Guardian Residential
Glass Innovation






Residential Glass Technical Reference Guide

Glass and Window Knowledge for Everyone

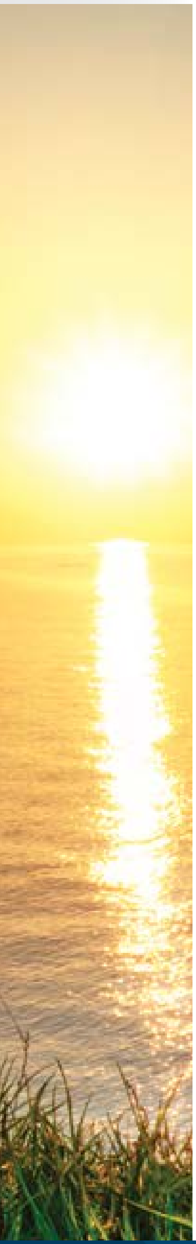
Residential Glass Innovation

Contents

Introduction

Guardian's family of residential glass products has you covered. Our glass engineers and technologists are continually developing glass innovations that make homes more energy efficient, beautiful, comfortable and safe. Those same innovations provide window makers with a competitive advantage.

This brochure provides technical information – including sought after definitions and explanations – to help you to gain knowledge and make educated window related decisions. In addition to this brochure, Guardian provides the Window InSight app for high-definition video explanations about low-E windows and the science of comfort – available for Android and iOS.

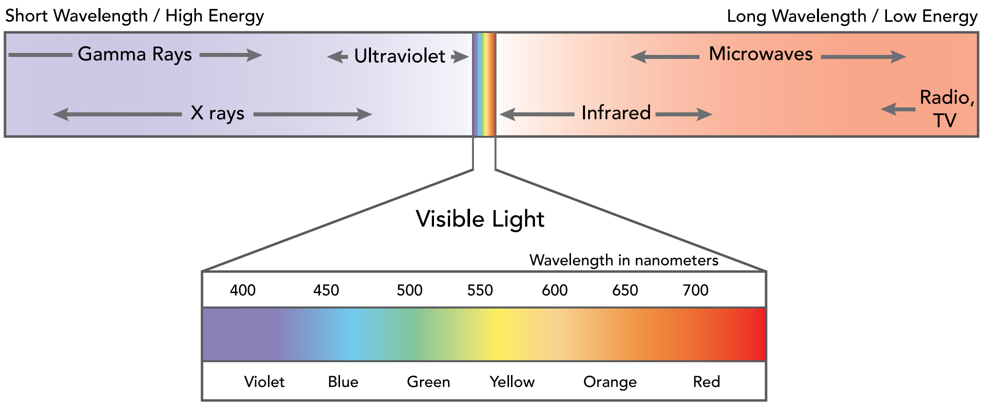


Light Basics

SUNLIGHT

The electromagnetic spectrum is a range of several forms of energy emitted by the sun and other sources. Sunlight, or radiant energy, is only one section of the vast electromagnetic spectrum. Sunlight and other forms of energy travel through space in a wave-like motion. Scientists measure an energy's wavelength (in nanometers) to determine its strength. The shorter the wavelength the more energy it carries. Sunlight ranges from approximately 300 - 2,500 nanometers, and is comprised of three bands of energy: ultraviolet, visible and infrared.

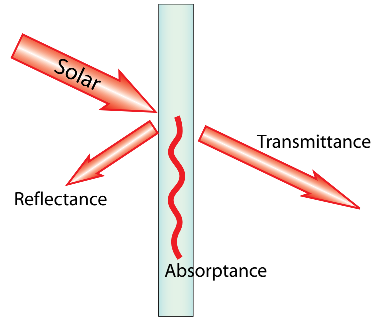
- Ultraviolet energy (300 - 380 nm) contains the most energy within sunlight. Long-term exposure to UV light may result in fabric and pigment fading, plastic deterioration and skin burns. UV light is invisible to the human eye.
- Visible light (380 - 780 nm) is the portion of solar radiation that is primarily associated with daylight. This is the section of energy that enables humans to recognize color. Visible light is a prominent source of heat.
- Near infrared energy (780 - 4,000 nm) is divided into two forms, short-wave and long-wave. Short-wave infrared energy comes from the sun and is the largest portion of solar radiation. Long-wave infrared energy is energy that is radiated by another object after it absorbs short-wave energy. This type of energy is invisible to the human eye and is a prominent source of heat.



SOLAR ENERGY

Radiant energy from the sun having a wavelength range of 300 to 4000 nm, which includes UV (300 to 380 nm), visible light (380 to 780 nm) and near infrared energy (780 to 4000 nm), may be reflected, absorbed or transmitted.

- % Reflectance Out – percentage of solar energy directly reflected from the glass back outdoors.
- % Absorptance – percentage of solar energy absorbed into the glass (held within the glass, then radiated into a space).
- % Transmittance – percentage of solar energy directly transmitted through the glass.



The sum of percent reflectance out + absorptance + transmittance = 100%. An additional consideration is emission, or emissivity. This refers to the reradiation of absorbed energy that can be emitted toward both the exterior and interior of the home. Emissivity is controlled through the use of low-Emissivity, or low-E coatings.

Visible light, or the radiant energy in the wavelength range of 380 nm to 780 nm is an important factor that must be considered by fabricators, contractors and homeowners.

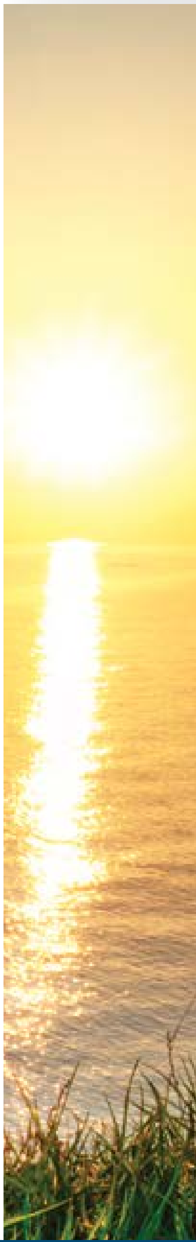
- % Transmittance (Tvis or VLT) – percentage of visible light transmitted through the glass. Certain regions and consumer preferences require a higher or lower Tvis. The higher the number the more natural light is able to enter a space.
- % Reflectance Indoors – percentage of visible light reflected from the glass back indoors.
- % Reflectance Outdoors – percentage of visible light reflected from the glass back outdoors.

FADING AND UV LIGHT

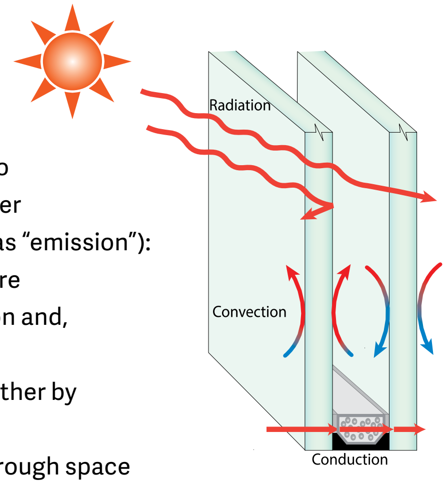
Household furnishings fade from prolonged exposure to ultraviolet (UV) light and other types of solar energy. Fading is caused by segments of solar radiation, specifically 40 percent to 60 percent UV light, 25 percent visible light, 25 percent infrared light and 10 percent miscellaneous (indoor lighting, humidity). No product can completely stop fading. Many factors contribute to fade resistance, such as the color and materials of your home furnishings; the frequency, duration and intensity of UV exposure; variations in temperature and humidity in the home; and the way home furnishings are used and maintained.

Heat doesn't cause fading, but it can speed it up. The solar infrared energy, or heat, coming through a window can accelerate the degradation of home furnishings. Fortunately, solar infrared energy can be effectively controlled by using spectrally selective Low-E glass. The window industry uses two standards to measure UV and fading: UV transmission (Tuv) and Weighted or Fading Transmission (Tdw-ISO). Tuv is a simple measure of the ultraviolet radiation that is transmitted through window glass. Tuv provides homeowners with a practical guide to assess window glass fade protection for typical household furnishings. The Tdw-ISO concept was developed in response to the needs of museums and art galleries to guide decisions regarding lighting and protection of highly sensitive materials. Tdw-ISO is a damage-weighted calculation taking both UV transmission (300–380nm) and the visible light spectrum from 380–700 nm into account, with additional weight placed on the blue region of the visible light spectrum. A window that was designed to have the lowest possible Tdw-ISO value would appear yellow and would have significantly lower visible light transmission than homeowners would find unacceptable.

Independent testing indicates a direct correlation between the percentage of ultraviolet radiation transmitted (Tuv) through a window and the fading of typical household furnishings. Analysis of damage-weighted transmission values as part of this testing indicated that Tdw-ISO is a poor predictor of fade protection of typical household furnishings. The underlying reason for this conclusion is that typical household furnishings are dramatically more resistant than museum artifacts to the fading energy of the visible portion of the spectrum. This is why many museums keep their more precious artifacts in windowless rooms and use lower light levels. Whereas Tdw-ISO is useful to museums and galleries, it is not an appropriate guide to fade protection for the typical homeowner.



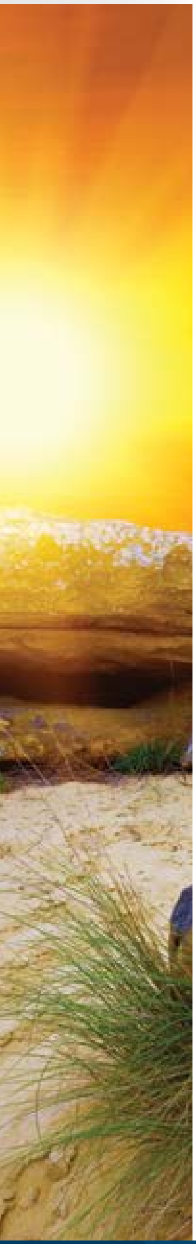
Heat Basics



HEAT TRANSFER METHODS

Heat, by nature, seeks out cooler objects and spaces with the intent to increase their temperatures, which is called heat transfer. Heat transfer occurs through convection, conduction or radiation (also referred to as "emission"):

- Convection results from the movement of air due to temperature differences. For instance, warm air moves in an upward direction and, conversely, cool air moves in a downward direction.
- Conduction results when energy moves from one object to another by direct contact.
- Radiation, or emission, occurs when heat (energy) can move through space or an object and then is absorbed by a second object.



HEAT GAIN AND SOLAR HEAT GAIN COEFFICIENT

Heat gain is heat added to a building interior by radiation, convection or conduction. Heat gain can be caused by radiation from the sun or the heat in hot summer air convected/conducted to the building interior.

The Solar Heat Gain Coefficient (SHGC) is the percent of solar energy on the glass that is transferred indoors, both directly and indirectly through the glass. The SHGC was created by the National Fenestration Rating Council to standardize window performance criteria; it is expressed as a value between 0 and 1. The direct gain portion equals the solar energy transmittance, while the indirect is the fraction of solar energy on the glass that is absorbed and re-radiated or convected indoors. For example, 1/8" (3 mm) uncoated clear glass has a SHGC of approximately 0.86, of which 0.84 is direct gain (solar transmittance) and 0.02 is indirect gain (convection/re-radiation). A higher SHGC value will result in more natural heating. Certain geographic regions will require either a lower or higher number depending on the local climate.

U-FACTOR (U-VALUE)

U-factor is a measure of the heat gain or loss through glass due to the difference between indoor and outdoor air temperatures. It is also referred to as the overall coefficient of heat transfer. A lower U-factor indicates better insulating properties. The units are Btu/(hr·ft^2·°F). The U-factor accounts for center of glass, edge of glass and frame performance. U-factors of windows will generally fall between .2 and 1.2; a lower value equates to less heat flow.

R-VALUE

R-value is a measure of heat flow resistance. It is determined by dividing the U-factor into 1, (R-value = 1/U-factor). A higher R-value indicates better insulating properties of the glazing. R-value is not typically used as a measurement for glazing products and is referenced here to help understand U-factor.

AIR LEAKAGE

A measure of how much outside air comes into a home or building through a product. Air leakage rates typically fall in a range between 0.1 and 0.3 and is calculated by cfm/ft.^{2}. The lower the air leakage, the better a product is at keeping air out. A significant amount of air leakage can increase heating and cooling costs. Air leakage is an optional rating, and manufacturers can choose not to include it on their window performance labels.

Types of Glass

Getting the right type of glass – or the right combination of types – can be critical to the performance of window glazing. This section defines the various kinds of glass, how they're made, and their strengths and characteristics. It also diagrams construction techniques to show how different glass types can be combined for the desired heat, light and insulation properties.

ANNEALED GLASS

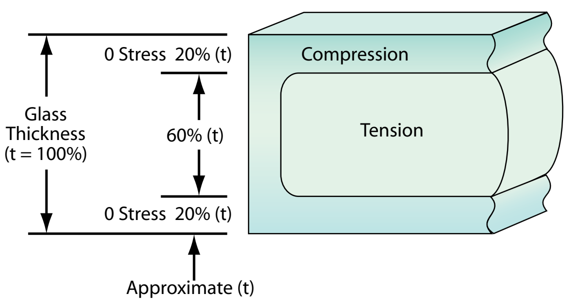
Float glass (also called "flat" glass) that has not been heat-strengthened or tempered is annealed glass. Annealing float glass is the process of controlled cooling to prevent residual stress in the glass and is an inherent operation of the float glass manufacturing process. Annealed glass can be cut, machined, drilled, edged and polished.

HEAT-STRENGTHENED GLASS

Heat-strengthened (HS) glass has been subjected to a heating and cooling cycle and is generally twice as strong as annealed glass of the same thickness and configuration. HS glass must achieve residual surface compression between 3,500 and 7,500 PSI for 6mm glass, according to ASTM C 1048. Please contact Guardian regarding thicker glass standards. HS glass has greater resistance to thermal loads than annealed glass and, when broken, the fragments are typically larger than those of fully tempered glass and initially may remain in the glazing opening. Heat-strengthened glass is not a "safety glass" product as defined by the various code organizations. This type of glass is intended for general glazing, where additional strength is desired to withstand wind load and thermal stress. It does not require the strength of fully tempered glass, and is intended for applications that do not specifically require a safety glass product. When heat-treated glass is necessary, Guardian recommends the use of heat-strengthened glass for applications that do not specifically require a safety glass product. HS glass cannot be cut or drilled after heat-strengthening and any alterations, such as edge-grinding, sandblasting or acid-etching, can cause premature failure.

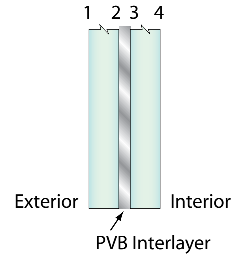
TEMPERED GLASS

Fully tempered glass is approximately four times stronger than annealed glass of the same thickness and configuration, and residual surface compression must be over 10,000 PSI for 6mm, according to ASTM C 1048. Please contact Guardian for thicker glass standards. When broken, it will break into many relatively small fragments, which are less likely to cause serious injury. The typical process to produce tempered glass involves heating the glass to over 1,000 degrees F, then rapidly cooling to lock the glass surfaces in a state of compression and the core in a state of tension as shown in the diagram.



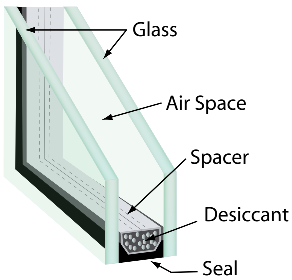
Tempered glass is often referred to as "safety glass" because it meets the requirements of the various code organizations that set standards for safety glass. This type of glass is intended for general glazing, and safety glazing such as sliding doors, storm doors, building entrances, bath and shower enclosures, interior partitions and other applications requiring superior strength and safety properties. Tempered glass cannot be cut or drilled after tempering, and any alterations, such as edge-grinding, sandblasting or acid-etching, can cause premature failure.

LAMINATED GLASS



Laminated glass is two or more lites (pieces) of glass permanently bonded together with one or more plastic interlayers (PVB) using heat and pressure. The glass and interlayers can be a variety of colors and thicknesses designed to meet building code standards and requirements as necessary. Laminated glass can be broken, but the fragments will tend to adhere to the plastic layer and remain largely intact, reducing the risk of injury. Laminated glass is considered "safety glass" because it meets the requirements of the various code organizations that set standards for safety. Heat-strengthened and tempered glass can be incorporated into laminated glass units to further strengthen the impact resistance. Hurricane resistance, bomb blast protection, UV protection, sound attenuation and ballistic or forced-entry security concerns are all primary uses for laminated glass. For complete industry-accepted information about laminated glass, please review the Glass Association of North America's Laminated Glazing Reference Manual.

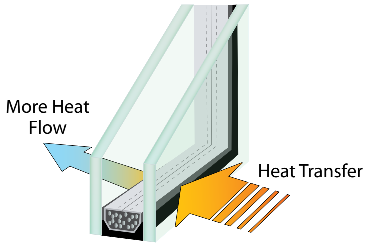
INSULATING GLASS

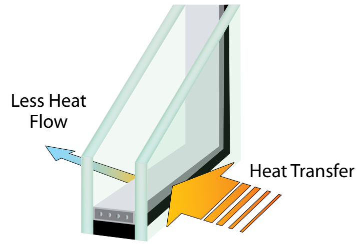


Insulating glass refers to two or more lites of glass sealed around the edges with an air space between, to form a double- or triple-pane unit. Commonly referred to as an "IG unit," insulating glass is the most effective way to reduce air-to-air (convection) heat transfer through the glazing. The air space may be filled with an inert gas (Argon, Krypton) to further reduce heat transfer and increase comfort within a building. When used in conjunction with low-E and/or reflective glass coatings, IG units become effective means to conserve energy and comply with energy codes.

As low-E coatings have become better at reducing air-to-air heat transfer, spacer technology has become the focus of incremental thermal improvements. Typical commercial spacers are composed of formed aluminum filled with desiccant to absorb any residual moisture inside the IG unit, thus reducing potential condensation. While this is a structurally strong material, the aluminum-to-glass contact point is a very efficient thermal conductor and can increase the potential for temperature differential between the center of glass and the edge of glass, which can lead to condensation and reduces the unit's overall U-Value.

Warm-edge spacer technology is another option for improving the thermal properties, reducing condensation and reducing U-values in IG units. There are a number of warm-edge spacer designs available, all of which thermally break the metal-to-glass contact point to some degree, while offering varying levels of structural integrity that may or may not be suitable for commercial applications. Warm-edge spacers can significantly reduce heat conduction when compared to conventional metal spacers.





Vacuum insulating glass (VIG) is a relatively recent IG unit development. The space between panes in a VIG unit has been reduced to only a few millimeters, and the air within the space has been completely removed. The result is a significant reduction of heat transfer and an increase in total insulating performance, when compared to double- and triple-pane IG units.

PATTERNED GLASS

Patterned glass contains an inlayed pattern or texture for use in privacy and decorative applications. The majority of patterned glass is used in bath and shower enclosures. It provides figure obscuration while permitting transmission of large amounts of light.

Patterned glass is produced by pressing semi-molten glass between rollers to imprint a distinct pattern or by using an acid etching process that partially dissolves parts of the glass leaving an aesthetically pleasant pattern. There are many varieties of patterned glass that provide varying degrees of obscuration.

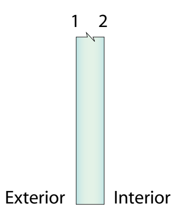
TINTED GLASS

Tinted glass is similar to flat glass in almost every aspect; however, during the manufacturing process colorants are added to molten glass that gives the glass color or tint. Glass tints are available in many colors including green, blue, bronze and gray. Tinted glass is utilized for several purposes including privacy, heat reduction, and decorative. The strength of the tint affects the glass' total performance (Tvis, privacy, heat-reduction capabilities, etc.).

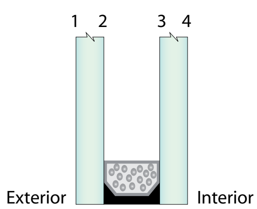
COMMON GLASS CONFIGURATIONS

The following images depict the most common glass configurations and identify the glass surfaces with numbers showing the glass surfaces counting from exterior to interior.

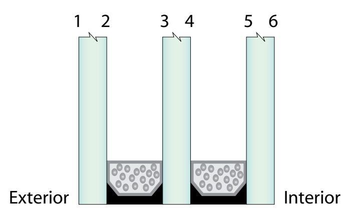
Monolithic



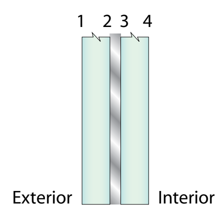
Double-Glazed Insulating Glass Unit



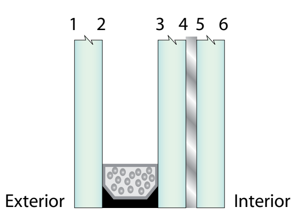
Triple-Glazed Insulating Glass Unit



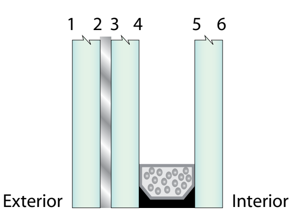
Laminated Glass



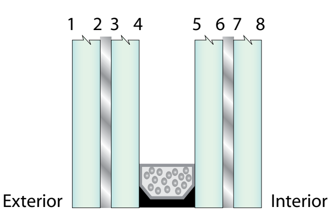
IG Unit Laminated Inboard

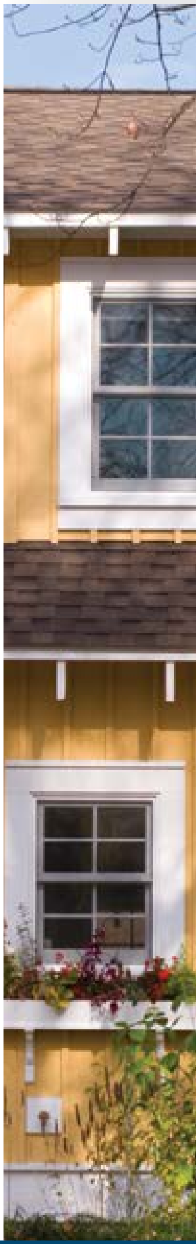


IG Unit Laminated Outboard



IG Unit Laminated Inboard/Outboard





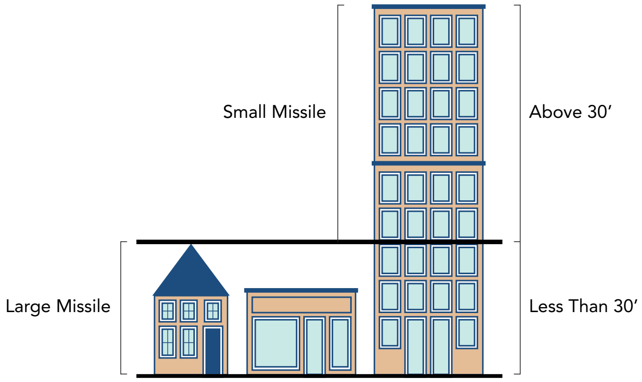
Specialized Glass Applications

HURRICANE GLASS

Hurricane codes in coastal areas of North America help to prevent catastrophic building failure during hurricane and storm conditions. Initially, Dade County, Florida, and the International Building Code enacted requirements that have been used as a model for other areas such as Texas and the Gulf Coast, as well as up the Atlantic Seaboard. The codes may vary regionally, so professionals are encouraged to research the local municipality codes when beginning new projects.

Specially designed laminated glass products form the basis of hurricane glass. Although the glass may break upon impact, the plastic interlayer and the structural bonding of the glazing system to the window frame helps the glazing panel to remain in place, protecting the interior of the building. Note that in addition to the specially designed glass package, an impact-resistant window requires the means to structurally fasten the glass to the window frame. The test protocol for compliance involves impacting the window in multiple locations and then subjecting the entire window system to positive and negative pressure cycles to replicate hurricane conditions. In all cases, qualification of hurricane protective glazing is based on total window system performance.

Comprehensive wind-damage surveys have identified patterns that seem to apply to all extreme wind events. Small debris, such as roof gravel, can impact all elevations of a building with sufficient velocity to break glass. Large debris, such as tree limbs, garbage cans, and building materials typically impact buildings closer to ground level with sufficient force to break windows and penetrate walls. This analysis led to the current "large missile / small missile" windborne debris impact categories for glazing systems.



SAFETY AND SECURITY GLASS

Safety glass is designed to help protect building occupants from injury or loss due to accidental or natural causes. Model building codes require safety glazing in hazardous locations such as operable doors, side-lites, and areas adjacent to walkways. Safety glazing performance standards are designed to protect humans who may accidentally impact the glass and to provide resistance to natural hazards. These standards are established by the Consumer Product Safety Commission (CPSC) and the American National Standards Institute (ANSI). Tempered glass is commonly used to meet safety glazing requirements; however, laminated glass represents an alternate method for compliance that offers additional performance benefits

Security glass is designed to help protect building occupants from injury or loss due to deliberate or intentional actions. Various code organizations require stringent testing of security glass to ensure its impact and blast resistance. Laminated glass is commonly used to meet security glazing requirements.

SLOPED GLASS

Glass that slopes at an angle of 15° or more from the vertical plane is used in sloped walls, overhead glazing, or skylights. The possibility of breakage of sloped or overhead glazing is a potential hazard and, with limited exceptions, building codes require laminated glass or screens to be used for occupant protection (tempered or heat strengthened) due to the intense loads that can be placed on sloped glass. When properly designed and installed, the adhesion of the glass to the interlayer means that laminated glass, even when broken, tends to remain in place, protecting occupants and property from injury and damage caused by rain, wind, snow, etc.

Center of glass values based on vertical installation are commonly used for simple comparison; however, U-factors for sloped glazing vary from vertical. A slower rate of heat transfer occurs in vertical glazing than in sloped glazing. In skylights, as the slope of the skylight becomes more horizontal, the rate of heat transfer through the glazing increases. If the same glass is used in a vertically-glazed application and in a sloped application, in the winter, the sloped-glazed application will lose heat more quickly than the vertically-glazed application.

TURTLE GLASS

It has been discovered that light shining brightly from buildings within the line of sight of the seashore attracts marine turtle hatchlings away from their natural environment at sea. Due to this behavior, window and glass installations along the Florida coastline require adherence to the Florida Model Lighting Ordinance for Marine Turtle Protection. The Florida Model Lighting Ordinance serves as a legal basis for the protection of sea turtles by prohibiting beachfront activities and lighting circumstances that would interfere with the successful hatching of the animals. Approximately 70% of Florida's coastline is covered by local legislation based upon the model code. Of particular importance, the Florida Model Lighting Ordinance requires the use of tinted glass, defined as a glazing product with no more than 45% visible light transmission (Tvis), on all windows and glass doors of structures located within sight of the beach.

Coating Basics

Technological advances in the last three decades have produced systems and equipment that can coat glass with razor-thin, neutral-color coatings to create high performance glass and windows. These coatings are extremely thin layers of metallic oxides and other compounds, designed to enhance both comfort and energy performance.

COATING TYPES

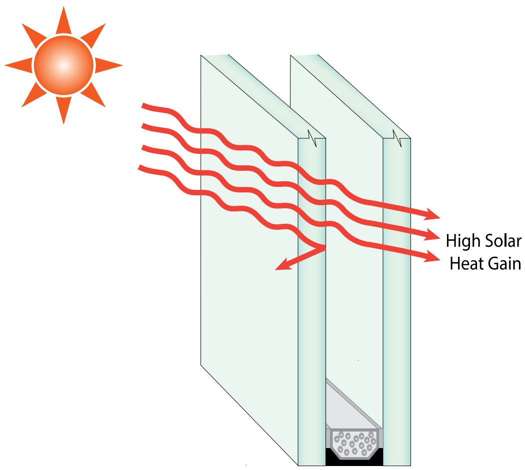
Flat glass may be coated with two types of coatings, sputter and pyrolytic. Sputter coatings are applied in a vacuum chamber as an alternate step in the fabrication process. Sputter coatings consist of multiple layers of incredibly thin, nearly invisible metal oxides (silver, nickel, tin) and other compounds. Each layer is roughly 1/10,000 the thickness of a human hair. The majority of sputter coatings are placed on the inner surfaces of an IG unit to protect them from weathering and other physical contact.

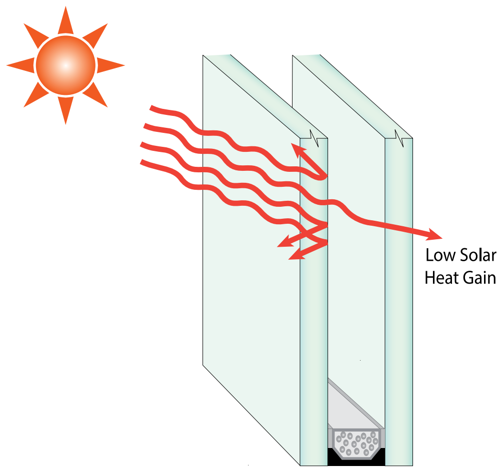
Pyrolytic coatings are applied directly to flat glass during the manufacturing process. Metal oxides and other compounds are deposited when glass is extremely hot, fusing the metals and compounds to the glass. Pyrolytic coatings are thicker and more durable than sputter coatings, however, they do not perform as well as sputter coatings.

LOW EMITTANCE COATINGS (LOW-E)

Relatively neutral in appearance, low-E coatings reduce heat gain or loss by reflecting long-wave infrared energy (heat) and, therefore decrease the U-factor and improve energy efficiency. Current sputter-coated low-E coatings are multilayered, complex designs engineered to provide high visible light transmission, low visible light reflection and reduce heat transfer.

There are two main types of low-E coatings: high-solar-gain and low-solar-gain. High-solar-gain low-E coatings are designed for cold northern climates and allow large amounts of solar heat and natural light into a space. This low-E coating takes advantage of the passive heat gain from the sun while keeping interior heat from escaping. Low-solar-gain low-E coatings are designed for hot southern climates to allow a minimal amount of solar heat to enter a space, while permitting moderate amounts of natural light.

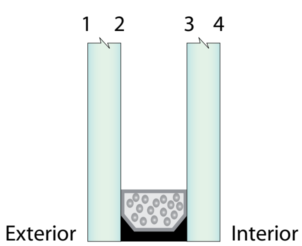


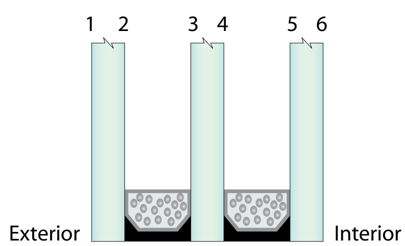


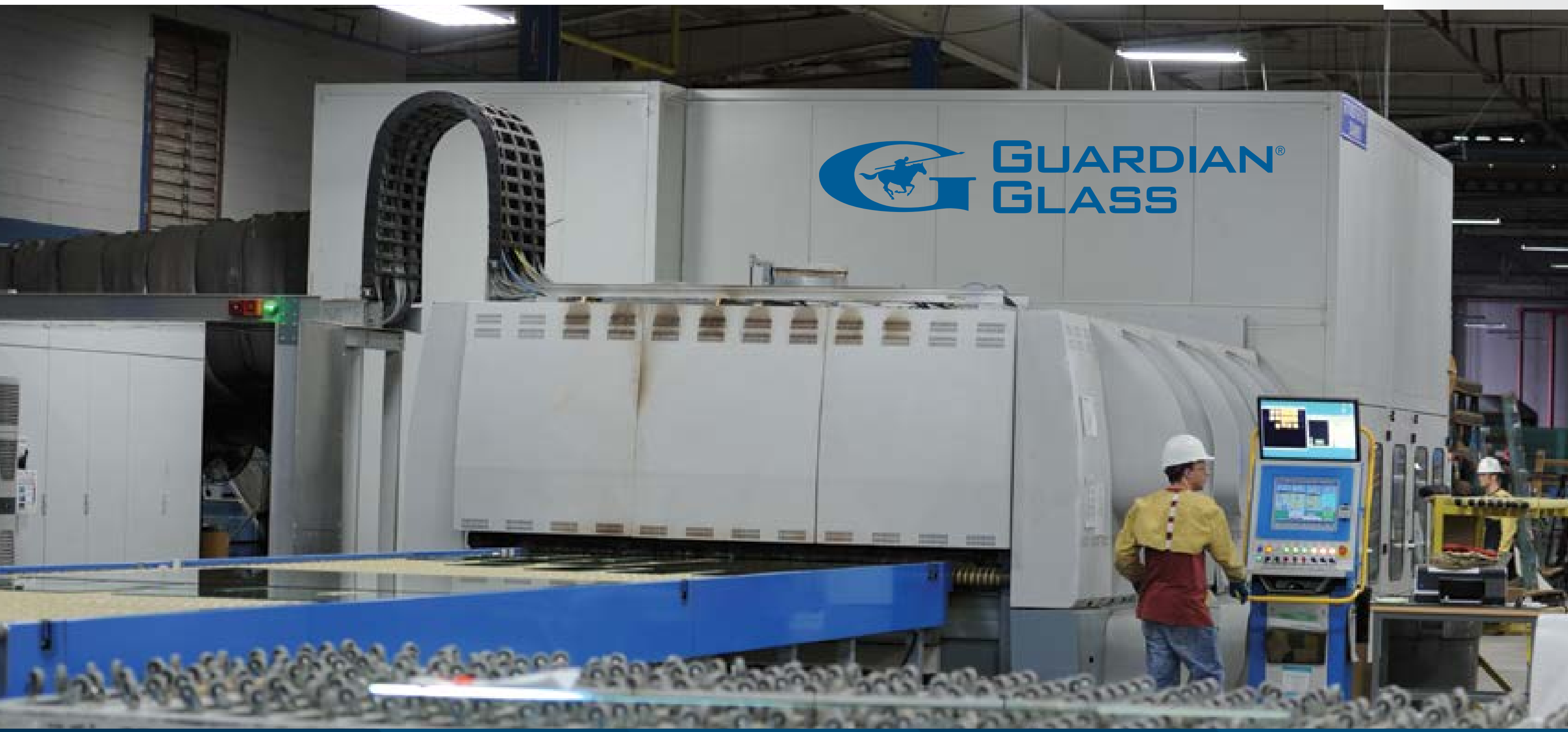
The application of certain low-E coatings may result in perceived color transmission and reflection differences. Perceived differences are dependent on the glass coating. Certain coatings may have a slight tint appearance or different color reflection when viewed straight on or off-angle, appearing purple, green or tan. The slight tint and color misrepresentation are due to the low-E coatings' inherent coloring, along with the transmission and reflection of certain segments of the visible light spectrum (i.e. colors). Reflection color misrepresentation is specifically due to surrounding objects (indoor and outdoor) creating a reflection on the glass due to their emission of ambient light. Color reflections are more discernible against darker backgrounds. Simulated Divided Lites (SDLs) are especially prone to causing reflection color misrepresentation and should be selectively chosen. Guardian recommends the creation of mock-up displays to ensure acceptable color transmission and reflection due to the unpredictability of combinations.

COATING PLACEMENT

The placement of a coating is fundamentally important in determining the performance properties and effectiveness of a coating. Coatings may be placed on a several surfaces within a window unit, depending on the type of coating, window system design and desired performance. The placement of coatings has a critical effect on solar heat gain performance and comfort. Each pane of glass has two surfaces a coating could be placed. A double-pane window will have four surfaces, the outside facing surface is considered #1 and the inside facing surface is considered #4. A triple-pane window will have 6 surfaces, the outside facing surface is #1 and the inside facing surface is #6.







Other Information

WINDOW ORIENTATION AND EXPOSURE

The directional orientation of windows can have a significant impact on home heating and cooling, and therefore, overall comfort. Windows facing the east, west and south will typically be exposed to large amounts of sunlight, while windows facing north receive less sunlight. Consumer preferences and local climate will determine whether a high- or low-solar-gain window is appropriate for optimal comfort.

Direct sun exposure will cause the interior temperature of a building to increase dramatically, requiring large amounts of cooling to ensure a comfortable environment. A large building with direct sun exposure and numerous occupants should be fitted with low-solar-gain low-E windows to help suppress cooling load requirements and reduce energy costs. The physical location of a large building is not relevant in the window selection process; buildings in both Phoenix and Minneapolis will require cooling throughout the year due to sun exposure and interior activity.

The ENERGY STAR® program encourages low-solar-gain low-E windows for use in southern climate zones for residential and commercial buildings. Buildings in northern climate zones are permitted to use low-solar-gain windows, however, it is recommended to use high-solar-gain low-E to allow the sun's natural energy to assist heating.

CONDENSATION

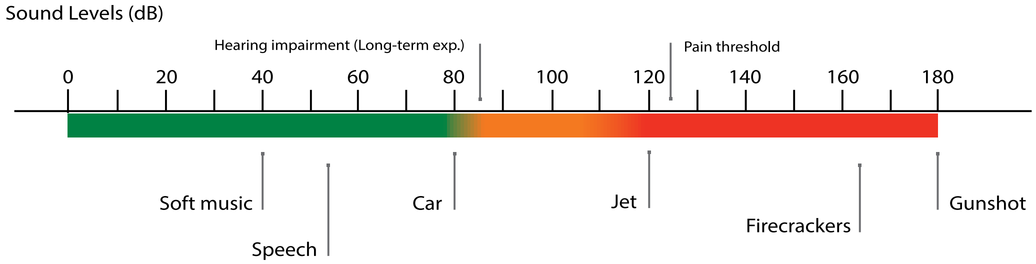
Condensation is the collection of water vapor as a visible liquid or haze on a surface. Excess humidity and water vapor inside or outside a home may contribute to window condensation. The difference between indoor and outdoor temperatures determine the amount of condensation that forms on a window. Warm air can contain significant amounts of water vapor compared to cool air. When moist warm air cools and reaches the dew point (the point when water vapor condenses at a certain temperature and pressure) it will condense on a glass pane as droplets and/or fog. Excess long term condensation may cause mold, mildew, and rot as well as stain the glass surface and window frame.

Depending on the time of year, condensation can occur on the interior or exterior glass surface and frame. Interior condensation usually forms during the winter when a home is being heated. As outdoor temperatures drop the inside glass surface will also cool. If there is excess humidity in a home, condensation can form on the cool interior glass surface. Good air circulation and the removal of objects that cause humidity will reduce the chance of interior condensation.

Exterior condensation forms most often during spring and fall when temperatures and weather fluctuate greatly. This characteristic seasonal variation will often cause condensation to form in the morning hours when the outdoor temperature increases. As temperatures rise in the morning, a window will remain cool from the night before due to the low heat transfer of energy efficient windows. As the temperature increases, so does the dew point; this creates a temperature difference between the cool window and the moist warm outside air. The difference will cause water droplets and/or fog to form on the glass surface. While unsightly, exterior condensation is not considered a problem and will dissipate as the glass and frame warm.

ACOUSTICAL INFORMATION

Sound travels in a wave-like motion measured in frequencies. Depending on the frequency, a sound may be able to penetrate deep into an object or space. There are two important components of sound: frequency – the number of wavelength cycles per second, and amplitude – which is related to its loudness. The frequency is measured in Hertz (Hz), while the amplitude is represented by its Sound Pressure Level (SPL), measured in decibels (dB). The frequency is what gives a sound its pitch, with high-pitched sounds such as typical human conversation having a higher frequency and shorter wavelength, and low-pitched sounds such as automobile traffic having a lower frequency and longer wavelength. An important feature of the human perception of continuous sound is that an increase or decrease in sound pressure level by 3 dB or less is barely perceptible; an increase or decrease of 5 dB is clearly perceptible; and an increase or decrease of 10 dB is perceived as a doubling or halving of noise level.



The effective sound insulation of a window depends on its area and on its sound transmission loss (the attenuation of the transmitted sound energy measured in decibels). Transmission loss is measured over a wide range of frequencies. The measurements are usually combined into a single-number rating, such as Sound Transmission Class (STC, per ASTM E413), to make it possible to rank products. STC is a rating system based on mid- and high-frequency noises that are typical of indoor sources such as speech, radio and television noise or household appliances; a higher STC rating equates to more noise reduction. Although STC is also commonly applied to building envelope components such as windows, the STC calculation should not be used to evaluate partitions exposed to machinery, industrial and transportation noise such as motor vehicles, aircraft and trains.

In order to correlate more closely with the lower-frequency noises that are typical of outdoor sources such as traffic, airport noises, and industrial processes, the Outdoor Indoor Transmission Class rating (OITC, ASTM E1332) was developed. Although not as widely recognized within the Window and Door industry as STC, OITC is considered by many experts to be a more appropriate measure of transmission loss in residential applications.

Reducing sound transmission through windows and doors is a function of component materials, system design, and installation. Changing component materials is the most common technique used to reduce sound transmission through windows and doors. Understanding the basic science of sound transmission is helpful in identifying the best potential options for reducing the sound transmission of window system components.

continued

Sound transmission loss in a window system is dependent on the mass, damping and stiffness of the glazing components. While it is not practical to increase glass stiffness (note that glass stiffness is not the same as glass strength, which can be increased through heat-treatment), it is generally understood that increasing glass thickness (mass) is an effective way to decrease sound transmission. Unfortunately, traditional residential fenestration is limited in its ability to incorporate greater glass thickness due to dimensional and weight limitations. Increasing the airspace between glass lites is also a technique that falls within the category of increased mass; however, traditional residential design is also limited in its ability to incorporate gap-widths that provide meaningful reductions in sound transmission.

Glass damping is therefore the only remaining option for reducing sound transmission in residential fenestration. Generally, glass has very low inherent damping, so adding damping elements such as the interlayer (PVB) used to make laminated glass is usually the most cost-effective option. When PVB is placed between two pieces of glass it absorbs sound waves, reducing transmission to the second lite of glass, and therefore reducing overall sound transmission.

Each of the rating methodologies gives slightly different classification numbers, so it is important to consider surrounding environmental conditions to ensure that the appropriate Sound Transmission Loss rating is emphasized. It is also important to recognize that the STC or OITC rating of a glass product does not represent the rating of the window system. The window system includes materials other than glass, including the window sash and frame, the insulating glass unit spacer material and sealant. In addition, proper installation is critical to ensure that sound does not enter through poorly fitted components.

While STC and OITC ratings are published for various glass configurations, accurate ratings for the window system can only be determined by full window system testing. It is best to enlist the assistance of an acoustic consultant to coordinate the design, testing, and interpretation of test-results, prior to making final design decisions.

ENERGY AND BUILDING STANDARDS

The National Fenestration Rating Council (NFRC) is a non-profit organization dedicated to providing fair, accurate, and impartial window labeling and ratings based on energy efficiency. The NFRC has created an industry standard window label, which depicts the most important facts about a window's specific energy performance. The goal of the label is to educate consumers on the many different windows available and aid in the decision making process. The label depicts the U-factor, solar heat gain coefficient, visible light transmittance, air leakage, and possibly condensation resistance.

The NFRC certifies both manufacturers and their products. The manufacturers and the products must meet targeted energy performance and quality requirements to become certified. The NRFC certification process consists of computer performance simulations, random product sample for quality tests, periodic technical audits and recertification every four years.

The International Energy Conservation Code (IECC) was created by the International Code Council, an association dedicated to the development of model codes and standards for use in design and construction, to promote safe, sustainable and resilient structures. Many state and local building codes implement and follow IECC guidelines, which call for substantially more stringent window requirements phased in over a period of time.

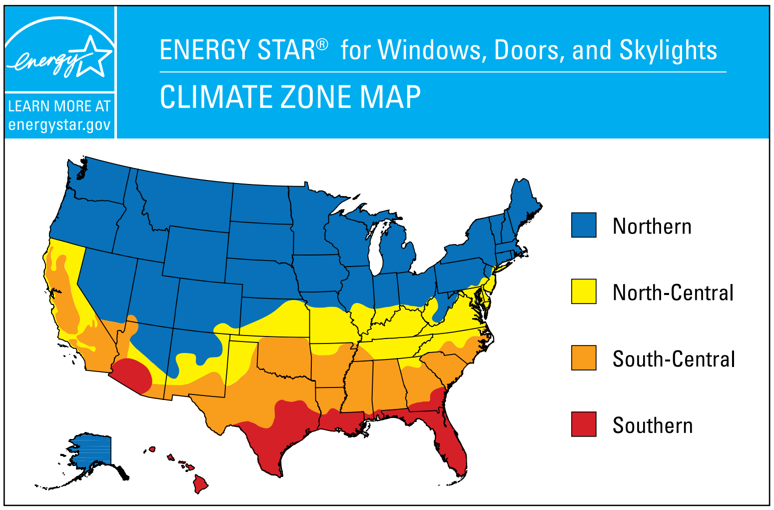
The evolution of building construction has led to the development of codes and standards that mandate structurally sound, energy-efficient and environmentally conscious buildings. Many of these codes and standards apply directly to glazing components and should be thoroughly investigated prior to design finalization. A few of the applicable standards include:

- ANSI Z 97.1 Glazing Materials Used in Buildings, Safety Performance Specifications and Methods of Test
- ASTM C 1036 Standard Specification for Flat Glass
- ASTM C 1048 Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass
- ASTM C 1464 Standard Specification for Bent Glass
- ASTM C 1172 Standard Specification for Laminated Architectural Flat Glass
- ASTM C 1376 Standard Specification for Pyrolytic/Vacuum Deposition on Flat Glass
- ASTM E 1300 Standard Practice for Determining Load Resistance of Glass in Buildings
- ASTM E 1886 Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials
- ASTM E 1996 Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes
- ASTM E 2188 Standard Test Method for Insulating Glass Unit Performance
- ASTM E 2190 Standard Specification for Insulating Glass Unit Performance and Evaluation
- ASTM F 1642 Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings
- CPSC 16CFR-1201 Safety Standard for Architectural Glazing Materials
- International Building Code (IBC) - Chapter 24

ENERGY STAR

The ENERGY STAR® program was developed by the U.S. Department of Energy and the Environmental Protection Agency (EPA) to promote energy efficient products and reduce energy consumption within the United States. Qualifying products will receive the ENERGY STAR label after meeting stringent energy efficiency requirements designed by the EPA. Furthermore, windows receiving the label must demonstrate certification by the National Fenestration Rating Council. The stringent requirements that must be achieved in order to obtain the ENERGY STAR label become more challenging as new versions of the program are introduced. Guardian ClimaGuard glass products can be used to construct ENERGY STAR qualified windows.

The ultimate goal of the ENERGY STAR program is to continue to drive product development while providing consumers with a simplistic energy efficiency message. Version 5 is currently implemented, with Version 6 partially implemented. Version 6 requires a lower U-factor and Solar Heat Gain Coefficient values for all climate zones. The ENERGY STAR program breaks down the United States into four regions: Northern, North-Central, South-Central, and Southern. Each region has different performance standards that must be met to obtain the ENERGY STAR label.



Energy Star Qualification Criteria

Climate Zones	Version 6	
	U-Factor	SHGC
Northern	≤ 0.27	Any
	= 0.28	≥ 0.32
	= 0.29	≥ 0.37
	= 0.30	≥ 0.42
North-Central	≤ 0.30	≤ 0.40
South-Central	≤ 0.30	≤ 0.25

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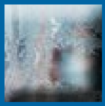
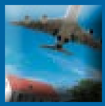
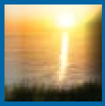
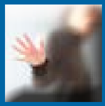

ENERGY EFFICIENCY


SAFETY AND SECURITY


SOUND CONTROL


FADE AND UV PROTECTION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