (SNiP 31-01-2003). These codes list the maximum thermal resistance for a window by specific building type and climate zone.
Programs	Energy Conservation and Thermal Performance for City of Moscow, MGSN 4.19-2005
SIN: Singapore	
Testing and	Guidelines for Envelope Thermal Transmittance Values for Buildings-2004

Rating	
Policy	Building and Construction Authority-CODE ON ENVELOPE THERMAL PERFORMANCE FOR BUILDINGS
Programs	BCA Greenmark for Nonresidential Buildings; Environmental Sustainability Code

CT: Chinese Taipei

Testing and Rating	None identified
Policy	• Nonresidential Building Energy Standard (pending) • Residential Building Energy Standard (pending)

THA: Thailand

Testing and Rating	No documents available. Use a simplified method to calculate the combined heat ventilation rate of building wall. The window heat rate is combined into this overall calculation. The code does not clearly indicate how the calculation must be made.
Policy	Ministerial Regulation: *Prescription of type or size of building and standard, criteria and procedure in designing building for energy conservation*; B.E. 2552. This code prescribes the heat rate through the wall for buildings > 2,000 square meters. Several different building types have specific heat rate maximums.

US: United States

Testing and Rating	NFRC certification system for residential and commercial window products dominates marketplace. NFRC is a nonprofit organization with 800 window manufacturing participants and 2.5 million rated products in an online database. NFRC 100 (U-factor) and 200 (SHGC and VT) are written and continuously updated by the NFRC membership.
	
	Applicable standards:
	• NFRC 100-U-factor simulation standard (click here)
	• NFRC 200-SHGC and VT simulation standard (click here)
	    o NFRC Approved Software: WINDOW and THERM (Lawrence Berkeley National Labs download site)
	    o NFRC Approved Software: Component Modeling Approach Software Tool download site
	• NFRC 102-U-factor testing standard (click here)
	• NFRC 700-Product Certification Program-program procedure (click here)

Policies	Each State, and some localities, references a common code, principally ASHRAE 90.1 for commercial buildings and the International Energy Conservation Code (IECC) for residential. State legislatures select a version of ASHRAE 90.1 and IECC and either mandate compliance or allow voluntary compliance. In both IECC and ASHRAE 90.1 NFRC window ratings per NFRC 100 and 200 are exclusively referenced and required for compliance. • American Society of Heating Refrigerating and Air conditioning Engineers Standard 90.1-2007 • International Energy Conservation Code-2009
Programs	Several voluntary programs exist in the US including ENERGY STAR for residential product, the US Green Building Council's Leadership in Energy Efficient Design (LEED). The US Government periodically offers tax credits for residential window product that exceed minimal codes. A list of programs that include NFRC rated

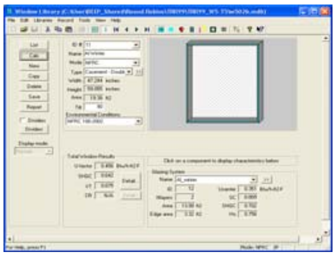
	window energy performance as part of the energy efficiency requirement is provided here: • US Green Building Council-Leadership in Energy Efficient Design (LEED, New Construction V3 included) • International Green Conservation Code-Public Version 2-2010 • US EPA/DOE ENERGY STAR window, door, skylight program and homes program • US EPA/DOE ENERGY STAR Building and Plants Numerous government and utility window installation incentives exist throughout the US and can be reviewed here: http://www.dsireusa.org/incentives/index.cfm?EE=1&RE=0&SPV=0&ST=0&technology=windows&sh=1
Programs	Canada's primary voluntary window program is the American ENERGY STAR window program that includes Canadian specifics on climate. USGBC LEED is present as well primarily for commercial projects. Other programs promoting energy efficient buildings include: • ENERGY STAR-Canada (http://oee.nrcan.gc.ca/residential/personal/windows-doors/buying.cfm?attr=4) • LEED-Canada (http://leedcanada.ca/) • Sustainable Buildings-Canada (http://www.sbcanada.org/index.html) • Built Green Canada (http://www.builtgreencanada.ca/)
Programs	None identified
Programs	None identified
VN: Viet Nam	
Testing and Rating	Testing and rating system not specified in Vietnam Building EE code. Code uses overall thermal transmittance value (OTTV) calculation for a wall where window U-factor and SHGC is embedded in this OTTV wall calculation. Maximum OTTVs are specified for compliance.
Policy	Vietnam Building Energy Efficiency Code-2005 (40/2005/QD-BXD)
Programs	None identified

Appendix B-Software and Equipment List for Setting Up of Building Envelop Energy Performance Laboratory

Simulation Software Program

WINDOW 5:

WINDOW 5.2 is a publicly available computer program for calculating total window thermal performance indices (i.e. U-values, solar heat gain coefficients, shading coefficients, and visible transmittances). WINDOW 5.2 provides a versatile heat transfer analysis method consistent with the updated rating procedure developed by the National Fenestration Rating Council (NFRC) that is consistent with the ISO 15099 standard. The program can be used to design and develop new products, to assist educators in teaching heat transfer through windows, and to help public officials in developing building energy codes.

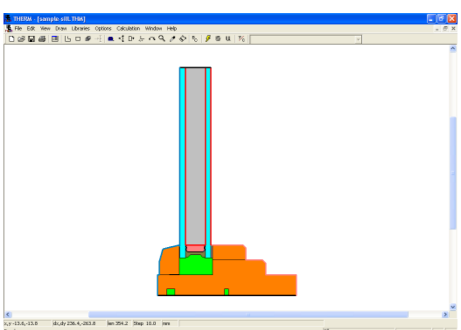


Glass Library to calculate the IGU (Insulated Glass Unit) results in the WINDOW Glazing System Library for a specific product)

THERM 5:

THERM is a module of the WINDOW+5 program developed by LBNL. THERM's results can be used with WINDOW's center-of-glass optical and thermal models to determine total window product U-factors and Solar Heat Gain Coefficients.

THERM is a state-of-the-art, Microsoft Windows™-based computer program developed at Lawrence Berkeley National Laboratory (LBNL) for use by building component manufacturers, engineers, educators, students, architects, and others interested in heat transfer. Using THERM, you can model two-dimensional heat-transfer effects in building components such as windows, walls, foundations, roofs, and doors; appliances; and other products where thermal bridges are of concern.



THERM's heat-transfer analysis allows you to evaluate a product's energy efficiency and local temperature patterns, which may relate directly to problems with condensation, moisture damage, and structural integrity. THERM's two-dimensional conduction heat-transfer analysis is based on the finite-element method, which can model the complicated geometries of building products.

For more information visit http://windows.lbl.gov/software/default.htm

Reference Documents:

ISO 15099, ISO 9050

EnergyPlus is a whole building energy simulation program that engineers, architects, and researchers use to model energy and water use in buildings. Modeling the performance of a building with EnergyPlus enables building professionals to optimize the building design to use less energy and water. Each version of EnergyPlus is tested extensively before release.

EnergyPlus models heating, cooling, lighting, ventilation, other energy flows, and water use. EnergyPlus includes many innovative simulation capabilities: time-steps less than an hour, modular systems and plant integrated with heat balance-based zone simulation, multizone air flow, thermal comfort, water use, natural ventilation, and photovoltaic systems. Read about new features.

EnergyPlus runs on the Windows, Macintosh, and Linux platforms. Free add-ons and other third-party software products are available for use with EnergyPlus. Read a fact sheet on EnergyPlus.

Download EnergyPlus

EQUIPMENT

Thermal Transmittance testing Chamber (Guarded Hot Box): This is used for the Measurement of the thermal transmittance, (U-factor) and thermal resistance, (R – Value) of fenestration and building walls assembly/ components.

The guarded hot box test method is used for establishing the thermal performance of building assemblies when exposed to controlled environmental conditions, (i.e surface heat transfer coefficients at temperature conditions representative of their use). This test method is used for large homogeneous or non-homogeneous specimens. Smaller flat homogeneous specimens can be tested using the Heat Flow Meter. This test method may be applied to building structures or composite assemblies of building elements for which it is possible to build a representative specimen appropriate for the test apparatus.

Components in Guarded Hot Box:

- Room Side Metering Chamber
- Environment Side Room Chamber

- Guard Chamber
- Surround Panel for installing test specimen

Room Side Metering Chamber:

- Heater
- Fans to circulate air in the metering room within natural convection flow requirements.
- Baffle
- Heaters for Baffle
- Humidity control
- Temperature controlled ON/OFF switch
- Thermocouple wire, Type T 30 gauge.

Environment Side Room Chamber:

- Refrigeration System
- Heater
- Fan System to generate required film coefficient
- Thermocouple wire, Type T 30 gauge.
- Baffle

Guard Chamber:

- Fans to circulate air
- Split system to maintain the required temperature in the guarded area
- Surround Panel:
- Foam of at least 4" thick for installation of products.

Controls:

- PID controller system for control of environmental conditions in the chambers.
- Data acquisition System to read thermocouple readings, heat energy,etc.
- Inverter, to control environmental chamber fan speed.

Calibrations:

- Calibration transfer standard
- Thermocouple calibrator
- Computer:
- Computer that would be able to hold required controller cards.

Reference Documents:

ASTM C 1363, C1199, and E1423, NFRC 100 and 102, ISO 8990, ISO 12567

Solar Calorimeter

This equipment is to be built to specifications and will not be available in the market place. WinBuild has state of art design for solar calorimeter construction.

Solar heat gain property measurements are made using solar calorimeters exposed to solar radiation under clear sky conditions, (outdoors) or using artificial solar radiation, (indoors). The test sample is illuminated with either direct beam radiation only, or with direct beam plus diffuse sky and ground reflected radiation.

This test method applies to all fenestration systems, glazed apertures and building envelope components in buildings, intended for the controlled admission of solar radiation. This includes windows, glazed doors, translucent panels, skylights, and glazing systems.

Components for Indoor Solar Calorimeter:

- Room Side Metering Chamber
- Guard Chamber
- Surround Panel for installing test specimen
- Sun tracking system

Equipment:

- Heater
- Fans to circulate air in the metering room within natural convection flow requirements.
- Absorbance Plate
- Water flow system to absorb incident and gain solar energy.
- Tracking system
- Thermocouple wire, Type T 30 gauge.
- Sample Plane Pyranometer: WMO Class 1 instruments, a pyranometer to measure the incident irradiance on a plane parallel to the test aperture.
- Horizontal Pyranometer - WMO Class 1 instruments, a horizontal pyranometer shall be used to measure the global horizontal (beam plus diffuse) irradiance.
- Wind Velocity meter
- Chiller system

Controls:

- PID controller system for control of environmental conditions in the chambers.
- Data acquisition System to read thermocouple readings, heat energy and etc.

Calibrations:

- Calibration transfer standard
- Thermocouple calibrator
- Computer:

Reference Documents:

NFRC 201, ASTM C 1363, C1199, and E1423, NFRC 200, and 300.

Spectrophotometer with Integrating Sphere:

These Instruments are used for determining the solar optical properties of glazing materials relevant to energy transfer in flat specular glazing materials. The solar absorbance, reflectance, and transmittance of materials are determined using a spectrophotometer and integrating spheres. This data is fundamental for simulation programs WINDOW, THERM, and

OPTICS to analyze the glazing and fenestration energy and spectral optical performance.

Equipment:

Lambda 1050 and The Optical model FTIR from Perkin Elmer are specially designed for optical and radiometric accuracy. These instruments are modified to meet the testing specification requirements.

Reference Document:

NFRC 300, ASTM E903, LBNL sample and data documentation.

Air Infiltration Water and Structural testing Chamber:

This equipment is to be built to specifications and will not be available in the market place.

The equipment is used to determine the air-le akage rates, water leakage and structural test of windows, doors and curtain wall.

Components for the equipment:

- Fabricated acrylic and steel wall
- Panel for installing test specimen and calibrations
- Air flow system including flow measurement and controls.
- Water spray system.
- Deflection system

Equipment:

- Fabricated acrylic and steel wall - Room Side Metering Chamber:
- Blower
- Pressure, Mass Flow, deflection measurement instruments
- Laminar flow device
- Water spray rack, with specified nozzles
- Reservoir water tank, and water pump
- Temperature and barometric pressure measurement device
- Clamping accessories
- Calibration plates

Controls:

- Data acquisition System to read measurement of pressure readings, flow rate and etc.

- Controls for controlling flow rate and pressure
- Computer
- Lab view software

Size: 12ft by 12 ft.

Reference Document:

ASTM E 283, E330, E331, E547,AAMA 101,

Sealed Insulating Glazing Units Testing: Structural testing Chamber:

- E 2188 Standard Test Method for Insulating Glass Unit Performance,
- E 2189 Standard Test Method for Testing Resistance to Fogging in Insulating Glass Units, and,
- E 2190 Standard Specification for Insulating Glass Unit Performance and Evaluation.

A simulation of weather cycling from hot to cold extremes with moisture added provides accelerated weather cycling testing under the standard.

This last referenced standard provides the testing protocol for insulating glass units. There are some minor differences in some of the temperatures used and sample sizes required in the ASTM E 2190 Standard. These differences are mostly attributed to conversions from English to metric units. The main differences can best be described by separating the standard into three parts: the high humidity test, the accelerated weathering test and the volatile fog test.

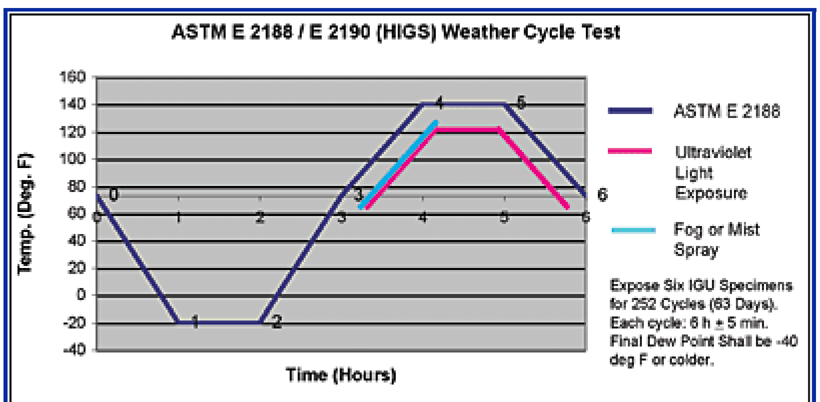
High Humidity Test

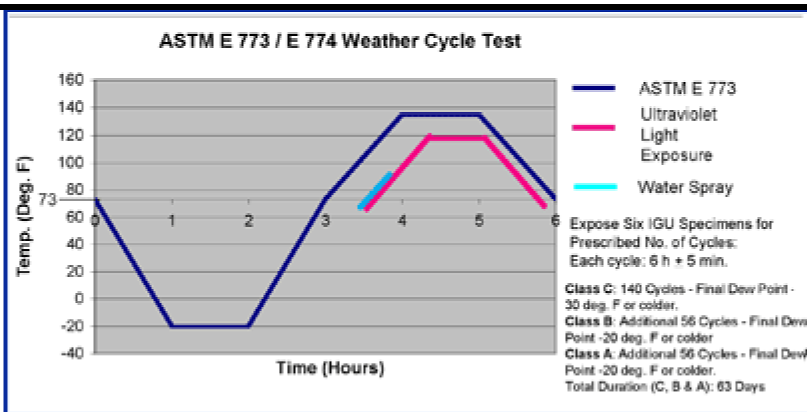
In this test, IG samples are subjected to high humidity and temperature. The objective is to force moisture into the hermetically sealed cavity of the IG unit. All three standards use the same type of box and similar high temperatures. The CGSB 12.8 cycles the units from 22°C to 55° C. E 773 and the ASTM E 2190 test method have no cycling. However, both the ASTM E 2190 and E 773 have 50% more time in the high-humidity box. Furthermore, CGSB 12.8 uses separate samples for the high humidity test and the accelerated weathering. The ASTM E 2190 and E 773 test require the same samples be used in both high humidity and accelerated weathering.

Insulating glass samples are subjected to high humidity and temperature tests.

Accelerated Weather Cycling

This test is used to simulate weather cycling from hot to cold extremes with moisture added during the hot cycle. The cycling boxes are essentially the same for all three methods. However, both ASTM E 2190 and E 773 have UV radiation during cycling. The CGSB 12.8 test has no UV. As noted previously, ASTM E 2190 and E 773 are required to test the same units in both the high humidity and accelerated weather cycling, while CGSB 12.8 allows separate samples for each test. CGSB 12.8 has more cycles (320 versus 252) but the cycles are of shorter duration than ASTM E 2190 and E 773 (63 days versus 53.3 days). The criterion for passing this test is a frost point of -40°C for both ASTM E 2190 and CGSB 12.8. For E 773, the criterion is warmer, -20° C.





Scientific testing procedures are part of the standard's requirements.

Volatile Fog Test

This test is used to show that the components in an insulating glass unit will not out-gas a volatile fog, which could result in a deposit on the interior glass surfaces. All three tests use UV radiation and elevated temperatures to accelerate the effects. ASTM E 1887 has a slightly higher UV output than ASTM E 2190 or CGSB 12.8, but it does not place the test samples in a box. In ASTM E 1887 only one corner of the sample sees the UV radiation and elevated temperature. ASTM E 2190 and CGSB 12.8 uses a temperature that is 10°C higher than ASTM E 774 (60 versus 50° C). However, ASTM E 2190 uses stricter evaluation criteria for viewing the fog. ASTM E 2190 has the observer view the fog at any angle with the sample at arms length. CGSB 12.8 uses a complicated viewing box with the observer at 2 m from the sample looking "normal" to the glass surface.

This test shows that insulating glass unit components will not out-gas a volatile fog.

Argon and Krypton Certification

Since 1997, IGMA has offered certification for initial gas fill such as argon and krypton in addition to the conventional durability certification testing to the ASTM E 2190 specification.

To participate in this part of the IGMA Certification Program, the insulating glass manufacturer must gas fill all test samples and achieve an initial gas fill level of 90%, averaged over 10 test specimens in order to achieve this certification designation. Manufacturers who gas fill and want to mark their insulating glass units as IGMA certified must have completed the initial gas fill certification program requirements. Insulating glass manufacturers who elect to certify to the conventional durability testing only may not mark their units as IGMA certified if they have only achieved the durability testing certification and they gas fill their production units. Much like the conventional durability testing requirements, the manufacturers are being tested on their ability to fill to a known level (90%) creating an apple-to-apple platform for the industry. Insulating glass manufacturer's actual production units may or may not be gas filled to this level. The percentage of gas fill required for a particular IGU is dependent on the thermal performance values the IG manufacturer wants to achieve. Other factors such as the window frame construction materials greatly influence the thermal performance of fenestration products.

Full testing to the current published version of the applicable standard is required before IGMA Certification is granted to a product. Units fabricated and submitted by the manufacturer for certification testing must reflect the manufacturer's actual product unit configuration in all respects.

For initial argon gas certification for the Canadian market, sample units for testing must be constructed in a gas fill configuration and subsequently filled with argon or

Heat Flow Meter:

The heat flow meter apparatus establishes steady state one-dimensional heat flux through a test specimen between two parallel plates at constant but different temperatures. By appropriate calibration of the heat flux transducer(s) with calibration standards and by measurement of the plate temperatures and plate separation. Fourier's law of heat conduction is used to calculate thermal conductivity, and thermal ressistivity or thermal resistance and thermal conductance. Two instruments are typically used for measuring low and high conductive materials.

Equipment:

LaserComp Fox 600.

Reference Document:

ASTM C 518, 1045

Reflectometer:

solar reflectometer helps determining the solar reflectance of flat opaque materials in a laboratory or in the field. The purpose of the test is to provide solar reflectance data required to evaluate temperatures and heat flows across surfaces exposed to so lar radiation.

Equipment:

- Reflectometer
- Pyranometer

Reference Document:

- ASTM C1549, ASTM E1918 and E1918A

Pyranometer:
The pyranometer measures the solar reflectance of various horizontal and low-sloped surfaces and materials in the field. The test method is intended for use when the sun angle to the normal from a surface is less than 45.

Equipment:

- Pyranometer meeting ASTM E1918

Reference Document:
ASTM E1918 and E1918A

Emissometer:

The portable differential thermopile emissometer covers a technique for determining the emittance of typical materials. The purpose of the test method is to provide a comparative means of quantifying the emittance of opaque or highly thermally conductive materials near room temperature as a parameter in evaluating temperatures, heat flows, and derived thermal resistances of materials

Equipment:

- portable differential thermopile emissometer meeting ASTM C1371

Reference Document:
ASTM C1371