Designing Windows and Doors for Energy Efficiency and Total Performance

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SPECIFIED
SYSTEMS, INC.
Innovative Energy Solutions for Commercial Windows and Doors

Why The Demand for Energy Efficiency?

- Continually high energy prices
- Increased energy use
- Natural gas and oil shortages
- Air pollution and greenhouse gas emissions

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Why The Demand?

According to the Energy Information Administration, buildings in the United States:

- Use over 70% of the country's electricity
- Consume nearly 40% of its energy
- Emit close to 40% of all its greenhouse gases

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Energy Loss

A building's windows and doors dramatically affect its energy efficiency.

- In winter, heat loss through typical windows can boost a building's heating bill as much as 25 percent.
- In summer, the heat flow reverses, with sunlight warming the building's interior through its windows and causing air conditioners to work harder.
- Energy-efficient windows can help in both these situations. And if the building's electricity comes from a fossil-fuel power plant, installing energy-saving windows also shrinks the building's carbon footprint by reducing greenhouse gas emissions at that plant.

Source: National Geographic—Green Living

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Quality of Life

- Since the U.S. Environmental Protection Agency estimates that Americans spend nearly 90% of their time inside buildings, improvements within the building environment can have a vast impact on an occupant's health, comfort, safety and welfare.

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Influencers of Energy Codes

Energy Codes

- DOE - *Department of Energy*
- ASHRAE - *American Society Of Heating, Refrigerating, and Air Conditioning Engineers*
- ICC - *International Code Council*
- NFPA - *National Fire Protection Association*

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Codes and Standards

ASHRAE 189.1-2011—**Standard for the Design of High-Performance Green Buildings**
(ANSI Approved; USGBC and IES Co-sponsored)

- ASHRAE standards are developed and revised through voluntary consensus and public hearing processes.

- Standard 189.1 provides a "total building sustainability package" for those who strive to design, build and operate green buildings. From site location to energy use to recycling, this standard sets the foundation for green buildings by addressing site sustainability, water use efficiency, energy efficiency, indoor environmental quality, and the building's impact on the atmosphere, materials and resources.

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Codes

Energy codes (IECC/IRC)

(International Energy Conservation Code/International Residential Code)

Specifies how buildings must perform

ICC – International Code Council

I-Codes

- The International Code Council, a membership association dedicated to building safety, fire prevention and energy efficiency, develops the codes used to construct residential and commercial buildings, including homes and schools. Most U.S. cities, counties and states choose the International codes, building safety codes developed by the International Code Council. The International Codes also serve as the basis for construction of federal properties around the world, and as a reference for many nations outside the United States.

Source: International Code Council

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IECC

Energy codes (IECC/IRC)

(International Energy Conservation Code/International Residential Code)

IECC – Introduced in 1998, the IECC addresses energy efficiency on several fronts including cost savings, reduced energy usage, conservation of natural resources and the impact of energy usage on the environment.

- 2012 important changes included commercial enhancements that required energy savings for windows, doors and skylights; thermal envelope efficiency; and increased efficiencies for installed HVAC equipment.

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Ultimate Goal

Net-Zero Energy Buildings (NZEB)

- A net-zero energy building must produce as much energy on site as it consumes. Green Building and Sustainable Architecture significantly contribute to that goal.
- 'By Executive Order 13514, the President mandated that by 2015, 15% of existing Federal buildings conform to new energy efficiency standards and 100% of all new Federal Buildings be Zero-Net-Energy by 2030'.
- The U.S. Department of Energy's Commercial Building Initiative (CBI) collaborates with the private sector, national laboratories, other federal agencies, and non-governmental organizations to advance energy-efficient and green commercial building technologies. "

Source: DOE

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How To Get There

How do you contribute toward the goal of Net-Zero Energy Goal In Buildings with Windows and Doors?

- Create products designed for increased Energy Efficiency and Total Performance
- Utilize High Performance Frames
- Utilize Superior Glass Packages
- Employ Innovative Thermal Barrier and Spacer Systems

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Total Performance

- Total Performance in Windows and Doors takes into consideration the performance of all of the elements and components of the window and door and the long-term performance of the entire unit.

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Energy Efficiency and Total Performance In Windows and Doors

What should you consider?

- Thermal Performance
- Glass Systems
- Spacer Systems
- Films/Coatings
- Structural Performance
- Framing Material
- Thermal Barrier Systems
- Air Infiltration
- Water Penetration
- Testing
- Finishes
- Hardware

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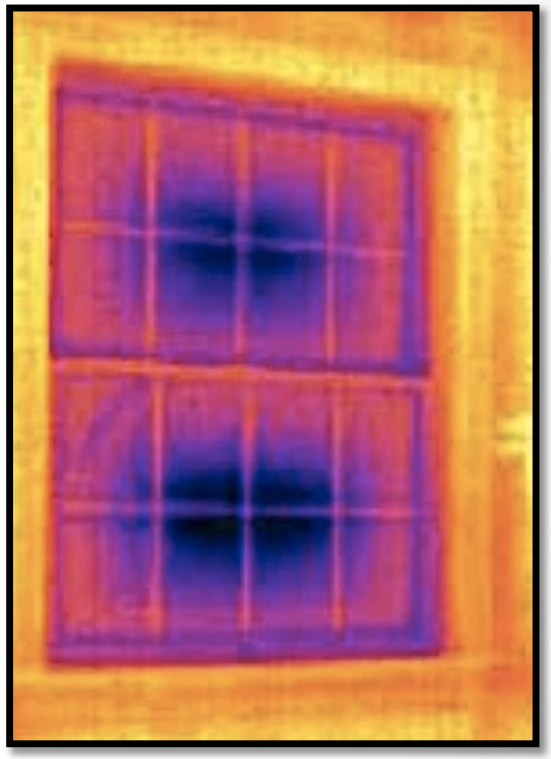
Thermal Performance

- A window's true thermal performance (U value) — is determined by a combination measurement of the center of glass, the edge of glass and the frame and its overall ability to resist heat flow.
- When there is a difference between inside and outside temperatures, heat transfers through a window. It's lost to the outside during the heating season and is gained from the outside during the cooling season.
- The whole window U value affects the Energy Efficiency and Total Performance of a window or door unit.



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Glass Systems

Glass Systems contribute to a building's Energy Efficiency, Total Performance and the occupant's health, comfort level and added safety.

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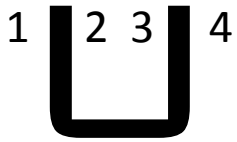
Insulated Glass

In order to achieve a low system U value, it is important that you start with a glass package that can also achieve a low U value.

Insulated Glass Systems —
Insulated glass systems were designed to provide better insulation for a window system by trapping air between the panes of glass

Sides



Outside Inside

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Spacer Systems

Spacer Systems affect Energy Efficiency and Total Performance

Types of Spacers

- Conventional – Metal Spacers
- Non Metal Spacers
- Hybrid Spacer Systems

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Spacer Systems

Conventional Metal Spacer Systems

- Aluminum spacer is a conductor of heat
- Aluminum spacer used in most standard edge systems represents a significant thermal "short circuit" at the edge of the insulating glass unit (IGU)
- In addition to the increased heat loss, the colder edge is more prone to condensation

Non Metal Spacer

- TPS
- Butyl based primary seal
- Silicone secondary seal

Metal Spacer

Non Metal Spacer

Source: Efficient Windows Collaborative

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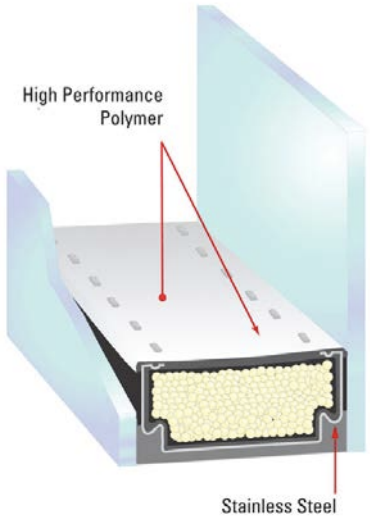
Hybrid Spacer Systems

How do Hybrid Spacer Systems contribute to Energy Efficiency and Total Performance?

- Enhanced thermal capabilities
- Structural rigidity
- True dual seal IG unit construction
- Exceptional condensation resistance
- Superior gas retention
- Aesthetically pleasing sightlines and colors
- Exceptional long-term durability



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Films

Films can affect the energy efficiency, daylighting, occupant's comfort level and Total Performance of Windows and Doors

Types of Films

- Low E coatings
- Heat Mirror
- Redirection Film

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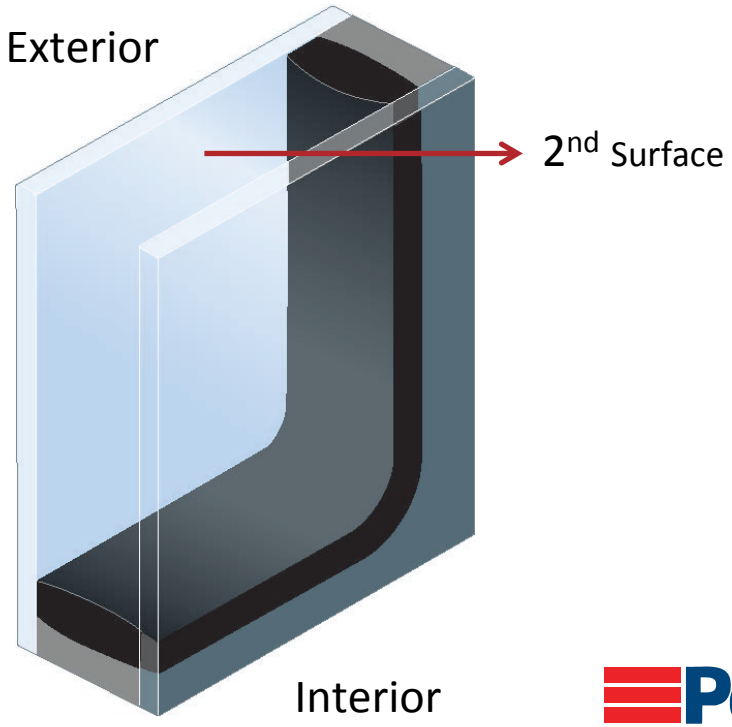
Low E Coatings

Low E, Energy Efficiency and Total Performance

A Low E coating is typically applied to the 2nd surface of an insulated unit to increase energy efficiency, reduce glare and harmful UV rays.



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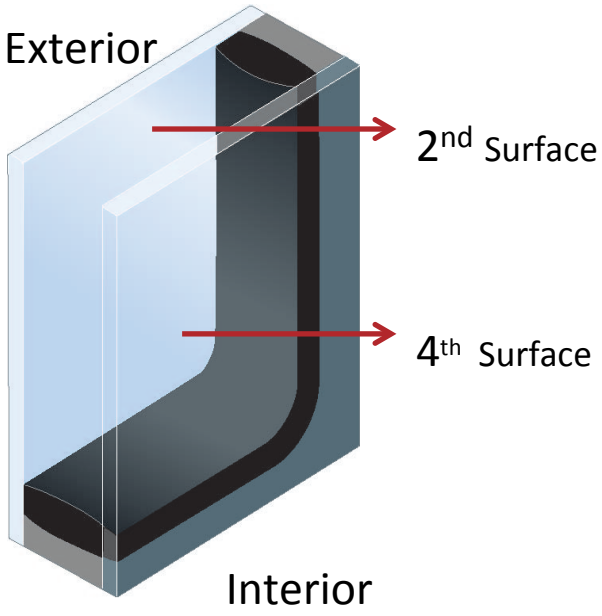
Dual Low E Coatings



The Advantages of Dual Low E

Surface #2 and #4

Dual Low E coatings increase the energy efficiency performance without sacrificing design or adding weight and material costs (compared with a triple paned glass unit)

Adding a Low-E coating to the #4 surface of the glass unit:

- Reflects infrared heat back into the building
- Reduces the amount of radiant heat loss through the glass
- Improves the thermal insulation by reflecting room heat back inside.
- Improves the overall insulation and energy efficiency of the IG unit.

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Gas Filled IGU

Air versus Gas Filled

Gas is used in Insulated Glass Units (IGU) to improve the energy efficiency of the unit by reducing the overall transfer of heat between the inside and outside

'Filling the space with a less conductive, more slow-moving gas minimizes the convection currents within the space, conduction through the gas is reduced, and the overall transfer of heat between the inside and outside is reduced.'

Types of Gas used:

- Argon—Inexpensive, nontoxic, nonreactive, clear and odorless (optimal spacing for an argon filled unit is ½")
- Krypton—Nontoxic, nonreactive, clear and odorless and has a better thermal performance, but is more expensive to produce (useful when spacing between glazing must be thinner approx. ¼")
- Mixture of Argon and Krypton — Provides better thermal performance than Argon and is less expensive than Krypton

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Heat Mirror

Heat Mirror, Energy Efficiency and Total Performance

Heat Mirror is a film suspended between lites of glass in an insulated unit that reflects heat back to its source—a mirror to heat.

How does it affect Energy Efficiency and Total Performance?

- Superior insulating performance reduces energy costs and enhances comfort
- Superior solar shading reduces expensive cooling costs
- UV protection helps reduce an occupant's exposure and the fading of furniture and drapes
- Noise reduction reduces noise pollution for added comfort

Source: Southwall Technologies

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Designing for Daylighting

Windows and Doors can affect the amount of Natural Sunlight that enters a building —

Why is natural daylighting important?

- Increases occupant's health, well being and satisfaction
- Reduces chronic work-related illness
- Increases productivity
- Minimizes environmental impact
- Reduces utility use and costs

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Natural light

Disadvantage of Natural light

With all of the advantages of natural sunlight there are some problems associated with natural direct sunlight such as glare and inadequate dispersal of light into a room.

Today, Light Shelves are used to redirect natural sunlight to an overhead position for better room illumination.

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Light Shelves

Advantages

- Shifts light from the window so that it comes from an overhead direction, improving the quality of illumination.

Disadvantages

- Aesthetically affects the interior design of the room
- Additional cost for material and engineers
- Initially requires an engineer and room modeling to test for adequate light dispersion. The pattern of illumination depends on the reflection characteristics of the light shelf, and it depends on the geometry and reflection characteristics of the ceiling surface.
- Requires periodic cleaning which is easy to neglect and continues to add cost of labor over time
- Can be a safety hazard if shelves are not maintained over time

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Redirecting Film

Daylight Redirecting Film

Daylight Redirecting Film —Redirecting Film brings natural light deeper into the interior of the building by changing the direction of light as it streams through windows. The film redirects light toward the ceiling, reducing the need for artificial light during the day.

How does it affect Energy Efficiency and Total Performance?

- The film uses a micro-replication process, a technology in which researchers create precisely shaped pyramids on the surface of the film that are all exactly alike. This precision enables the properties of the Daylight Redirecting Film to reduce glare and excess light near the window and move more natural light to occupant spaces. The film acts like a light shelf that redirects the light while blocking ultraviolet rays to minimize fading of carpets, furniture and window fabrics.

Source: 3M

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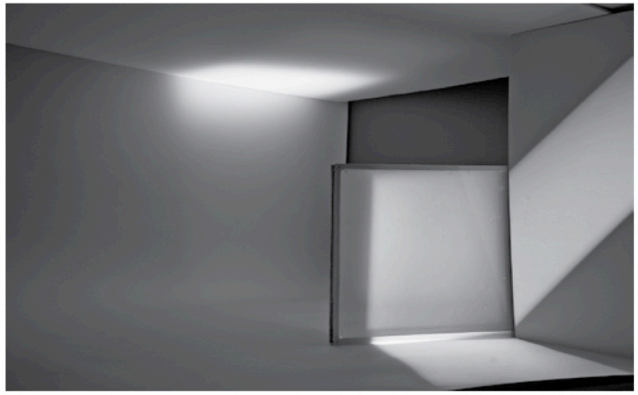
Film

Redirection Film

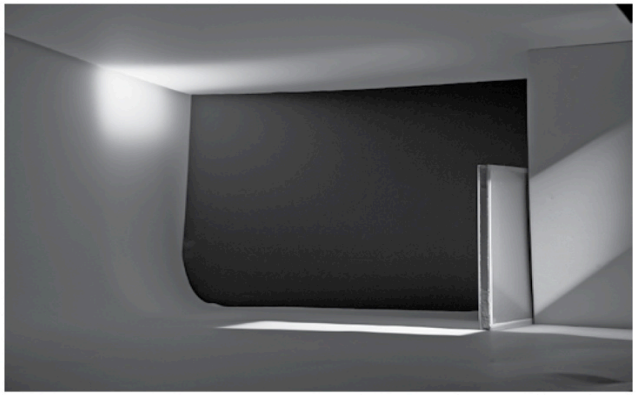
With Daylight Redirecting Film

Without Daylight Redirecting Film

Front View



Side View



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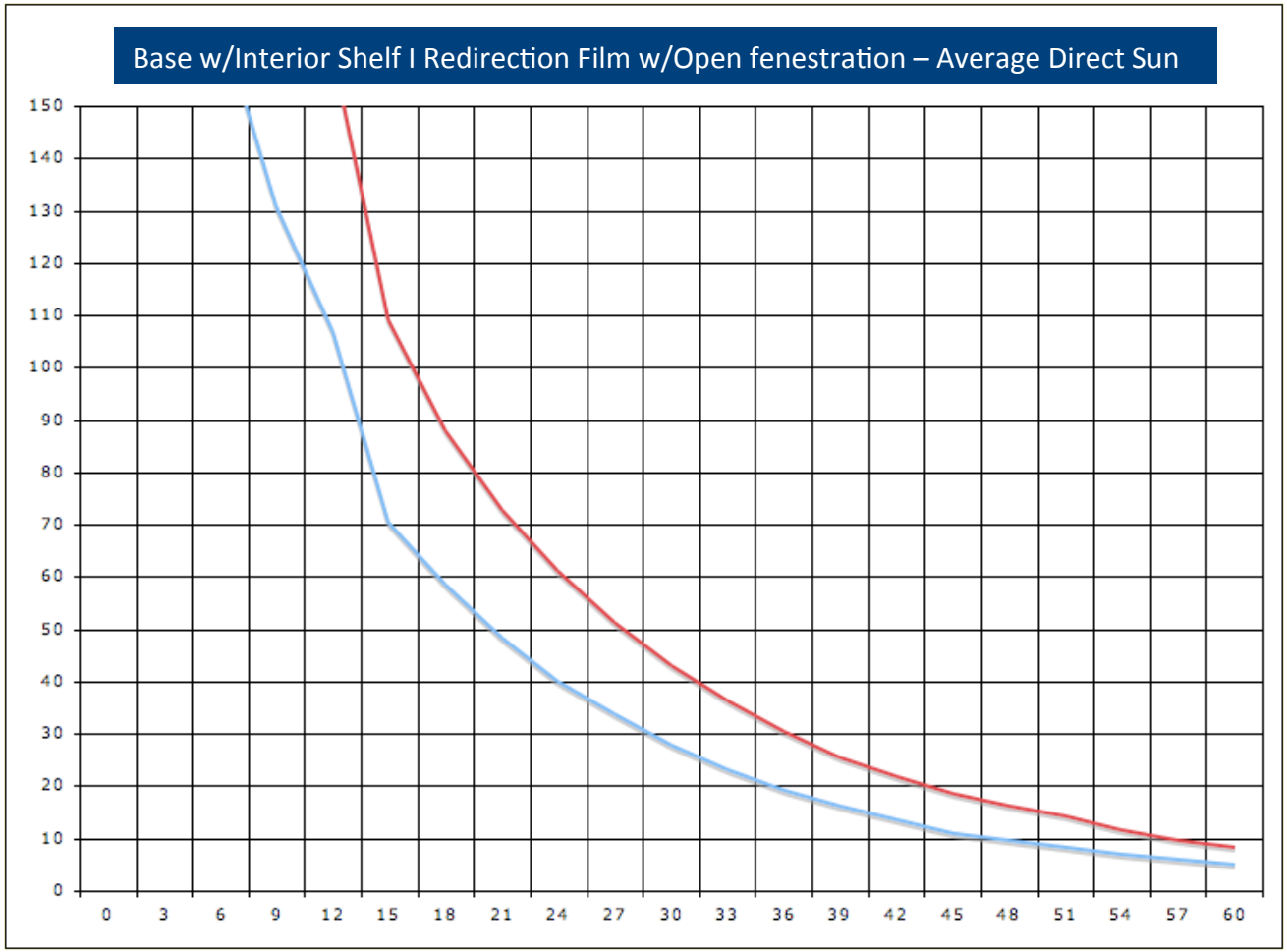
Source: 3M

Lighting Study



Clear Top Lights

Redirecting Film Top Lights

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Safety Glass

Safety Glass, Energy Efficiency and Total Performance

Laminated Safety Glass

- Used in Blast and Hurricane windows and doors to protect people from flying shards of glass and glass impact by holding the glass together when its broken or shattered
- Provides added safety for vandalism

Tempered Safety Glass

- Used to provide added safety and protection
- Tempered glass is four times stronger than ordinary glass, it's difficult to break, can withstand impact of 24,000 lbs. per sq. inch and crumbles into tiny pellets for added safety when it does break

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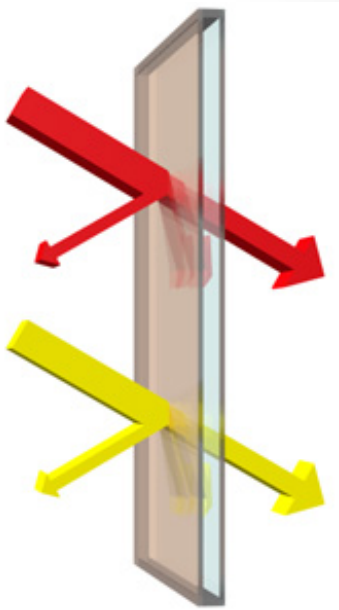
Tinted Glass

Purpose of Tinted Glass:

- To reduce Solar Heat Gain



When you reduce the Solar Heat Gain with Tinted Glass however, you also reduce the Visible Light Transmittance (VT)

It's important to balance Solar Heat Gain and Visible Light Transmittance. If your Tinted Glass becomes too dark you may have to use more artificial light which can increase energy use and costs.

Solar Heat Gain Coefficient (SHGC): How well a product blocks heat caused by sunlight, as expressed by the amount of solar radiation that passes through a window.

Visible transmittance (VT): How much visible light is transmitted through the product.

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Tinted Glass

Tints, Energy Efficiency and and Total Performance

Benefits:

- Increases occupant's comfort
- Lets the natural light in
- Keeps costly and harmful UV rays out

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Structural

Structural Strength is the amount of pressure the window frame and sash will withstand under load.

Structural Strength affects the Entire Window's Performance and continues to affect its ability to perform year after year

Glass deflection limit — expressed as L/175 — is for all glass holding members:

- Deflection limits are needed to ensure there is no damage to supported construction members
- Excessive deflection can compromise the integrity of the seal increasing air and water infiltration, which will increase energy use and costs
- Deflection limits are also needed for the occupant's safety and comfort

The structural strength of aluminum windows resistance to deflection provides a better resistance to air and water infiltration caused by glass deflection

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The Importance of Framing Material

Window and Door Framing Material can affect Energy Efficiency and Total Performance including structural integrity, thermal, air, water and acoustical performance and maintenance requirements over time. It's important to consider the advantages and disadvantages of the material used.

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Frame Material

Types of Architectural Frames typically used in Commercial buildings include:

- Wood—Strong and Durable
  - Cannot achieve high design pressures
  - Heavy Sightlines and High Maintenance requirements
- Steel—Strong and Durable
  - Heavy weight
  - Not thermally efficient
- Aluminum —Excellent strength to weight ratio
  - Superior Structural Performance
  - Ideal for large window openings
  - Flexibility with design and minimal maintenance

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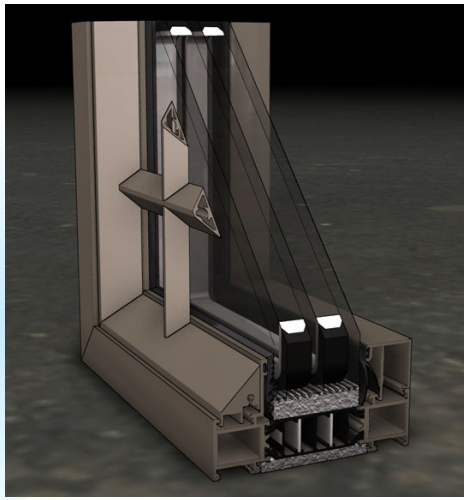
Frame Design

The frame design can also affects the Energy Efficiency and Total Performance of the unit.



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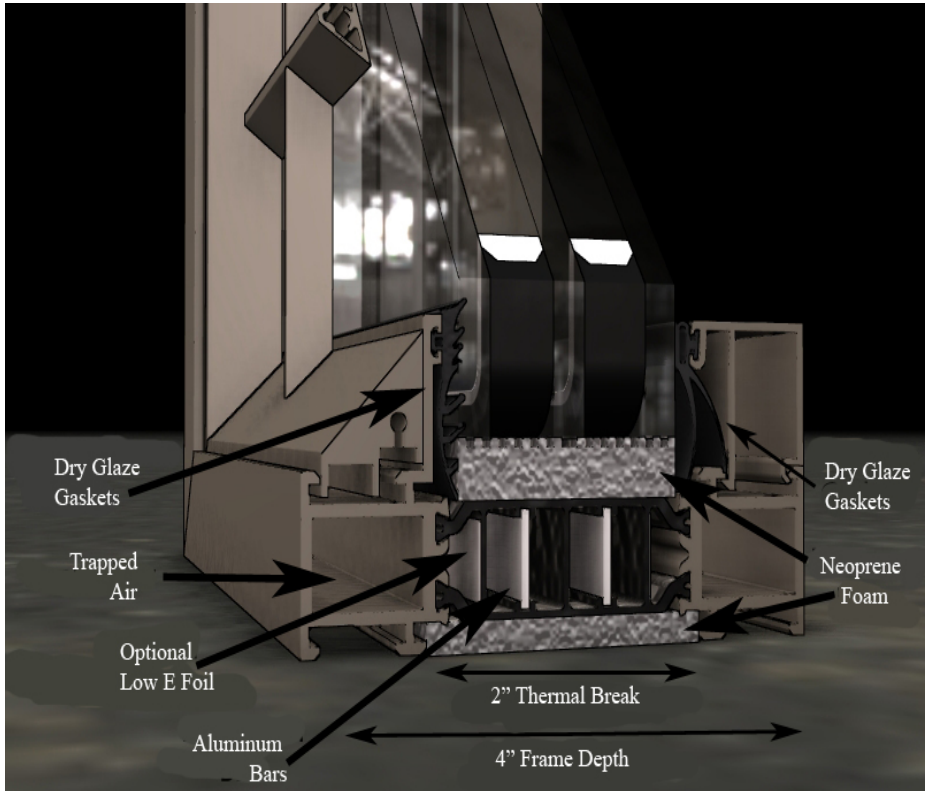
Frame Design

- Frames can be designed to reduce heat flow and water and air infiltration in a window/door unit.



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Thermal Barrier Systems

How do Thermal Barrier Systems affect Energy Efficiency and Total Performance?

Reduction of temperature transfer

- Thermal break- separates the frame into 2 separate interior and exterior pieces joined with a less conductive material to reduce temperature transfer
- Additionally reduces sound transmittance
- Thermal barriers reduce heat loss or heat gain through the aluminum
- Thermal barriers improve the U-value characteristics of finished systems Thermal barriers are about energy conservation, U-values and government codes
- Currently there are two principal types of thermal barriers used in North America: Pour and Debridge (P&D) and Polyamide Thermal Barrier Strips

Pour and Debridge

Polyamide Thermal Barrier Strips

Source: *AAMA/WDMA U.S. Industry Statistical Review and Forecast*

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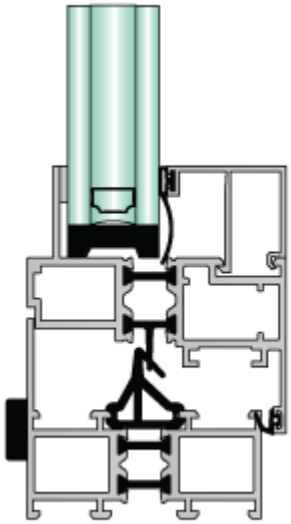
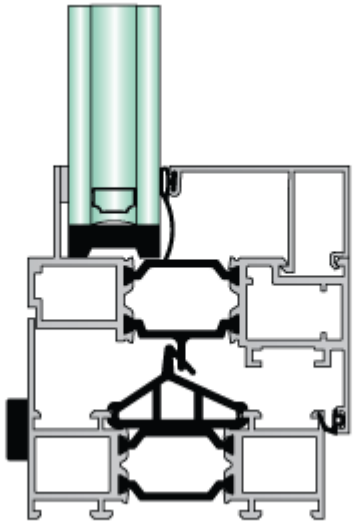
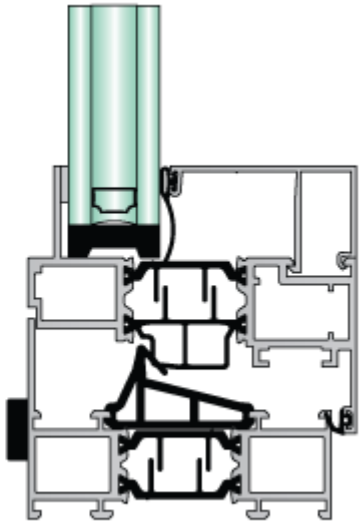
Polyamide Technology Easily Allows for Varying Window Depths



14.6 mm
U-Value: 0.35



32 mm
U-Value: 0.33



34 mm
U-Value: 0.30

Different widths of Polyamide Strips

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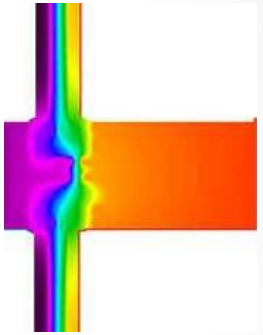
Thermal Barrier Systems



- 70% of aluminum fenestration systems produced in North America contain a thermal break
- Primarily used in colder climates to reduce heat loss
- Increasing use of thermal barriers to reduce heat gain and also reduce heat loss
- Developers, architects and designers are demanding better performance in terms of power usage
- Stricter government regulations to reduce power usage in buildings to combat environmental concerns
- The use of thermal barriers will assist manufacturers to achieve improved LEED® performance

Source: *AAMA/WDMA U.S. Industry Statistical Review and Forecast*

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Thermal Barrier Systems

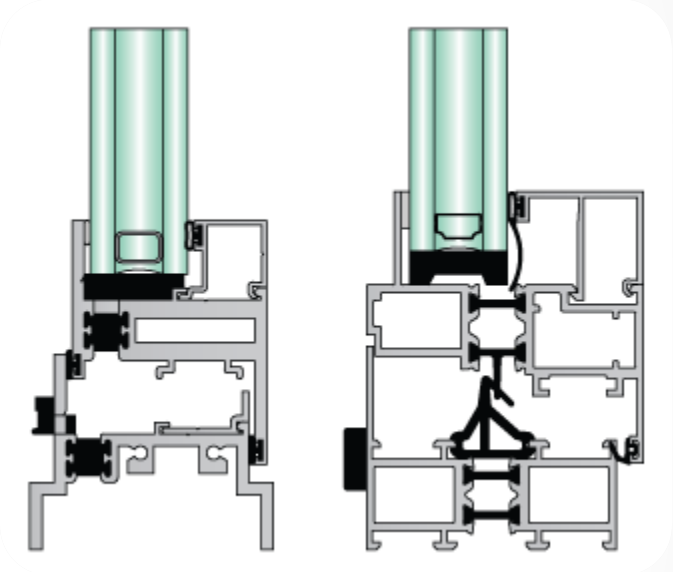
Old—Conventional

- Provides thermal isolation of only the Framing.
- Channel Frame allows thermal convection to pass under window.
- 1/8” walls required for screw attachment of hardware.

New

Controlled thermal convection at edge of framing.

- Hollow cavities and thermal isolation enhances insulation of system.
- Frame hollows and Euro-groove hardware track provides superior strength.



Conventional Innovative

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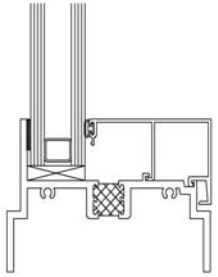
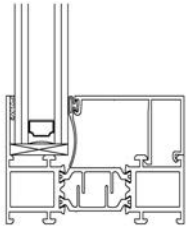
Advanced Thermal Strut System

Understanding U Values
Compare the Differences in window units using Pour and Debridge, Thermal Strut Systems and films/coatings/gas filling



Projected

Glass	Clear Glass	Hard Coat	Soft Coat	Soft Coat w/ Argon	Dual Low E	Heat Mirror	Triple Glaze	Triple Glazed w/ Argon
Pour & Debridge Projected window	0.59	0.49	0.45	0.41	0.41	0.37	0.35	0.35
Thermal Strut Projected Window	0.5	0.4	0.36	0.32	0.32	0.28	0.25	0.22



Fixed

Glass	Clear Glass	Hard Coat	Soft Coat	Soft Coat w/ Argon	Dual Low E	Heat Mirror	Triple Glaze	Triple Glazed w/ Argon
Pour & Debridge Fixed Window	0.55	0.44	0.4	0.36	0.35	0.31	0.3	0.3
Thermal Strut Fixed Window	0.49	0.38	0.34	0.3	0.29	0.25	0.23	0.23

Casement

Glass	Clear Glass	Hard Coat	Soft Coat	Soft Coat w/ Argon	Dual Low E	Heat Mirror	Triple Glaze	Triple Glazed w/ Argon
Pour & Debridge Casement window	0.62	0.54	0.51	0.48	0.47	0.44	0.42	0.42
Thermal Strut Casement	0.5	0.41	0.38	0.35	0.34	0.31	0.28	0.26

U Value is the measure of heat transmission through a window. U values are calculated by two industry-recognized methods: AAMA 1503 or NFRC 102

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Total Performance Systems

Increase Glass/Wall Ratio

- A system's Total Performance comes closer to equaling that of a wall by minimizing the heat loss through the balanced use of a high performance glass package design and a framing system and innovative thermal barriers and spacer systems design.

Benefit:

- Enables the increase of glass/wall ratio on a project design

which will increase more natural light in a building

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Air Infiltration

Air Infiltration, Energy Efficiency and Total Performance

- Air Infiltration is the measurement of the amount of air that can pass through a window. The lower the number, the lower the amount of heat and cooling loss which affects the window and door's total performance.

Testing/Certifications

- ASTM E283-04 Standard Test Method is used for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen, are used widely in the industry to account for product design, and to some extent, quality control.

- AAMA/WDMA/CSA 101/I.S.2/A440, NAFS - North American Fenestration Standard/ Specification for windows, doors, and skylights (Canadian supplement CSA A440S1-09) was developed for window, door, and skylight performance, including permissible air leakage. This specification is generally consistent with building codes used throughout the United States.

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Source: NFRC

Water Performance

Water Resistance, Energy Efficiency and Total Performance

- Water Resistance measures the ability to prevent wind driven water from entering a unit.

Performance Standard

AAMA/WDMA/CSA 101/I.S.2/A440-08

The water penetration resistance test pressure is based on 20% of the design pressure (DP) for AW performance classes.

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Testing

The following organizations provide third party technical standards and performance ratings to insure consistent Quality, Energy Efficiency and Total Performance;

- AAMA/WDMA/CSA 101/I.S.2/A440, NAFS
- ASTM E283-04
- NFRC

AW and Life Cycle requirements determine durability of products which help to ensure that windows and doors continue to perform and do not lose energy over the life of the product due to air and water infiltration.

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AAMA Certification

LIFE CYCLE TESTING VERIFIES AW PRODUCT DURABILITY

- One criterion of product quality is its ability to maintain required or expected performance levels throughout a reasonably long service life.
- Life cycle tests, described in AAMA 910, employ accelerated testing methods to model the normal wear that can be expected due to the typical number of basic operating cycles and locking hardware opening/closing cycles experienced during the life of a typical AW class product. Loading conditions expected during washing, maintenance and the occasional, predictable misuse (such as improper operation or maintenance and excessive operating force) are also simulated.
- Air leakage and water penetration tests are conducted both before and after life-cycling and simulated misuse to evaluate any performance changes. In addition, there must be no damage to hardware and other components that would render the window inoperable.

Source: AAMA

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Finishes

High Performance Paint Coatings and High Grade Anodizing can extend the life of the units and the long-term performance by protecting Windows and Doors from the elements—sun, cold, UV radiation, moisture, acid rain, pollutants, salt etc.,

Standards for testing and performance of coatings on Architectural Aluminum Extrusions and Panels

AAMA - AMERICAN ARCHITECTURAL MANUFACTURERS ASSOCIATION

Voluntary Specifications:

Paint

- AAMA 2605
- AAMA 2604
- AAMA 2603

Anodized Architectural Aluminum

- AAMA 611

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Hardware

Hardware design and material type can affect the Energy Efficiency and Total Performance of units.

- Poor fitting inferior hardware and non durable materials can affect heat and cooling loss and the long-term operation of the units

Life Cycle testing can ensure durability of the products

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Conclusion

- Many organizations including federal, state and local governments are driving codes and standards for greater Energy Efficiency and Total Performance
- Many components affect the Energy Efficiency and Total Performance of Windows and Doors
- It's important to review how the Windows and Doors have been designed and look closely at:
  - Certifications obtained
  - The AAMA and NFRC Performance ratings
  - If the Glass package provides superior energy efficiency, performance, comfort and safety
  - If the units utilize an innovative Thermal Barrier and Spacer System that maximizes energy efficiency and performance
  - If the units feature a High Performance Frame

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Conclusion

Benefits of designing and selecting windows and doors for greater Energy Efficiency and Total Performance include:

- Increasing the Efficiency, Performance and Life of the Building and window and door products
- Reducing the heating and cooling loss in a building
- Improving the occupant's health, quality of life and safety
- Contributing to Green Building efforts and initiatives
- Helping to reduce depletion of oil and gas resources

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