Aluminum Windows and Doors: Thermally Broken Sash and Frames for Residential Projects

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Purpose and Learning Objectives

Purpose: Selecting energy-efficient fenestration products that promote comfort, daylighting and views, and natural ventilation while supporting environmental impact concerns can further discussions regarding resource efficiency, material manufacturing, waste reduction, and life cycle impact. This course examines the attributes of thermally broken aluminum windows and doors and explains why they are energy-efficient, sustainable fenestration products.

Learning Objectives: At the end of this program, participants will be able to:

- evaluate the unique properties and sustainable attributes of aluminum, and recognize why fenestration construction products fabricated from aluminum meet today's stringent energy and building codes
- examine the window design technologies that can impact a window's energy and long-term performance to determine how to balance sustainable design goals, aesthetics, and costs when selecting fenestration products for a building project
- review the design and construction of thermally broken aluminum windows and doors to determine how they can promote healthy living conditions for the occupants by improving indoor air quality and increasing natural daylight in a living space, and
- recall how the energy performance of a window is assessed to determine how thermally broken aluminum windows and doors can improve the interior and exterior built environment and contribute to earning credits under the LEED® certification program.

Contents

Introduction

Introduction

Aluminum fenestration products are specified for a range of market sectors, including residential, commercial, industrial, retail, education, healthcare, and historic replacement. This is because aluminum windows can meet the durability, thermal, daylighting, aesthetic, maintenance, longevity, and budget requirements of virtually any building project. Aluminum windows and doors can contribute to green building certification programs because they address environmental concerns regarding saving energy, reducing waste, resource efficiency, material recyclability, and product longevity.

Aluminum Windows

Aluminum windows were first used in streetcars, buses, and railroad cars c.1912 because they were weathertight and easy to operate and maintained their aesthetic. By the 1930s, they were being used in commercial buildings. Their hollow construction meant they were lighter than steel window construction, and their low maintenance requirements made them more appealing than wood window construction. Aluminum frames were used on tall buildings because they met the required aesthetics of the Art Deco movement and were strong enough to hold the large pieces of glazing being specified to maximize views.

Throughout the 1940s, aluminum windows were manufactured in greater numbers to support military applications and the war effort. By this time, a lighter-gauge aluminum was being used and aluminum windows were being fabricated in a wide variety of sizes and configurations. Joseph Eichler, one of the most influential builders of modern homes, utilized aluminum sliding doors in the 1950s and ’60s, and California Modern was born.

Aluminum Windows

The energy crisis of the 1970s motivated the construction industry to develop more efficient technologies. The fenestration industry found ways to improve the performance of glass, window seals, and framing systems. To reduce heat transfer through the framing, thermal breaks were added within a frame's structure. Environmental concerns and the stricter energy codes of the 2000s have pushed the fenestration industry to refine their designs and thermal break technology even further to make aluminum fenestration products, including windows, swinging doors, sliding doors, and window walls, more energy efficient and resilient.

Aluminum Fenestration Systems

There are many reasons why architects choose aluminum windows over other types, especially when large-format windows and doors or window walls are desired; but how do you select an aluminum window or door that is energy efficient and sustainable?

Let’s begin this discussion by looking at the physical and mechanical properties of aluminum that enable aluminum fenestration products to play a major role in making building envelopes energy efficient while meeting a project’s architectural requirements for shape and aesthetics.

Why Aluminum?

Aluminum

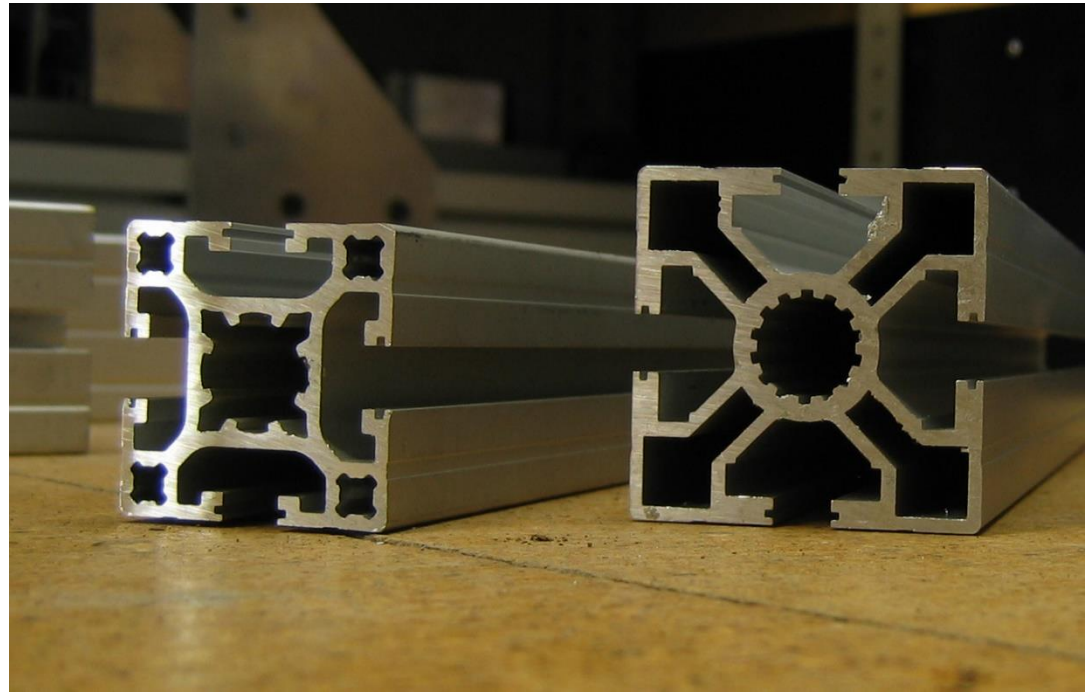
Aluminum is the most abundant metal found in the Earth's crust, although it does not commonly appear in its pure form in nature. It is derived from bauxite, a mineral that is mined, crushed, and processed before the aluminum raw material used for the fabrication of building products is created.

Aluminum metal is typically an alloy in which the aluminum has been combined with one or more other elements such as copper, magnesium, tin, zinc, or silicon to produce an aluminum metal with specific performance properties. Aluminum alloys can be formed into virtually any shape, size, and form, for structural and nonstructural uses, without compromising their integrity. For example, aluminum alloys can be formed into sheet and plate, foil, extrusions, forged and casted components, cable, and wire.

Aluminum Extrusions

The aluminum extrusion method is a forming process that is used to transform a cylindrical billet or log of alloyed aluminum into a simple or complex shape with a defined profile for a specific need. At the time of extrusion, the aluminum alloy is heated to the point that it becomes a malleable solid, allowing it to be pushed through solid, semihollow, or hollow dies. The shape and number of voids in the die will determine the thickness and profile of the extrusion.

Aluminum extrusions are typically designed to minimize or eliminate the need for machining—holes, notches, and surface designs can be easily integrated into the design of the die. If further machining is required, aluminum extrusions can finished, cut, bent, welded, or assembled to suit the appearance and physical performance needs of the end product.



Unique Properties of Aluminum Extrusions

Ease of fabrication and flexibility of design

Aluminum extrusions are versatile building products, making them ideally suited for the fenestration industry where tight tolerances for complex shapes with thin walls are required. The wide range of surface treatments and colors available means they can meet the aesthetic requirements of industrial, commercial, and residential building projects.

Sources: Aluminum Extruders Council and The Aluminum Association

Unique Properties of Aluminum Extrusions

Low density and light weight

The atomic number of aluminum (Al) is 13 and its standard atomic mass is 27. This means aluminum is lightweight—about one-third the weight of iron or steel.

Strength and high strength-to-weight ratio

Aluminum alloys can be made to be extremely strong—stronger than steel in some cases, with tensile strengths as high as 90,000 psi. This means aluminum extrusions for the fenestration industry can accommodate large expanses of glass and resist deformation caused by extreme weather elements or building movement typical in seismic or hurricane zones. Aluminum's high strength-to-weight ratio means aluminum extrusions can be used in residential window wall systems or applications such as curtain walls in residential and commercial projects. One-piece aluminum extrusions are seamless and stronger than comparable assemblies that must rely on mechanical joining to retain their strength and structural integrity.

Sources: Aluminum Extruders Council and The Aluminum Association

Unique Properties of Aluminum Extrusions

Corrosion resistance

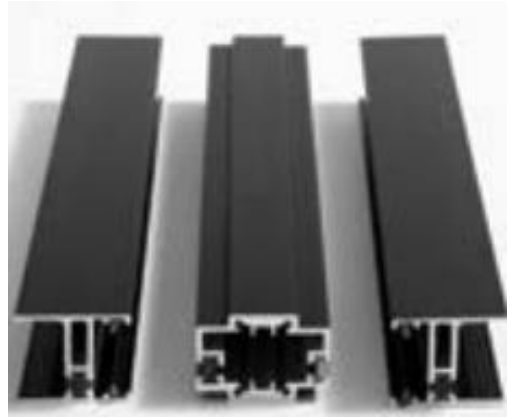
Aluminum extrusions do not rust and are protected by aluminum's naturally occurring, inert oxide film. This means aluminum fenestration products can retain their aesthetic while being exposed to a wide range of environmental conditions.

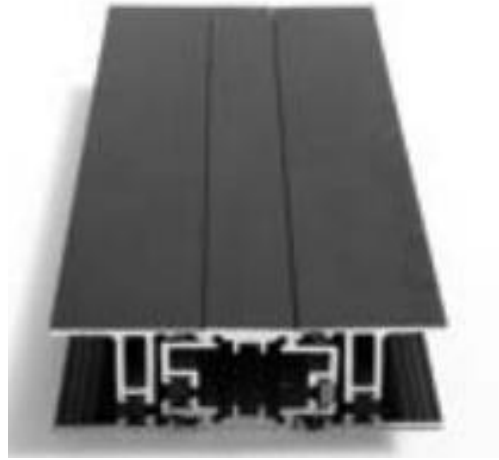
Noncombustible and nontoxic

Aluminum extrusions do not burn and do not produce toxic fumes if exposed to high temperatures. While in use, aluminum extrusions do not negatively impact the environment or the building occupants.

Resilient and stable

Aluminum extrusions will not crack, rot, or flake. They will not warp in warm weather conditions, and they become stronger in cold weather climates.





Sources: Aluminum Extruders Council and The Aluminum Association

Unique Properties of Aluminum Extrusions

Recyclable and sustainable

Aluminium is 100% recyclable and is one of the most recycled metals in the construction industry. It can be recycled an infinite number of times without loss of structural properties. Nearly 75% of all aluminum ever produced is still in use today. Producing recycled aluminum is 92% more energy efficient than making new aluminum.

Because aluminum extrusions are lightweight, more product can be transported in one shipment, reducing transportation costs and emissions. Thermally broken aluminum windows and doors can help to reduce energy consumption in homes and commercial buildings, as will be shown later in the presentation.

Due to aluminum's abundance in the Earth's crust, ease of scrap recovery, high rate of recyclability, durability, and longevity, it is considered an economically and environmentally sustainable material.

Sources: Aluminum Extruders Council and The Aluminum Association

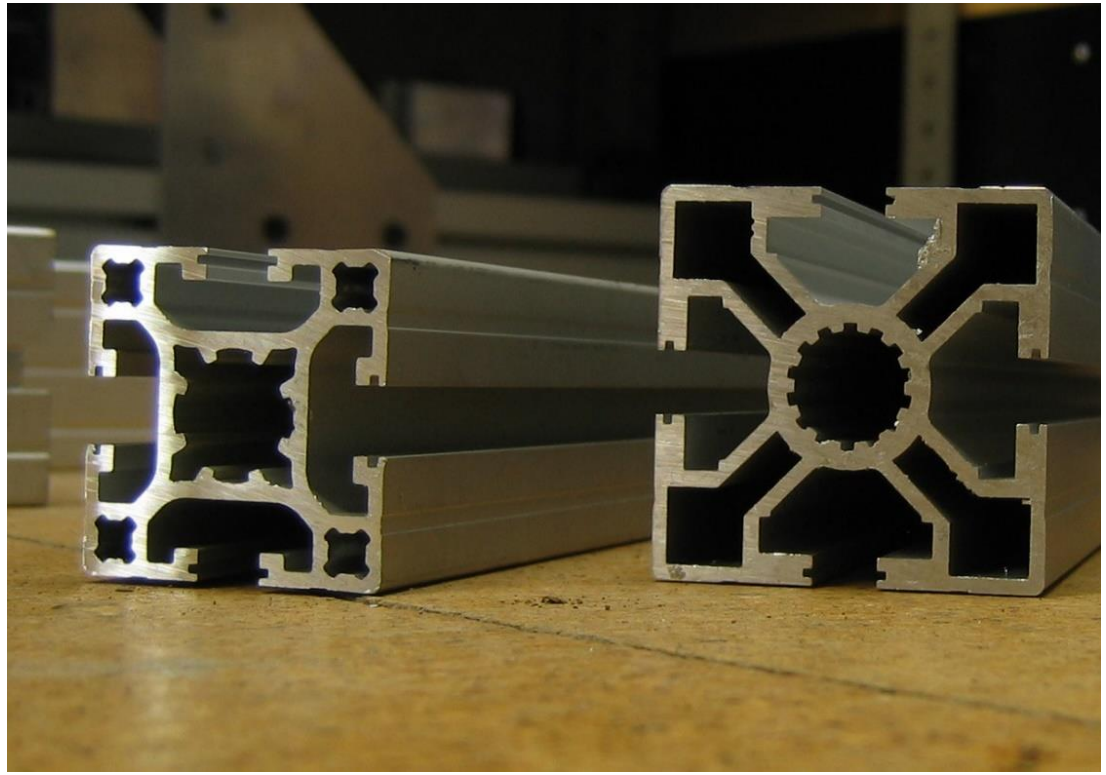
Review Question

What is an aluminum extrusion and what advantage does it offer the construction industry?

Answer

The aluminum extrusion method is a forming process that is used to transform a cylindrical billet or log of alloyed aluminum into a simple or complex shape with a defined profile for a specific need.

Aluminum extrusions are typically designed to minimize or eliminate the need for machining—holes, notches, and surface designs can be easily integrated into the design of the die.



Achieving Energy Efficiency

Thermal Performance of Fenestration

All fenestration (windows, skylights, and doors) must be rated according to the requirements of the National Fenestration Rating Council (NFRC) with respect to the performance of the fenestration in the (mandatory) categories of U-factor, solar heat gain coefficient (SHGC), and visible light transmittance (VT).

One thing to remember is that the frame is a small part of the surface area of an aluminum window or door, and the type of glazing selected contributes a great deal to the overall efficiency of the fenestration product. Double insulating units, gas-filled spaces, triple glazing, energy-efficient coatings, seamless surfaces, and innovative thermal break design technologies enable aluminum windows to meet today's energy efficiency requirements.

NFRC ratings account for the performance of a whole window or door assembly (frame/mullion/spacer/glazing system) and their labels are designed to help consumers compare the energy performance of fenestration products.

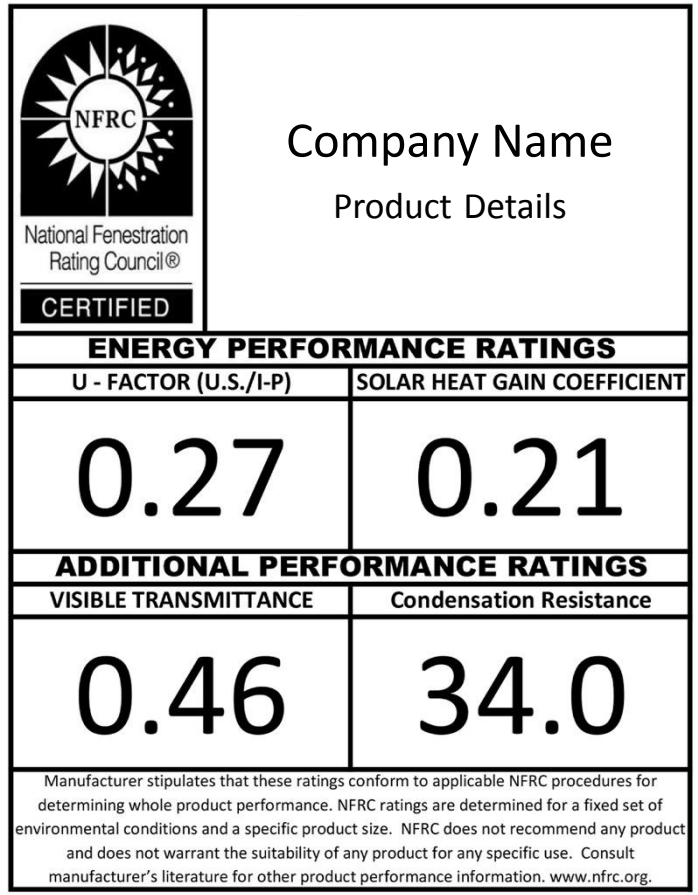
Energy Efficiency: NFRC Label

To the right is an example of an NFRC label for a fixed window.

U-factor is a measure of a window's resistance to heat flow (how well a window prevents heat from leaving the interior). U-factor indicates rate of heat loss, and values can range from 0.20 to 1.20. The lower the number the better the window resists heat flow (insulates).

Solar heat gain coefficient (SHGC) is a measure of how well a window can resist the transmittance and absorption of solar heat gain. SHGC values range from 0 to 1, and the lower the number the better the window performs.

Visible transmittance (VT) is a measure of the amount of visible or natural light a window lets in. VT values range from 0 to 1, and the higher the number the more effective the window is at lighting an interior space with daylight.



Example: NFRC window label

Energy Efficiency

In addition to the mandatory NFRC ratings, the fenestration industry also evaluates a window's energy performance by determining how much air will enter a space through the window and by measuring its R-value, condensation resistance, and fading transmission. Air leakage and condensation resistance are NFRC optional ratings.

An **air leakage (AL)** rating is a measure of the amount of air that passes through (via cracks or gaps) a window assembly.

R-value is a measure of the window's resistance to the passage of heat. It is the inverse of the U-factor.

Condensation resistance (CR) is a measure of how well a window resists the formation of condensation on the inside surface. CR values range from 0 to100, and the higher the number the better the window performs.

Fading transmission is a measure of how much fade-causing solar radiation passes through a window.

Role of Thermal Break Systems

Thermal conductivity is the rate of transfer of heat through a given material. Aluminum is a good conductor of heat and has a high thermal conductivity—its only shortcoming when used in fenestration products. To reduce the thermal conductivity of an aluminum fenestration product, a thermal break must be included in its design.

A thermal break is a component of relatively low conductivity that is used to separate two components of a window or a door (e.g., aluminum profiles) with a high conductivity to eliminate or reduce the rate of heat transfer through a window or door product. An effective thermal break will improve the product's U-factor and resistance to condensation.

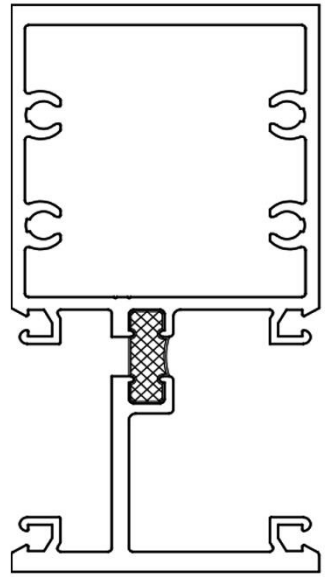
There are two main types of thermal break technology used in aluminum fenestration in North America: polyurethane and polyamide. They differ in how they are incorporated into the fenestration product and in the way they perform.

Sources: Aluminum Material Council. "Aluminum: The Total Solution for Sustainable, Strong, and Efficient Commercial Building Design." American Architectural Manufacturers Association (AAMA), AMC-1-13, n.d.

Polyurethane Thermal Break Systems

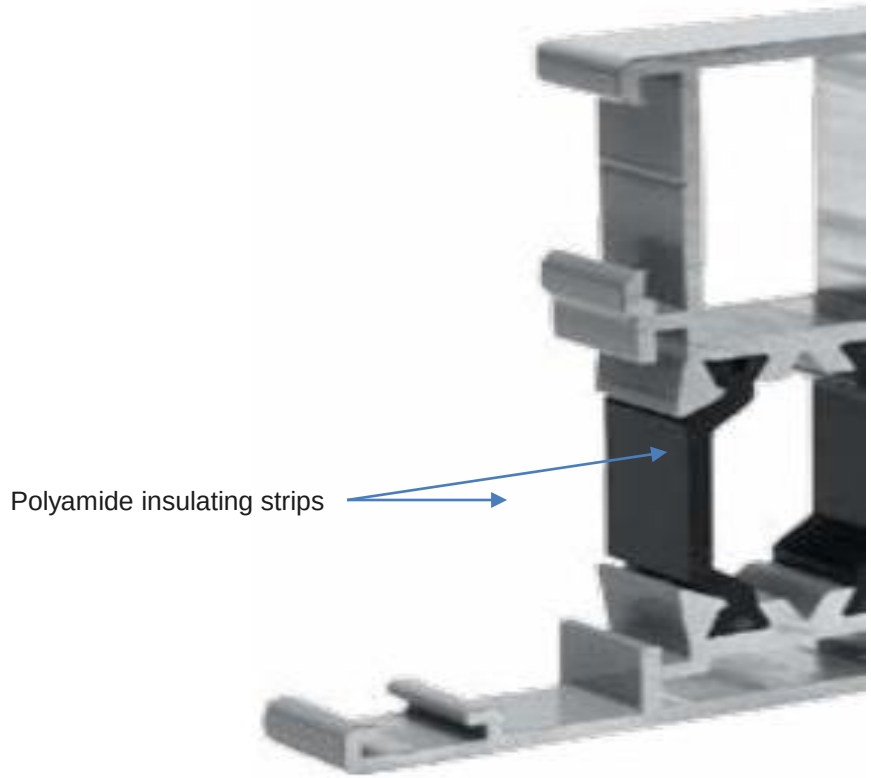
A polyurethane thermal break system, also known as a polyurethane pour and debridge (P & D) system, allows for an aluminum extrusion profile to be designed and extruded with a strategically placed channel to accept and encapsulate an insulating polymer (a liquid polyurethane polymer resin that is poured into the pocket and hardens almost immediately). The underside of the cavity is then “debridged” or saw cut about 1/8″ to 3/16″ wide along the length of the extrusion to separate both sides of the aluminum. This causes both sides of the aluminum extrusion to be separated by a nonconductive material and thus prevent thermal conductivity from one side of the extrusion to the other.

Polyurethane systems are strong and can support wide spans of glazing. They may be available as either single- or double-pour and debridge systems to accommodate different types of glass and the performance needs of a specific project.

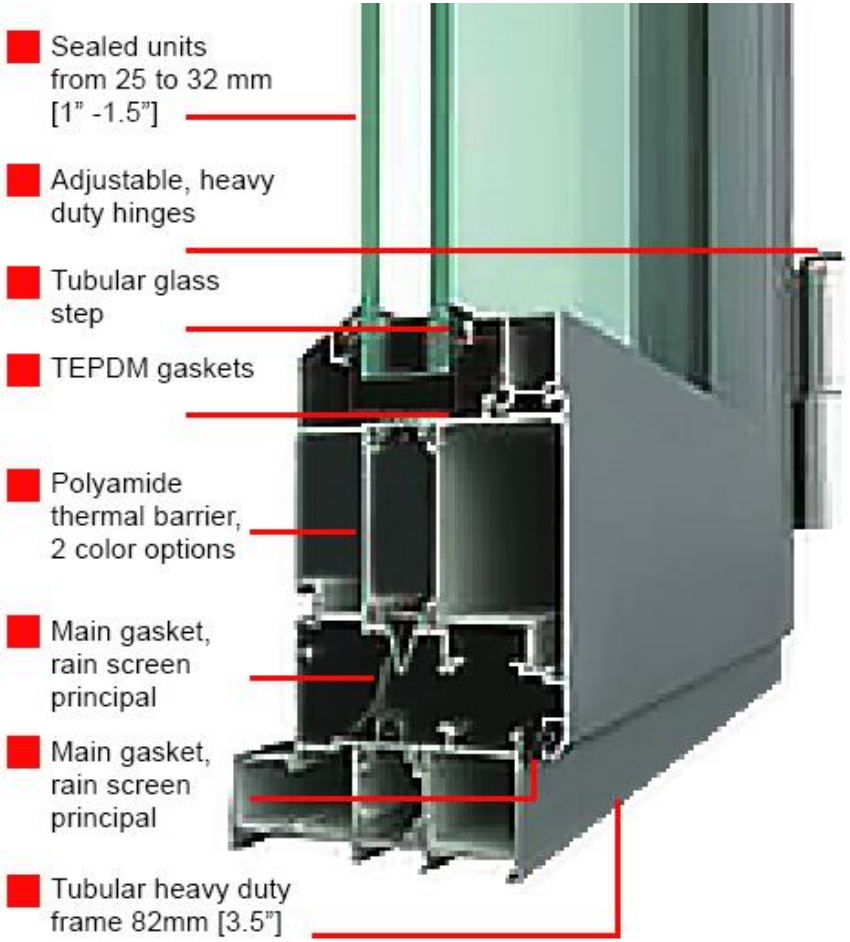


Polyamide Thermal Break Systems

Polyamide thermal break systems, also known as thermal strut systems, use polyamide insulating strips to separate and secure the interior and exterior sections of aluminum profile extrusions. Thermal strut systems comprise two separate extrusions joined together through the use of engineered structural plastic struts. Both the inside and outside aluminum profiles are extruded independently with a cavity that will ultimately receive the strut.

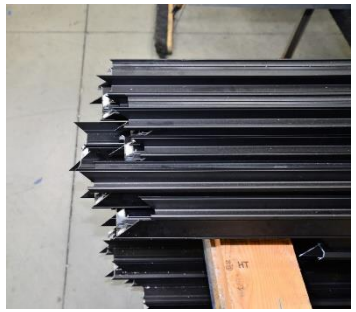


Example: Polyamide Thermal Break System



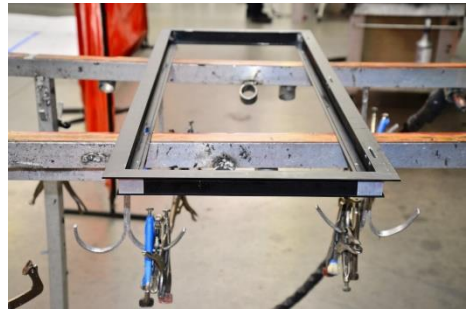
Example: Fabrication of Thermally Broken Aluminum Windows

The 24′ extrusions are anodized or painted and then received by the manufacturing facility.



Profiles are cut to the appropriate length.

Computer numerical control (CNC) equipment is used to drill holes into the profiles for assembly points, hardware, etc.



Frames are assembled from cut and drilled profiles with screws, or the corners are crimped.

Welding is done, if required. Mullions and hardware are installed.

Example: Fabrication of Thermally Broken Aluminum Windows

Glass is received and inspected for quality.

Glass is inserted into the frame using rubber gaskets and sealants. Precut, simulated divided lites are applied to the product. Next, NFRC labels are applied.

Factory glazing of thermally broken aluminum windows and doors allows for the use of structural glazing techniques and control over the squareness of the assembly, ensuring a correct fit and sightline. Structural glazing contributes to the overall strength and structural integrity of the unit. By structurally bonding the glass to the frame, a weathertight seal is created.

Glazing

Thermally broken aluminum windows and doors should be specified to meet the comfort levels required by the application and local climate.

Glazing options typically include single glazed, dual glazed, and triple glazed. When selecting a given glass makeup, consider the thickness of the panes of glass and the overall thickness of the system (glass plus the spacer).

Dual glazed

1″ overall glass thickness

Glass makeup
¼″ x ½″ x ¼″

Triple glazed

1½″ overall glass thickness

Glass makeup
¼″ x ⅜″ x ¼″ x ⅜″ x ¼″

Glazing

The type of glass selected for a structure will depend on the needs of the project. Considerations may include the solar and energy needs of the climate, sound control, fade and ultraviolet (UV) light protection, privacy needs, and safety and security.

Glass options may include:

- clear tempered (heat strengthened)
- clear laminated (two or more pieces bonded together)
- tinted or frosted, e.g., gray or bronze
- low-E coated, and
- custom glass types, e.g., textured.

Glazing: Low-E Coatings and Tints

Low-emissivity or low-E coatings are made up of one or more thin, almost invisible, layers of metal or metallic oxide. They are applied to one or more of the panes of glass and are capable of reflecting solar and ambient heat from the interior and exterior. Low-E glass is designed to admit visible light and keep the heat inside during winter and outside during the summer. According to the Department of Energy's (DOE's) *Energy Saver* website, windows manufactured with low-E coatings may cost 10% to 15% more than regular windows, but they reduce energy loss by as much as 30% to 50%.

Spectrally selective low-E coatings are special types of low-E coatings that have been manipulated so that specific wavelengths of the energy-light spectrum (UV and infrared light) are transmitted and others are reflected. Because these coatings do not admit heat, they create a window with a low U-factor and a low SHGC. In addition, this type of advanced window glazing can maintain higher interior glass temperature than other types of glass, increasing occupant thermal comfort levels even in cold weather climates.

Tinted glass can also cut solar heat gain, reducing energy consumption and creating comfortable interiors. The tint does not impact a product's U-factor, but it does reduces glare, a benefit in climates with months of intense sunlight.

Gas Fills and Spacers

Heat loss through fenestration products can be further reduced by filling the airspace between the glazing layers with an inert gas such as argon or krypton. The gas will slow down air movement and help to prevent heat loss. Krypton costs more than argon, but it has been shown to have a higher thermal performance, and it works well between thin panes of glass—a benefit when the weight of a window or door system is a design concern.

Spacers are used to insulate the edges of a sealed glass unit and control the thickness of the space between the panes of glass. The material used for the spacer will impact the energy performance of the product and determine how well the product can accommodate pressure differences and stress and resist fog and condensation. A warm-edge spacer is one that improves the thermal performance of the window. This means that in an aluminum product, the spacer may fabricated from stainless steel (it is less conductive than aluminum), a polymer, or a silicone foam.

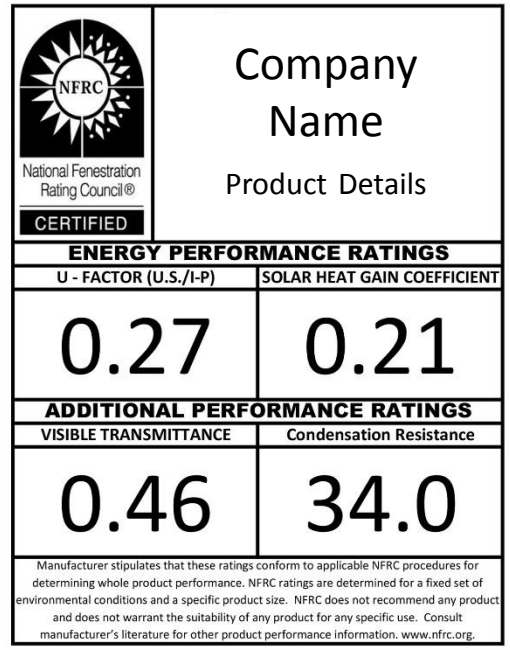
Review Question

What three mandatory performance categories must all fenestration be rated to according to the requirements of the NFRC?

Answer

All fenestration must be rated according to the NFRC with respect to the performance of the fenestration in the (mandatory) categories of:

- ***U-factor***
- ***solar heat gain coefficient (SHGC), and***
- ***visible light transmittance (VT).***



Example: NFRC window label

Performance Beyond Energy Efficiency

Resilience

Aluminum fenestration products can be fabricated to be both hurricane and blast/impact resistant.

The glass and the frame of a window or door each play a role in ensuring an assembly can protect the home or building from strong winds and airborne debris. While the glass is more likely to experience the initial impact of airborne debris or a wind force, the frame must be able to hold the glass in place, even if it fractures.

The design pressure rating of a fenestration product identifies the amount of wind load or blast the product has been tested to withstand and is expressed in pounds per square foot (psf) of wind pressure. Wind load charts provide a basic structural analysis tool based on engineering calculations for stress and deflection. A professional engineer should be consulted to review design and installation requirements to meet a specific application.

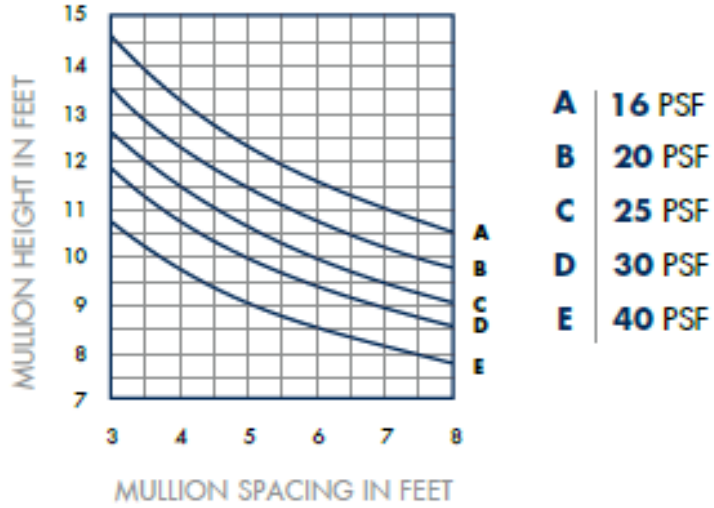
Source: “Impact and Blast Protection.” American Architectural Manufacturers Association (AAMA).

Resilience

Mullions are horizontal or vertical members that are used to permanently connect smaller windows together to create a larger unit. They also allow different types of fixed or operable windows and doors to be connected in the same opening. Mullions that run vertically are typically structural elements, whereas horizontal mullions can be a structural component or an integral, nonstructural part of a unit. Narrow, shared, integral mullions can delicately divide fixed glass and operating windows to create a seamless wall of glass.

Mullions are assumed to be single-span, simple beam elements, uniformly loaded and adequately braced to prevent lateral torsional buckling. A design professional should be consulted to confirm that no lite of glass deflects more than H/175 or 3/4″, whichever is less, where H indicates the height of glass.

Example: Wind load chart



Wind load pressure determinations should be per ASCE 7, “Minimum Design Loads and Associated Criteria for Buildings and Other Structures,” and according to local governing codes.

Water Penetration Resistance

The water penetration resistance test method is ASTM E547, “Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference.” Fenestration products designed for use in high-rise and midrise buildings must also pass ASTM E331, “Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference.”

Test samples are installed according to a manufacturer’s instructions and then subjected to wind-driven rain under controlled conditions. During testing, no water can penetrate a vertical plane located at the innermost surface of the frame. Because laboratory testing cannot account for poor installation techniques, weather events, or wind pressure that exceeds that which the product was tested for, the American Architectural Manufacturers Association (AAMA) has created field testing methods, e.g., AAMA 502, “Voluntary Specification for Field Testing of Newly Installed Fenestration Products.”

Air Leakage Resistance

Air leakage resistance is tested in accordance with ASTM E283, “Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.”

It is important to remember that several factors will determine how well a product can resist air leakage, including:

- the type of product (different types of windows and doors allow for different air infiltration rates)
- the installed location of the product (different sides of a home or building can be exposed to different environmental conditions), and
- how a product was installed (the product should be square, level, and plumb and installed per a manufacturer’s instructions).

LEED®

The Leadership in Energy and Environmental Design (LEED®) rating system was developed by the U.S. Green Building Council (USGBC). LEED is the preeminent program for the design, construction, maintenance, and operations of high-performance green buildings. To further the discussion about the sustainable attributes of aluminum fenestration, the following slides identify some typical LEED v4 credits in the Building Design and Construction rating system to which aluminum windows and doors may contribute to and help a building project earn LEED certification.

Consult individual manufacturers for specific details about their products.

LEED v4 Credits: Energy and Atmosphere (EA)

EA Prerequisite: Minimum Energy Performance
Aluminum windows and doors are energy efficient and glazed with high-performance glass to maximize energy performance. They reduce air leakage and all three types of heat transfer: radiation through the glazing, conduction through the spacer bars, and conduction through the window frame.

EA Credit: Optimize Energy Performance
Aluminum framing systems can accommodate double-pane and triple-pane glass. Aluminum windows and doors meet ENERGY STAR® qualification standards, including specific U-factor and SHGC performance values, contained in NFRC reports.

EA Credit: Renewable Energy Production
Aluminum window and door performance values are NFRC certified and can be used to achieve desired goals in these sections.

LEED v4 Credits: Materials and Resources (MR)

MR Credit: Building Product Disclosure and Optimization – Environmental Product Declarations

This credit encourages the use of products for which life cycle data is available. To recycle scrap aluminium takes only 5% of the energy that was required to produce the original metal. Up-to-date life cycle data and environmental product declarations (EPDs) may be available from a manufacturer and from organizations such as The Aluminum Association, the International Aluminum Institute, and the Aluminum Extruders Council.

The 2015 report, “Aluminum and Life Cycle Thinking. Towards Sustainable Cities,” published by the International Aluminum Institute, compared life cycle data of four types of window unit frames: aluminum, wood, aluminum-clad wood, and unplasticized PVC. The study found:

- well-maintained aluminum window frames to be the least environmentally impactful option across all categories
- the global warming potential (GWP) of a moderately maintained aluminum assembly was 68% less than PVCu and 50% less than aluminum-clad wood, and
- moderately and well-maintained aluminum windows require less energy to be produced and maintained over their lifetimes than any of the wood scenarios.

LEED v4 Credits: Materials and Resources (MR)

MR Credit: Building Product Disclosure and Optimization – Sourcing of Raw Materials
This credit looks for products that have environmentally, economically, and socially preferable life cycle impacts. Aluminum extrusions can contain 40%–50% postconsumer recycled content.

MR Credit: Building Product Disclosure and Optimization – Material Ingredients
Ask the manufacturer whether they have voluntary ingredient reporting that demonstrates the chemical inventory of their products.

MR Credit: Construction and Demolition Waste Management
Aluminum scrap and old aluminum windows and doors can be diverted from landfill. Aluminum can be recaptured and recycled into new metal.

LEED v4 Credits: Indoor Environmental Quality (EQ)

EQ Prerequisite: Minimum Indoor Air Quality Performance
Operable aluminum windows and doors can contribute to a natural ventilation strategy and allow occupants to control an opening.

EQ Credit: Enhanced Indoor Air Quality Strategies
Aluminum windows and doors can be an integral part of an indoor air quality strategy.

EQ Credit: Low-Emitting Materials
A durable paint or coating system for an aluminum window can produce no or low volatile organic compound (VOC) emissions.

EQ Credit: Thermal Comfort
Operable aluminum windows and doors provide occupants with thermal comfort control. Allowing occupants to control the thermal comfort of their indoor space can improve their well-being and productivity.

LEED v4 Credits: Indoor Environmental Quality (EQ)

EQ Credit: Daylight
With their narrow sightlines, aluminum windows and doors can maximize interior daylight and reduce the use of electrical lighting.

LEED v4 Credits: Indoor Environmental Quality (EQ)

EQ Credit: Quality Views
Aluminum windows can give building occupants a connection to the natural outdoor environment by providing quality views. Aluminum extrusions can support large expanses of glass to help maximize the largest achievable view.

EQ Credit: Acoustic Performance
Window wall systems can meet the sound transmission class (STC) rating determined in accordance with applicable ASTM standards, e.g., ASTM E413, “Classification for Rating Sound Insulation.”

Review Question

What are mullions and what purpose do they serve in a window system?

Answer

Mullions are horizontal or vertical members that are used to permanently connect smaller windows together to create a larger unit.

Mullions allow different types of fixed or operable windows and doors to be connected in the same opening. Mullions that run vertically are typically structural elements, whereas horizontal mullions can be a structural component or an integral, nonstructural part of a unit.

Narrow, shared, integral mullions can delicately divide fixed glass and operating windows to create a seamless wall of glass.

Design Options

Fixed Windows

Featuring narrow sightlines, fixed windows are designed to let in light and frame beautiful, broad views. This nonoperational, thermally broken window is ideal for modern luxury homes with high or vaulted ceilings or used with other windows throughout the home.

Casement Windows

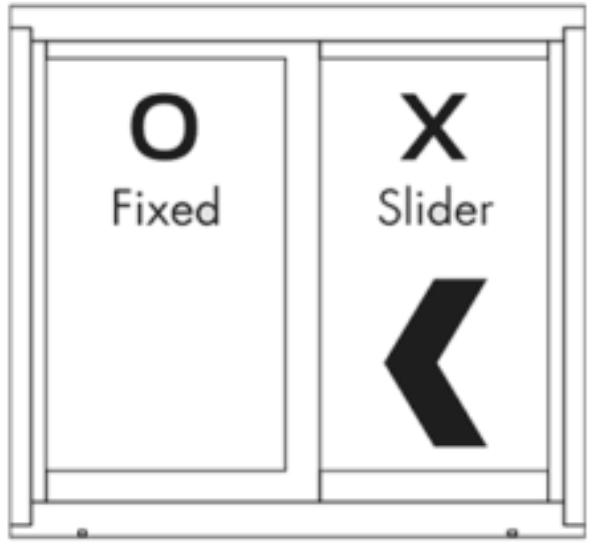
With crank-out or push-out operation, casement windows can be easily used to direct breezes inside for better ventilation in any location. These windows can also be coupled seamlessly to doors and other windows. Deeper frames, such as 3¼″, can accommodate larger-sized windows and triple-glazed glass to meet the energy efficiency needs of the application.

Awning and Hopper Windows

Awning and hopper windows provide easy ventilation and complement other window styles throughout modern luxury homes. Venting windows are thermally broken with awning windows opening outward, away from the home, while hopper windows open inward into the home.

Sliding Windows

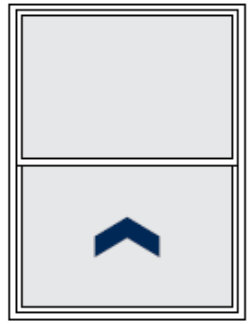
Sliding windows offer contemporary design, easy functionality, and optimum ventilation for homes of all types.



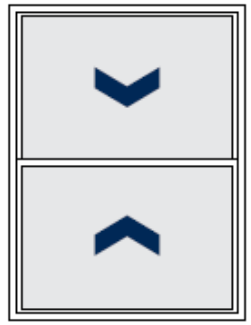
May be available as XO, OOX, OXO, OXXO, and XOOX configurations.

Single- and Double-Hung Windows

Single- and double-hung windows are very popular due to their versatility and function, especially in traditional architectural style. In a single-hung window, the lower sash is operable and lifts up, with the upper sash always being fixed, whereas the double-hung configuration allows both sashes to operate.



Single hung



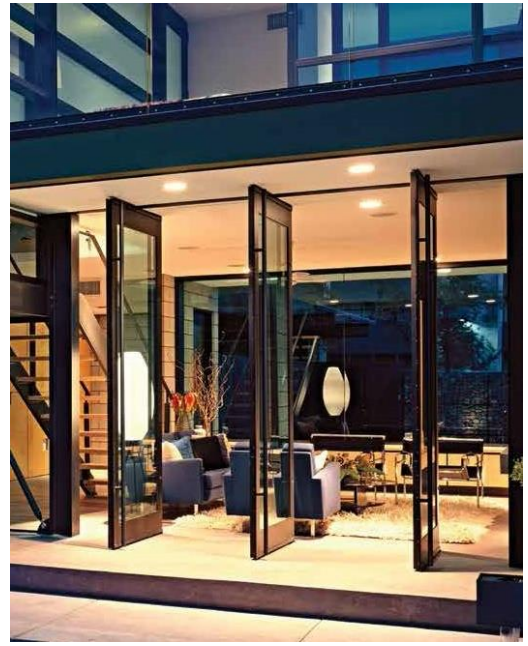
Double hung

Steel-Look Aluminum Windows

Steel-look aluminum products are very similar to traditional steel systems and more than simply “steel-look” products. Thermally broken and artistically designed, the products retain many of the features and aesthetics of classic steel windows. What makes them really look like steel is the narrow frame depth, the lock box synonymous with traditional steel doors, the beveled glass stop, and a beveled muntin that simulates the look of original “putty” glazed windows. Steel-look aluminum products can be combined with steel window products, increasing their design flexibility. Consult individual manufacturers for specific details about their products.

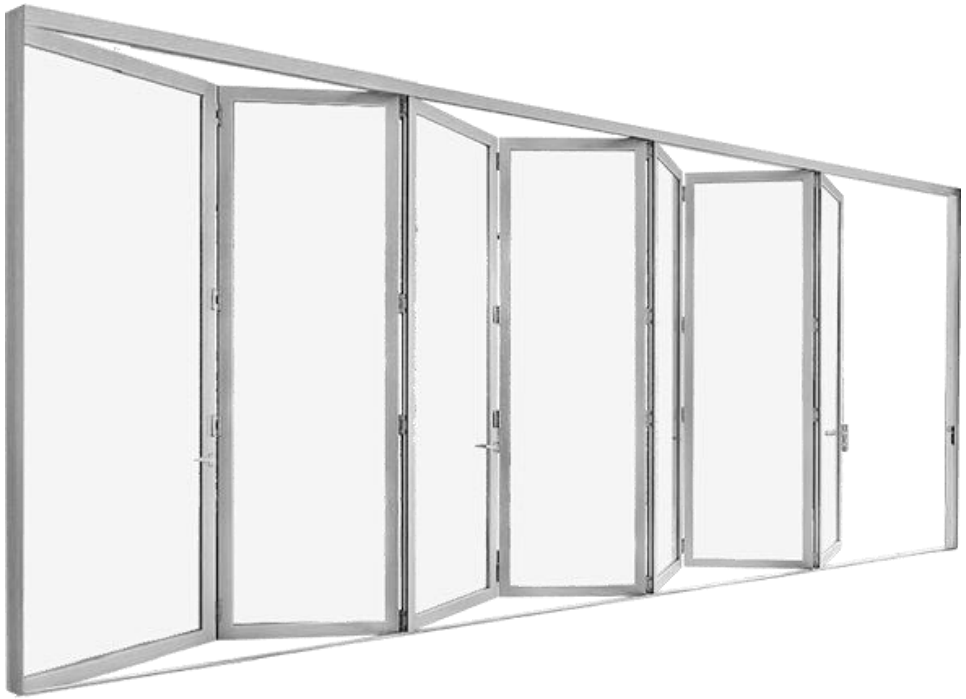
Swing Doors

With the option of inswing or outswing entry, installed as a single door or in pairs, or configured with transoms or sidelites, entrance or French swing doors are the epitome of versatility combined with elegant simplicity. Slim sightlines allow them to seamlessly incorporate into a variety of window wall configurations or serve as a stand-alone door. A pivot door is perfectly balanced to effortlessly swing open in dramatic fashion. A heavy-duty concealed floor and header, center-hung, pivot hardware set allows for the installation of a completely functional, large statement door.



Swing Doors

A multifold door is a top-hung system for large openings. The door panels can be folded away to reveal an uninterrupted view when open, yet remain in the same plane when closed. Removing the need for fixed panels or structural posts allows for maximum sunlight and fresh air to enter the room.



Sliding Doors

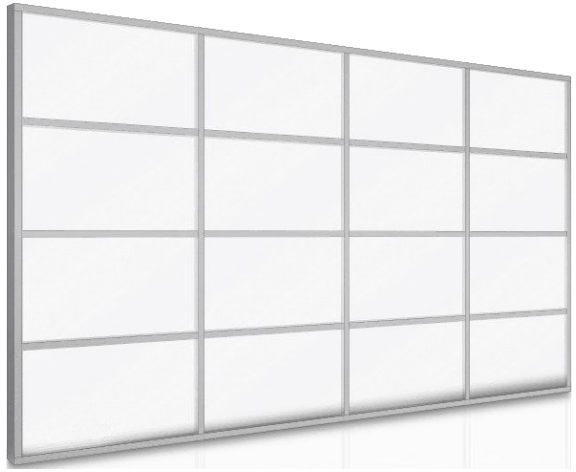
Sliding doors have earned a reputation as the most versatile and practical door type for access to decks and patios. They also score highly for delivering expansive views while remaining cost effective.

They offer security and strength with sleek profiles. Smooth and effortless sliding is typically achieved through high-performance rollers. A range of configurations may be available, from two-panel and three-panel sliders to multisliding and pocketing door systems.

Window and Curtain Walls

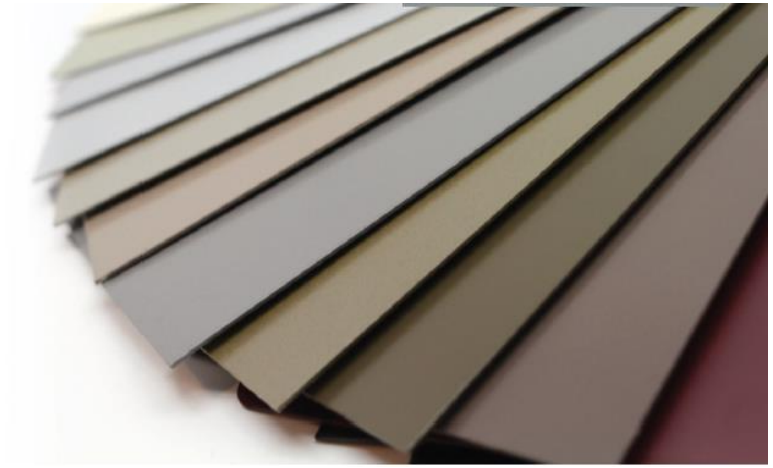
Flexible and functional, window and curtain wall systems allow the homeowner to select just the right combination of fixed glass, operating windows, and doors to create the configuration that most complements their home and the surrounding landscape.

Curtain walls are designed and engineered for extreme expanses of glass. The systems used in commercial high-rise buildings can be tailored for modern, residential use. Entire facades of glass can be designed to meet a variety of size, design, and wind load criteria to suit a residential application.



Finish Options

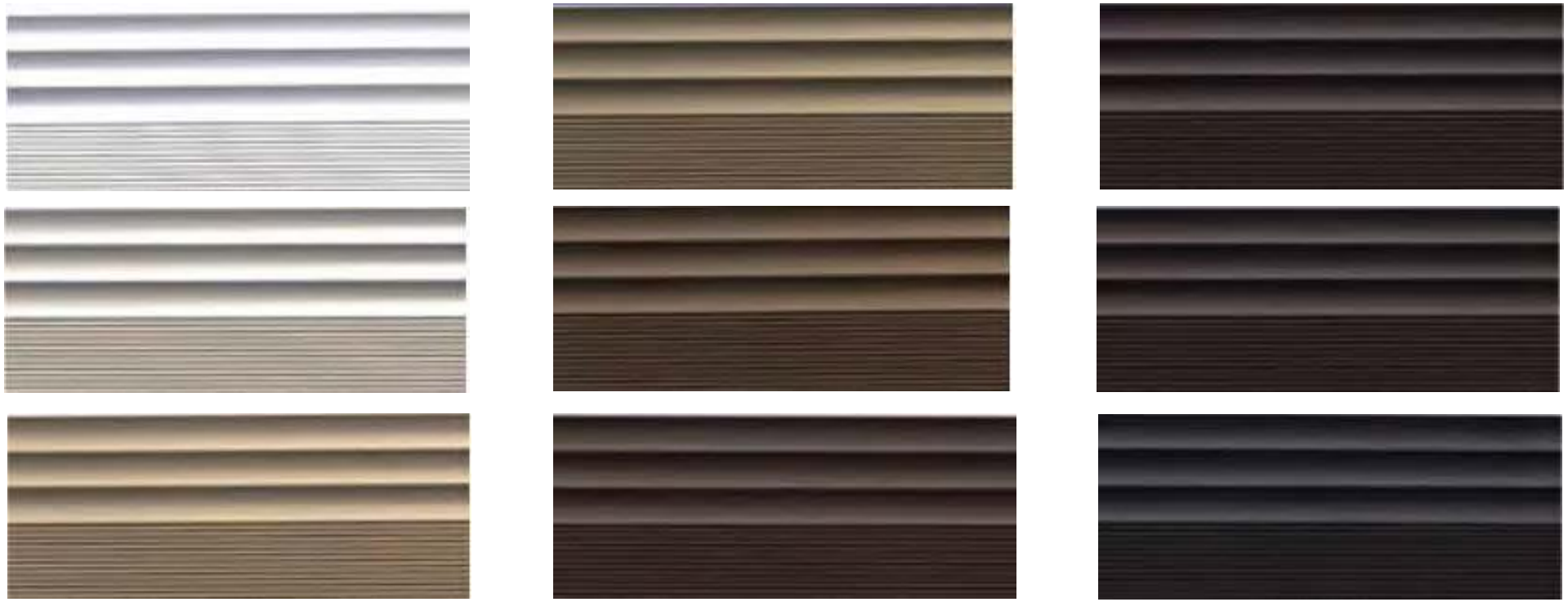
Aluminum windows and doors can be personalized to fit the look of a home. Many manufacturers will offer an anodized or painted finish color.
The AAMA has developed standards for the testing and performance of coatings applied to metal (aluminum) extrusions.



- AAMA 611, “Voluntary Specification for Anodized Architectural Aluminum”
- AAMA 612, “Voluntary Specification, Performance Requirements, and Test Procedures for Combined Coatings of Anodic Oxide and Transparent Organic Coatings on Architectural Aluminum”
- AAMA 2603, “Voluntary Specification, Performance Requirements, and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels,” addresses standard polyester coatings
- AAMA 2604, “Voluntary Specification, Performance Requirements, and Test Procedures for High-Performance Organic Coatings on Aluminum Extrusions and Panels,” addresses SMP paint systems
- AAMA 2605, “Voluntary Specification, Performance Requirements, and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels,” typically applies to 70% PVDF coatings

Finish Options: Anodized

Anodizing is a process in which the aluminum is submerged in electrically charged acid. This creates a chemical reaction that darkens the aluminum, giving it color and creating a very hard surface. The process and result is somewhat artistic and can create some color variation in the finish and from part to part. Since anodized color is influenced by the alloy, if exact color uniformity is desired, a painted anodized finish is a better choice.



Finish Options: Paint

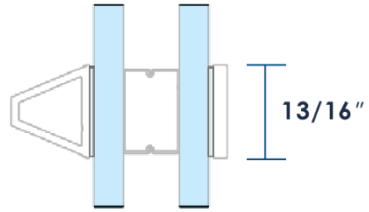
Aluminum frames can be finished with a two-coat paint system. The process consists of cleaning and pretreating the aluminum surface, a primer coat, then a baked-on color coat. A fluoropolymer paint system containing 70% polyvinylidene fluoride (PVDF) resin will provide protection against weathering, aging, and pollution. This type of paint finish can resist dirt pickup, chalking, and fading, and since it also adheres well while maintaining some flexibility, it can resist chipping, cracking, and crazing. Custom colors may be available from some manufacturers.

Muntins

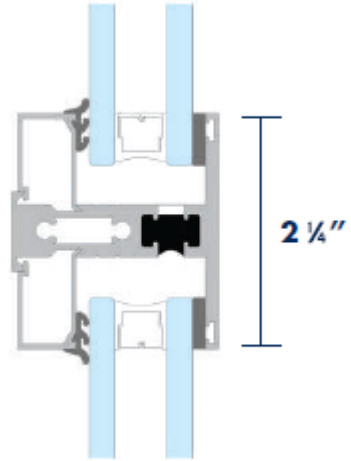
Muntins are narrow glazing bars that are used to divide individual panes of glass. There are two ways to apply muntins to achieve a window with a divided lite pattern.

True divided lite (TDL) windows comprise multiple, small panes of glass with muntins in between the individual panes. Unlike a mullion, muntins in TDL windows do not carry a load.

Simulated divided lite (SDL) windows comprise a single pane of glass with the muntins mounted on the glass—essentially achieving the look of a TDL window. In an insulating glass (IG) unit, shadow bars may be sandwiched between the panes to create the look of a TDL window.

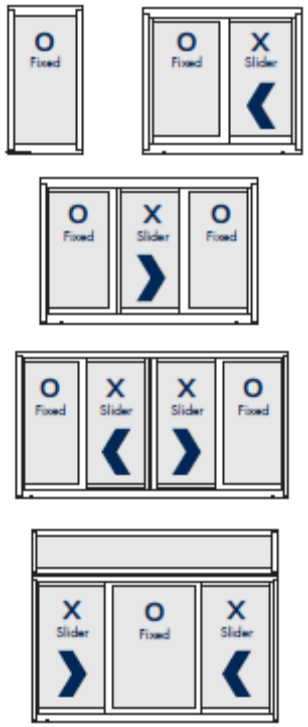


SDL – Window detail



TDL – Window detail

Examples: Window Configuration Options



Fixed and sliding window system in 1-, 2-, 3-, or 4-window configurations

Fixed and awning/hopper windows

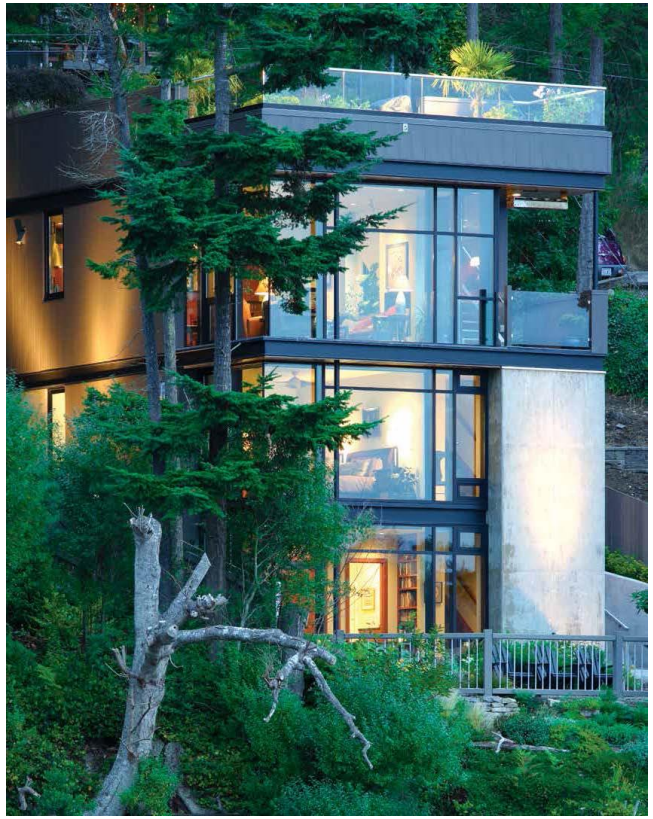
Fixed and casement windows

Fixed windows

Examples: Window Configuration Options

Fixed glass can be combined with any of the following windows and doors to create a window wall or a curtain wall (in excess of 50′ wide and 30′ high, with spans between mullions up to 8′ wide):

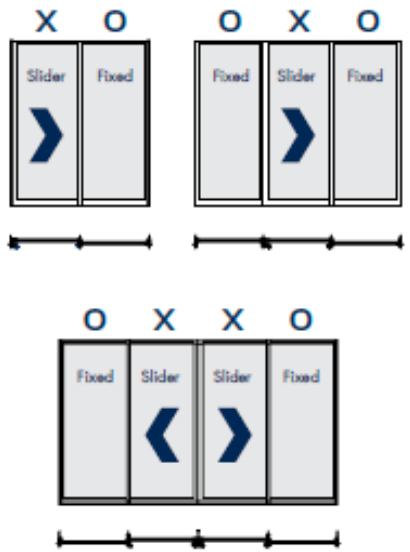
- operating window
- sliding window
- terrace door
- entrance door
- sliding door



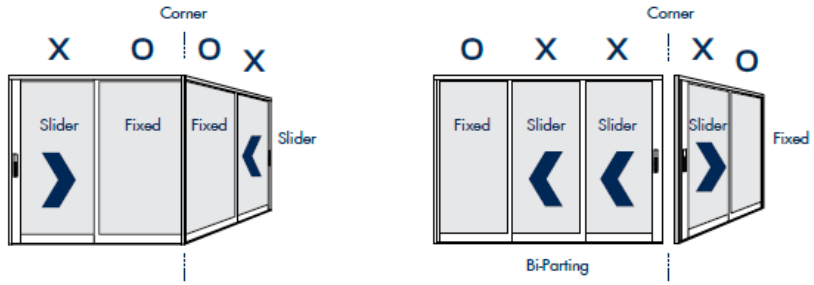
Window wall with fixed glass and awnings

Window wall with fixed glass

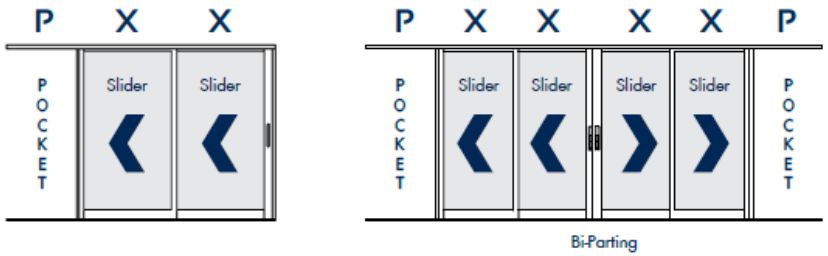
Examples: Door Configuration Options



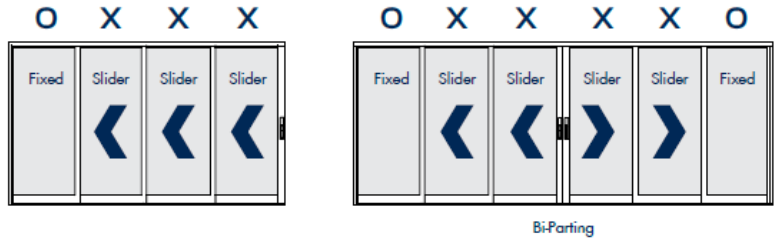
Sliding glass door system in 2-, 3-, or 4-door configurations



Multislide door systems: corner



Multislide door systems: pocket



Multislide door systems: wall-to-wall jamb

Corner pocketing sliding door

Examples: Door Configuration Options

Multifold door systems: up to 8 folding doors in either direction, with operable daily use or main door. Individual door panels may be up to 39″ wide, 10′ tall. Overall length a maximum of 50′ wide, 10′ tall, with up to 16 door panels.

Please remember the **test password OPTION**. You will be required to enter it in order to proceed with the online test.

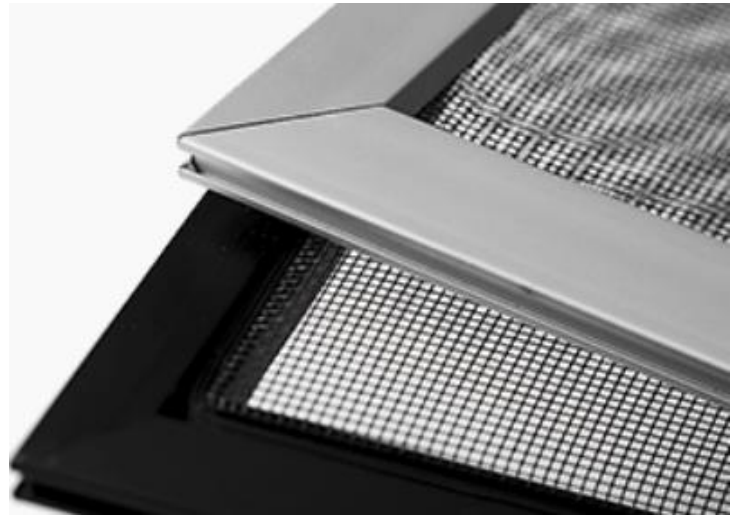
Examples: Window Hardware

Roto-crank handle

Multipoint lock

Casement handle

Butt hinge



Removable fixed aluminum screen for roto-crank operation
Hinged aluminum screen for push-out operation

Examples: Door Hardware

Multipoint handle

Flush handle with thumbturn

Wire pull handle with projected thumbturn and exterior keyed cylinder

Hinge

Ladder pull

Case Study

Project Type: Midcentury Modern Custom Home

Location
Rancho Mirage, California

Architect
Stuart Silk Architects

Builder / General Contractor
West Coast Builders

Thermally broken aluminum windows and doors installed

- Fixed windows
- Casement windows
- Sliding doors
- Window wall system

Project Type: Midcentury Modern Custom Home

“Our clients wanted to create an updated, midcentury modern home that isn’t too modern,” the architects explain of the project, dubbed Thunderbird Heights. “Our goal was to capture the feel of a home that could have been built in the 1950s but also has the elements of today. We wanted to integrate fresh ideas alongside design elements popular in the 1950s in Southern California.”

Project Type: Midcentury Modern Custom Home

Thermally broken aluminum windows replaced all original glazing, while large expanses of floor-to-ceiling glass were installed to open the home up to greater natural light and views of the outdoors. The windows and doors with light champagne and bronze anodized finishes helped achieve the homeowners' goal of indoor/outdoor living.

Summary and Resources

Course Summary

- Aluminum extrusions are a versatile building product, making them ideally suited for the fenestration industry where tight tolerances for complex shapes with thin walls are required. They are seamless, lightweight, and strong. Due to aluminum's abundance in the Earth's crust, ease of scrap recovery, high rate of recyclability, durability, and longevity, it is considered an economically and environmentally sustainable material.

- To reduce the thermal conductivity of an aluminum fenestration product, a thermal break must be included in its design. There are two main types of thermal break technology used in aluminum fenestration in North America: polyurethane and polyamide.

- The physical and mechanical properties of aluminum mean aluminum fenestration products can play a major role in making building envelopes energy efficient while meeting a project's architectural requirements for shape and aesthetics.

- All fenestration must be rated according to the requirements of the NFRC with respect to the performance of the fenestration in the (mandatory) categories of U-factor, SHGC, and VT.

- Aluminum fenestration products for both residential and commercial applications now include windows, swinging doors, sliding doors, window walls, and curtain walls. Thermally broken aluminum windows and doors may contribute to and help a building project earn LEED certification.

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Conclusion

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