



TECHNICAL GUIDELINES

BUILD WITH LIGHT™

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Introduction

Architects, designers and builders have more types of glass to choose from than ever before. This choice can make a tremendous difference to your project's cost, energy efficiency and environmental impact. So you need accurate, detailed information to ensure that you choose the correct glass.

This brochure provides technical information, including performance capabilities and glazing guidelines, for all types of SunGuard® Advanced Architectural Glass made by GUARDIAN. It also contains instructions for correct handling and maintenance. We believe that you will find most of the answers you need in this brochure, but you are always welcome to consult with your local SunGuard® Advanced Architectural Glass specialist or to order a glass sample.



Types of Glass

Specifying the correct glass or combination of glass types can be critical to the success of your project. This section defines the various kinds of glass, how they are made, and their strengths and characteristics. It also contains diagrams of glass constructions to show how different glass types can be combined for the required heat, light and insulation properties.

Annealed glass

Float glass that has not been toughened or heat strengthened 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.

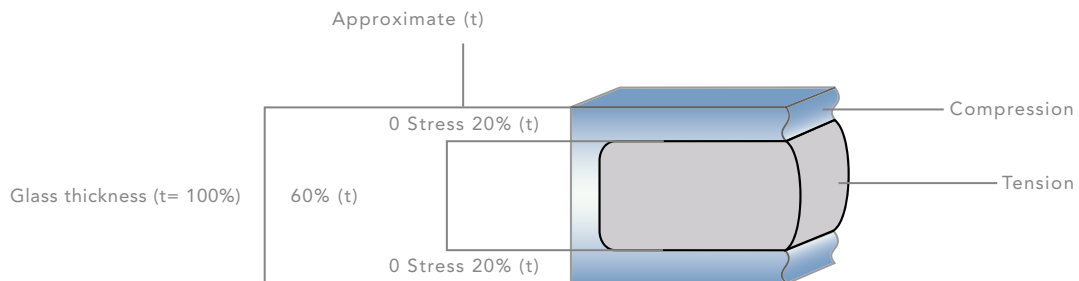
Heat-strengthened glass

Heat-strengthened 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. Heat-strengthened glass must comply with all the requirements of EN 1863: Parts 1 & 2. Heat-strengthened glass has greater resistance to thermal loads than annealed glass and, when it breaks in service, the fragments are typically larger than those of toughened glass. Heat-strengthened glass is not a safety glass product as defined by European Building Regulations and Standards. This type of glass is intended for general glazing, where additional strength is required to withstand wind load and thermal stress. It does not require the strength of toughened glass, and is intended for applications that do not specifically require a safety glass product. Heat-strengthened glass cannot be cut or drilled after heat-strengthening and any alterations such as edge-grinding, sandblasting or acid-etching will weaken the glass and can cause premature failure.

Toughened glass

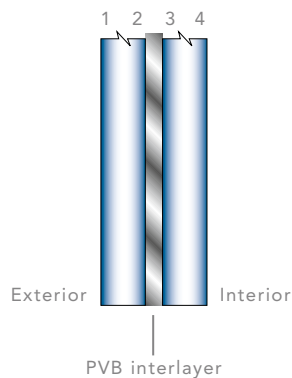
Thermally toughened glass is approximately four times stronger than annealed glass of the same thickness and configuration, and must comply with the requirements of EN 12150: Parts 1 & 2. When broken, it will break into many relatively small fragments, which are less likely to cause serious injury. The typical process for the production of thermally toughened glass involves heating the glass to over 600 degrees Celsius, then rapidly cooling it to lock the glass surfaces in a state of compression and the core in a state of tension as shown in the diagram. Toughened glass is often referred to as "safety glass" because it meets the requirements of the various European Building Regulations and Standards which apply to safety glass. This type of glass is intended for general glazing, and for safety glazing such as that used in sliding doors, building entrances, bath and shower enclosures, interior

partitions and other applications requiring increased strength and safety properties. Toughened glass cannot be subjected to further processing – such as cutting, drilling, edge grinding - after toughening and any alterations such as sandblasting or acid-etching will weaken the glass and can cause premature failure.



Laminated glass

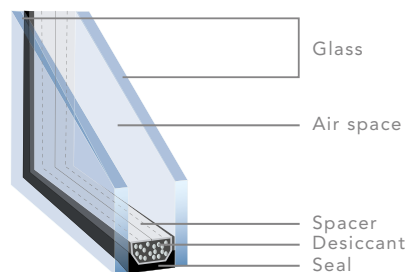
Laminated glass consists of two or more lites permanently bonded together with one or more polyvinylbutyral (PVB) interlayers using heat and pressure. The glass and interlayers can be a variety of colours and thicknesses designed to meet relevant building code standards and requirements as necessary. Laminated glass can be broken, but the fragments will tend to adhere to the plastic (PVB) interlayer and remain largely intact, reducing the risk of injury. Laminated glass is considered "safety glass" because it meets the requirements of the various European Building Regulations and Standards. Heat strengthened and toughened glass can be incorporated into laminated glass units to further strengthen the impact resistance. Bomb blast protection, the need for sound attenuation and ballistic or security concerns are all uses for laminated glass.



Insulating glass

Insulating glass refers to two or more lites of glass sealed around the edges with a perimeter spacer creating a cavity between to form a single unit. Commonly referred to as an "IG unit" insulating glass is the most effective way to reduce air-to-air thermal transfer through the glazing. When used in conjunction with low emissivity and/or reflective glass coatings, IG units become effective means to conserve energy and comply with energy regulations.

Low-emissivity coatings have gradually become better at reducing air-to-air heat transfer, and spacer technology has become the focus of incremental thermal improvements. Typical commercial spacers are composed of formed aluminium filled with desiccant to absorb any residual moisture inside the IG unit, thus reducing the potential for condensation to form. 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 centre of glass and the edge of glass, which can lead to condensation and reduces the overall thermal insulation (U-value) of the window.



Spandrel glass

Spandrel glass is the area of glass panelling that conceals structural building components such as columns, floor slabs, heating, ventilating and air conditioning (HVAC) systems, electrical wiring, plumbing, etc. often contained within false ceilings on each floor of a building, spandrel glass is typically located between vision glasses on each floor.

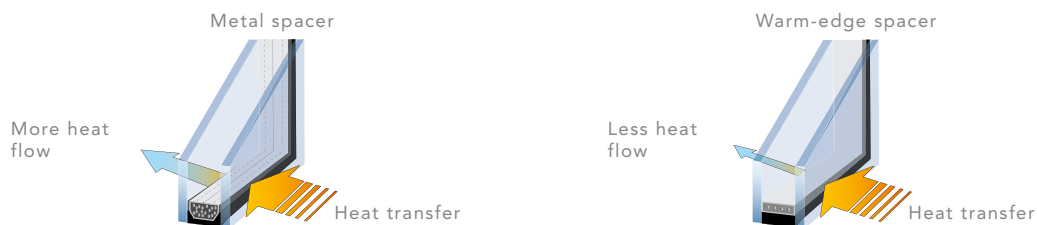
Curtain wall and structurally glazed designs often require the use of spandrel glass to achieve a designer's vision of the finished project. Spandrel glass applications can be a complementary or contrasting colour with respect to the vision glass appearance. Spandrel glass must be heat treated to avoid thermal stress breakage. GUARDIAN has extensive experience with spandrel glass applications and can help architects and building owners achieve the desired appearance, while reducing the risk of thermal stress breakage.

When high light transmission or low reflection vision glass is specified, achieving an exact spandrel match can be challenging. Daylight conditions can have a dramatic effect on the perception of vision to spandrel appearance. For example, a clear, bright sunny day produces highly reflective viewing conditions and may provide a good vision to spandrel glass match. A grey, cloudy day may allow more visual transmission from the exterior and produce more contrast between the vision and spandrel glass. GUARDIAN recommends full size, outdoor mock-ups be prepared and approved in

order to confirm the most desirable spandrel option for a specific project. For further information regarding particular colour-matching spandrel solutions and the manufacturing of reflective spandrel glass based on SunGuard®, please refer to our specific directives. These documents can be obtained from our GUARDIAN technical centres or from your local sales representative.

Warm-edge spacer

Warm-edge spacer technology is another option for improving the thermal properties, reducing condensation and reducing U-values in insulating glass 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 aluminium spacers.



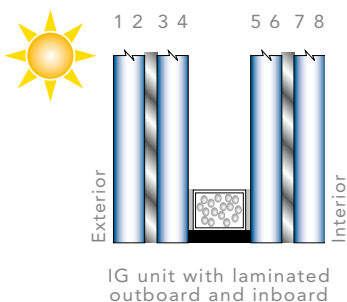
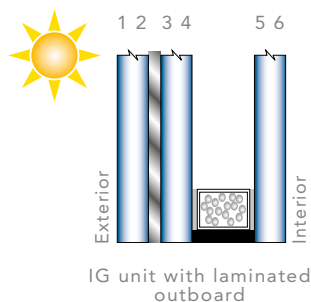
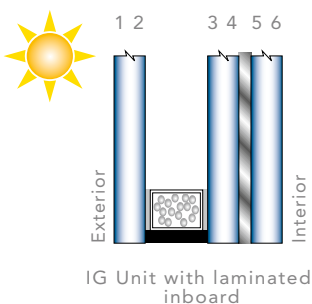
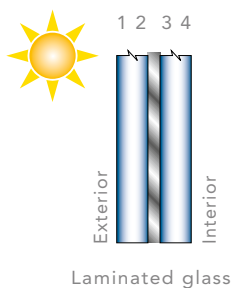
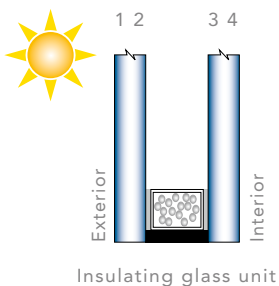
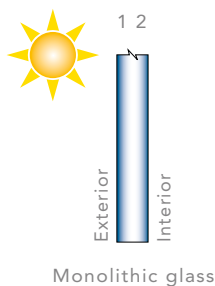
Tinted glass as compared to coated glass

Coatings are designed to reduce the amount of direct solar energy entering the building. Before the development of these coatings, architects relied on body tinted glass to reduce solar energy transmission. Tinted glass almost always requires heat treatment to reduce potential thermal stress breakage and tends to reradiate the absorbed heat. Solar reflective coatings effectively reduce heat gain but also reduce visible light transmission. High-performance, low-emissivity coatings are usually designed to reflect solar energy away from the glazing, often without requiring heat treatment.



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.



Performance Characteristics of Glass

What are the effects of wind and heat on architectural glass? What degree of light reflectance and heat absorption can be expected? What optical and acoustical effects are normal? This section shows how to get the maximum performance from SunGuard® Advanced Architectural Glass.

Energy conservation and coated glass

The use of coated glass and insulating glass units can have a significant impact on the energy consumption of commercial buildings. A reduction of the cooling capacity of the air conditioning system reduces the initial investment, and annual savings from reduced energy consumption for heating and cooling requirements provide a return on glazing investment year after year (studies have shown that over a ten-year period, the energy savings from high-performance coated glass can be considerable and for a typical six-storey building, the payback period can be as short as two years).

GUARDIAN Industries has invested substantial resources over the years in search of reduced solar heat gain and U-values of commercial coated glass products. The SunGuard® product range is one of the results of that investment, providing a wide range of performance characteristics to satisfy the requirements of European Building Regulations and Standards. SunGuard® products are among the highest performing, most energy-efficient coatings available today.

Glass performance

Today's advanced architectural glazing products attempt to balance the demands of aesthetic appearance, energy conservation and building occupant comfort. Theoretically speaking, an "ideal" solar control glazing would transmit the sun's visible energy (light) and reflect, or block, the ultraviolet and infrared energy, while providing an aesthetically pleasing appearance from both the exterior and interior of the building. GUARDIAN has scientists dedicated to finding new technologies to achieve the best energy performance possible, coupled with desirable aesthetics to help designers find that balance.



SunGuard® Advanced Architectural Glass

The SunGuard® glass product line is designed to deliver energy efficiency that will meet or exceed energy standard requirements and includes products offering a variety of aesthetically pleasing colour options. The High Selective range presents the highest performing energy characteristics available in high light-transmitting low-emissivity coatings from GUARDIAN. The High Performance range provides a selection of light transmission, reflection and energy conservation qualities to choose from. The Solar range lets the design professional work with traditional "reflective" coatings that are excellent at lowering heat gain.

Acoustic information

The acoustic performance of windows and glazing assemblies may be defined by a number of terms, most common being the acoustic performance measured at octave centre frequencies of 125, 250, 500, 1000, 2000 and 4000 hertz. The attenuation of various glass configurations needs to be established by measurement and used as a guide to the acoustic attenuation performance of the glass. There are also single figure acoustic indices, the two most commonly used being the weighted reduction, R_w , which includes a correction for the varying sensitivity of the human ear at different frequencies and traffic noise reduction, $R_{A,tr}$, which is relative to a standard traffic noise spectrum. The above terms have now been integrated into a single number quantity in accordance with EN ISO 717-1, which defines three terms as follows:

$$R_w(C;C_{tr})$$

where R_w is the weighted sound reduction index, which takes account of the human ear's sensitivity to a range of frequencies and may be used to compare the performance of alternative products.

C is the adaptation term for pink noise, which takes into account higher frequencies and is determined by the equation:

$$(R_w + C) = R_A$$

C_{tr} is the adaptation term for the traffic noise spectrum, which takes into account lower frequencies and is determined by the equation:

$$(R_w + C_{tr}) = R_{A,tr}$$

For further information regarding acoustic performance solutions and GUARDIAN's range of laminated glass products with special sound control features, please refer to our specific documents which can be obtained from our GUARDIAN technical centres or from your local sales representative.

How to view and evaluate glass samples

Coated glass is normally selected based on technical requirements and reflected colour, as is seen in normal outdoor lighting conditions. To see the reflected colour of glass, it is best to view samples against a black background.

GUARDIAN recommends that samples be viewed in natural outdoor lighting conditions, preferably in slightly overcast conditions so as to obtain the most accurate rendering of transmitted and reflected colour. Architects are also encouraged to consider angle of observation, interior lighting conditions and potential effects of glare when choosing glazing products.

When evaluating samples outdoors, we recommend viewing them at various times of day and under varying lighting conditions, e.g. cloudy versus sunny conditions. This will provide a more accurate indication of what the glass will look like, as well as giving you the opportunity to see how varying light conditions impact your intended design.

We recommend viewing glass samples outdoors whenever possible. Place samples in a vertical or slightly angled position. Viewing the glass with a black background not too close behind the sample is preferable so as to replicate lighting once installed in the structure. Then look through the glass to provide the best indication of the appearance of the installed glass.



Fabrication and Glazing

What are the guidelines for optical distortion? What can contribute to the risk of glass thermal breakage? How should glass be cleaned? This section provides more detailed information on many important areas related to SunGuard® Advanced Architectural Glass.

Optical distortion

Many conditions may contribute to optical distortion, including glazing errors and processing procedures. Minimising optical distortion resulting from a heat treatment process will greatly enhance the appearance of the final product. Roller wave and bow are sources of optical distortion that can result from tempering or heat strengthening and as such influence the appearance of the final product.

- Roller wave occurs as glass passes over the rollers in a horizontal, oscillating heat treatment furnace. As the glass heats up, it may sag between the rollers at the reversal of each oscillation, which then becomes "set" in place during the cooling (quench) process. This may produce roller wave distortion in the finished product
- Bow occurs as a result of the heat treatment process and can be reduced through the correct control of the heating and cooling. EN 12150 addresses bow and describes how overall and local bow should be determined

Strain pattern

Strain pattern refers to a specific geometric pattern of iridescence or darkish shadows that may appear under certain lighting conditions, particularly in the presence of polarised light (also referred to as "quench marks", "leopard spots" or anisotropy). The phenomena are caused by the localised stresses imparted by the rapid air cooling of the heat treatment process. Strain pattern is characteristic of heat-treated glass and is not considered a defect.

Thermal breakage

Thermal breakage can be influenced by a number of factors. There are many factors to be considered in the early stages of glass selection that can influence the thermal stress in the finished product.

One element to be considered is whether the glass will be shaded. When glass is partially shaded by building overhangs or extensions, it becomes cooler in those areas and stress in the glass may occur, which can result in thermal breakage. The degree to which the central area of the glass becomes hot is largely dependent on the solar absorption of the glass, which varies between different types of glass.

In areas where thermal breakage may be of concern, a thermal stress analysis must be completed to determine if heat treatment (heat-strengthening or tempering) may be needed. Heat treatment may anyway be required due to high wind loads or safety glass requirements. Some additional factors that may influence thermal breakage are listed below:

- Highly conductive glass framing or framing that is in direct contact with concrete or other materials that may contribute to the cooling of the glass edge
- Excessive coverage of the glass edge by the frame
- Heat absorbent film attached to the glass after installation
- The use of internal shading devices such as curtains, drapes or Venetian blinds increases the thermal stress and should be validated with a thermal analysis
- The airflow from room cooling or heating vents must be directed away from the glass
- Glass may also be subject to thermal stress during on-site storage, prior to being glazed. Care should be taken to store glass in a clean, dry environment which is not exposed to direct sunlight
- Buildings not heated during the construction phase may experience an increase in thermal breakage

The potential risk of thermal breakage can be estimated by a computer-aided thermal stress analysis. Contact your GUARDIAN representative or local technical department for assistance.

Heat soak testing

All float glass contains some level of imperfection. One type of imperfection are nickel sulphide (NiS) inclusions. Most NiS inclusions are stable and cause no problems. There is, however, the potential for NiS inclusions that may cause spontaneous breakage in fully tempered glass without any load or thermal stress being applied.

Heat soak testing is a process that exposes critical NiS inclusions in fully tempered glass. The process involves placing the tempered glass inside a chamber and raising the temperature to approximately 290° C to accelerate nickel sulphide expansion. This causes glass containing nickel sulphide inclusions to break in the heat soak chamber, thus reducing the risk of potential field breakage. The heat soak process is not 100 percent effective, but provides a defined level of confidence that is described in EN 14179.

Heat-strengthened glass has a much lower potential incidence of spontaneous breakage than tempered glass, and may be used where additional glass strength is required but safety glazing is neither mandatory nor specified.



Wind and snow loads

Wind and snow loads are usually considered and calculated in accordance with local standards and regulations depending where the building is sited. GUARDIAN is capable of determining the minimum thickness for the type of glass to be installed to resist the specified loads. These loads must be addressed in the early stages of design. Contact your GUARDIAN representative or local technical department for assistance with wind and snow load analysis.

Glass centre deflection: An important consideration in the choice of glass is centre deflection. Excessive centre deflection can result in edge pull-out, distortion of reflected images and possible glass contact with interior building components, e.g. room dividers and interior blinds.

Insulating glass: The effects of wind on insulating glass units are, in many cases, complex and require a computer-assisted wind load analysis to adequately consider some of the variables.

Design professionals must take into account the following variables:

- Load sharing other than 50-50
- Air space contraction and expansion due to changes in temperature, barometric pressure and altitude variation in weathering of the glass surfaces, e.g., surface #1 vs. surface #2
- Glass edge supported on all sides or only partially
- Asymmetrical loading, i.e. panes of different thickness
- Thermal stress

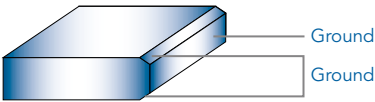
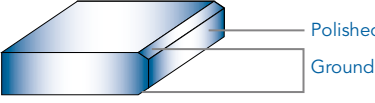
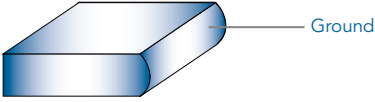
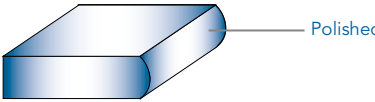
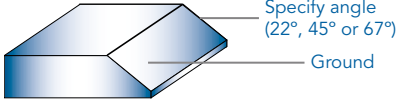
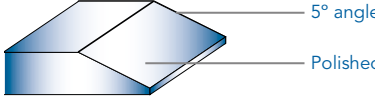
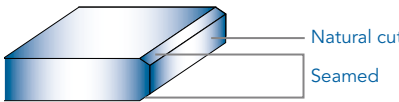
When all or some of these variables are taken into account, the maximum wind load may vary considerably.

Bending GUARDIAN sputter coated glass

SunGuard® heat treatable coatings are thermally stable and have been utilised in bent glass applications. SunGuard® products used in bent glass applications maintain their aesthetic, optical and performance properties. Bending constraints are based on coating type, choice of bending process (tempered versus annealed bending), radius and concave vs. convex applications. GUARDIAN recommends a full scale mock-up be produced and viewed prior to final specification approval. Please contact your GUARDIAN representative or technical department for further advice and information regarding bent glass applications.

Glass edge types

The condition of the edge of finished glass products can impact the long term structural performance of the glass system. This table of edge types is provided to help design professionals understand typical applications.

Edge diagram	Description	Typical application
	Flat ground	Silicone structural glazing with exposed edges
	Flat polish	Silicone structural glazing where edge condition is critical for aesthetic reasons
	Ground pencil edge	Mirrors, decorative furniture glass
	Polished pencil edge	Mirrors, decorative furniture glass
	Ground mitre	Silicone structural glazing
	Bevel	Mirrors, decorative furniture glass
	Seamed edges	Normal edge treatment for heat-treated glass

Coated glass: maximum and minimum sizes

To determine the minimum and maximum sizes available for finished glass products, the glass processor must be consulted. Physical or mechanical capabilities together with constraints of the processor will affect the final finished glass size availability.

Special considerations for large finished glasses

It is important for designers to understand that the maximum glass sizes manufactured by GUARDIAN do not suggest that insulating glass unit and heat treatment equipment capabilities can process these sizes. On the contrary, there are many factors that need to be taken into account when designing glazing for today's architecture.

Maximum glass sizes available from the primary manufacturer are one consideration, others are the processing equipment limitations, the capabilities of the contract glazier to install the unit, the availability of specialised transport and handling equipment to deliver the unit, and the specific glass configuration, such as coated glass, silk-screened glass, and heat-treated glass, laminated glass, insulated glass or some combination of these items.

GUARDIAN recommends the specific glass configuration be reviewed with a glass processor so that the availability of glass to meet project lead times and budget can be confirmed.

Statistical probability of glass breakage

Statistical probability of glass breakage is a complex topic. The following section should only be regarded as an introduction to the issue.

Glass is a brittle material. It acts elastically until it fractures at ultimate load. That ultimate load varies, depending upon the type and duration of the loads applied and the distribution, orientation and severity of the inhomogeneities and micro-flaws existing in the surface of the glass. Because of its nature, glass cannot be engineered in the same way as other building envelope materials with a predictable specific strength. In those cases, factors are assigned to minimise the likelihood that breakage will occur at the selected design load. Because the ultimate strength of glass varies, its strength is described statistically. Architects and engineers, when specifying a design factor for glass in buildings, must choose the anticipated wind load, its duration and the probability of glass breakage (defined as x per 1000 panes of glass at the initial occurrence of the design load). Glass manufacturers can provide the appropriate data for determining the performance of their products. However, the responsible design professional must review these performance criteria and determine if they are suitable for the intended application.

Glass handling, storage, maintenance and cleaning

Glass is a hard substance, but it can be scratched. Glass is resistant to many, but not all, chemicals. Glass is generally a durable material, and if properly maintained, can last almost forever.

One of the most harmful materials to glass is glass itself. When glass is stored prior to fabrication, it should be separated by an air space, suitable separator or paper. When removing glass from storage, avoid sliding one pane over another, as they can be scratched or abraded. Glass edges should not come into contact with the frame or other hard surfaces during installation. Glass should be washed frequently to remove surface dirt and also to protect the glass from staining. Glass staining occurs when the sodium within the glass reacts with moisture in the air. When combined with small amounts of water, sodium can form sodium hydroxide, which is corrosive to glass. If this sodium hydroxide is left on the glass surface for a prolonged period of time, the glass will be permanently damaged and may have to be replaced. The sodium hydroxide is easily removed with water and normal glass cleaning solutions, e.g. alcohol and water, or ammonia and water. Installed glass is less prone to sodium hydroxide damage due to the natural cleansing of the glass surface by rain.

Recommended cleaning or washing solutions

A. General glass cleaning

- Use water applied by a saturated clean cloth
- Use proprietary glass cleaning solutions ensure you follow all printed instructions. Immediately remove cleaning solutions with a clean, soft, dry cloth
- Use a 50-50 mixture of alcohol and water, or ammonia and water, followed by a warm rinse. Glass must be dried with a clean, soft cloth or a chamois and cellulose sponge

B. Precautions

- Avoid abrasive or highly alkaline cleaners. Do not use petroleum products, i.e. petrol, diesel or lighter fluid
- Hydrofluoric and phosphoric acid are corrosive to the glass surface and should not be used
- Protect the glass surface from over spray or run-off from acids and cleaning agents used to clean metal framing, brick or masonry and splatter from welding processes
- Keep all cleaning solutions and other materials from coming into contact with the edges of laminated glass or insulated glass
- Do not use abrasive brushes, razor blades or other objects that may scratch the glass
- Immediately remove any construction materials, i.e. concrete, fireproofing, paints, labels and tapes
- Clean a small area at a time, and inspect the glass surface frequently to ensure that no glass damage has occurred
- For most effective results, clean glass at a time when its surface is shaded. Avoid direct sunlight or hot glass

For the correct handling and treatment of coated glass please refer to GUARDIAN's Processing Directives for Architectural Glass Products.



Quality inspection guidelines

The following quality standards are offered as suggested guidelines for the evaluation of coated glass products, based partially on current European Standard EN 1096.

General:

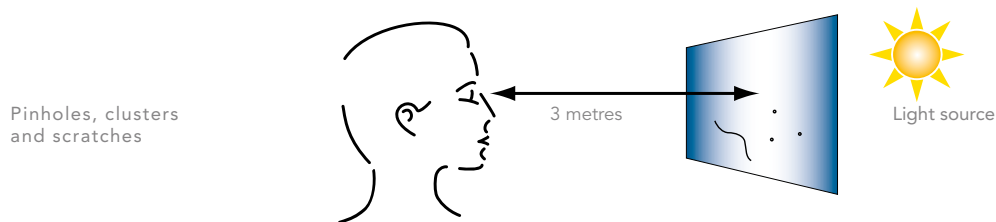
- Normal viewing distance is a minimum of 3 metres for vision glass and 5 metres for spandrel glass. The viewing angle should be 90° against a bright, uniform background. Spandrel glass is viewed against a dark, uniform background
- The area of most importance is the central viewing area, which is defined by 90% of the length and 90% of the width dimensions centred on a pane of glass. The remaining area is considered the outer area. No more than 20 seconds should be spent viewing the glass

Pinholes and clusters (viewed in transmission):

- Pinholes between 2 and 3mm are acceptable if not more than 1/m².
- A cluster is defined as two or more pinholes up to 2mm each that are readily apparent
- Clusters of pinholes within the central viewing area are not acceptable, but they are acceptable in the outer area

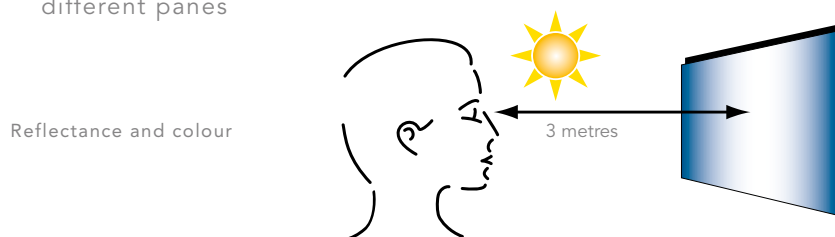
Scratches (viewed in transmission):

- Scratches longer than 75mm within the central viewing area are not acceptable



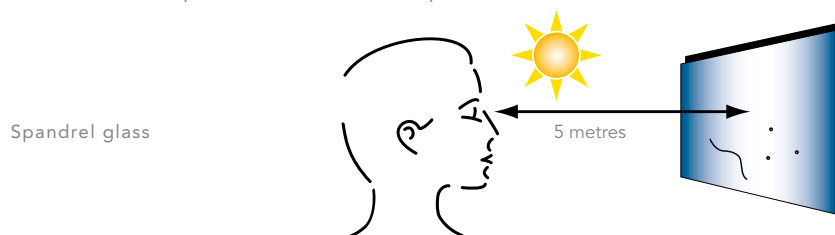
Colour uniformity (viewed in reflection):

- Colour variations are acceptable as long as they are not regarded as visually distracting. This applies to colour variation within one pane or variations between different panes



Spandrel glass (viewed in reflection):

- Colour and reflectance may vary slightly overall and be considered acceptable
- Pinholes up to 3mm are acceptable
- Scratches up to 75mm are acceptable



Glossary

Colour rendering index (CRL)

The ability of transmitted daylight through the glazing to portray a variety of colours compared to those seen under daylight without the glazing. The scale is 1 – 100. For instance, a low CRL causes colours to appear washed out, while a high CRL causes colours to appear vibrant and natural. In commercial glass, CRL indicates the effect the specific glass configuration has on the appearance of objects viewed through the glass.

Environmental (solar gain) factors

Numbers related to and derived from shading coefficients, which also describe the ability of the glazing to reduce solar heat gain.

The solar gain factors for glazing, transmitted to the environmental point, with no internal shading, are as follows:

Average solar gain factor to air point = $0.8 \times \text{total shading coefficient}$

Cyclic solar gain factor to air point for lightweight buildings = $(0.65 \times \text{Short Wave Shading Coefficient}) + (0.84 \times \text{Long Wave Shading Coefficient})$

Cyclic solar gain factor to air point for heavyweight buildings = $(0.48 \times \text{SWSC}) + (0.76 \times \text{LWSC})$

The solar gain factors for glazing, transmitted to the environmental point, with internal shading are as follows:

Average solar gain factor to environmental point = $(1.65 \times \text{SWSC}) + (0.546 \times \text{LWSC}) - 0.135$, or $(0.76 \times \text{SWSC}) + (0.26 \times \text{LWSC})$, whichever is the greater.

Cyclic solar gain factor to environmental point for lightweight buildings = $(1.25 \times \text{SWSC}) + (0.546 \times \text{LWSC}) - 0.115$, or $(0.60 \times \text{SWSC}) + (0.26 \times \text{LWSC})$, whichever is the greater.

Cyclic Solar gain factor to environmental point for heavyweight buildings = $(0.9 \times \text{SWSC}) + (0.546 \times \text{LWSC}) - 0.125$, or $(0.44 \times \text{SWSC}) + (0.26 \times \text{LWSC})$, whichever is the greater.

The solar gain factor for glazing, transmitted to the air point, with internal shading are as follows:

Average solar gain factor to air point = $0.345 \times \text{LWSC}$

Cyclic solar gain factor to air point for both lightweight or heavyweight buildings = $0.39 \times \text{LWSC}$



Note: The cyclic factors may also be referred to as alternating factors.

Environmental factors for glazing combinations are often required by computer software, such as Hevacomp, for the modelling of heating and ventilation levels in buildings. These can be derived from knowledge of the shading coefficients, short wave, long wave and total.

Solar gains through windows arise due to:

Part of the solar radiation absorbed in the window which is transmitted to the environmental point transmitted solar radiation absorbed on internal room surfaces which also appears at the environmental point.

Where internal shading devices are considered, there is an additional convective load realised at the air point. As steady state conditions are rare in buildings, it is more common for conditions to cycle on a regular daily pattern. Such cycles can be considered in two parts, a 24-hour average and a cyclic variation about the mean. Cyclic solar gain factors will differ between building types, depending on whether the construction is lightweight or heavyweight.

Heat gain

Heat gain is heat added to a building interior by radiation, convection or conduction.

Heat transfer methods

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. Radiation, or emission, occurs when heat (energy) can move through space to an object and is then transmitted, reflected or absorbed.

Reflective coatings

A combination of medium outdoor reflectivity and low-e performance qualities. These coatings allow the designer to combine low U-values, reduced solar heat gain and visual aesthetics. GUARDIAN offers a wide range of these products.

Infrared (long-wave) energy

Energy generated by radiated heat sources such as electric coil heaters or natural gas powered, forced air furnaces. Also, any object that can absorb heat and radiate it produces low-wave, infrared energy.

Note: When short-wave energy from the sun is absorbed and radiated by glazing, it is converted to long-wave energy.

Selectivity

Ratio of the visible light transmittance to the solar heat gain coefficient. A higher selectivity ratio means sunlight entering the room is more efficient for daylighting, especially for summer conditions where more light is desired with less solar gain. This ratio is the measurement used to determine whether the glazing is "spectrally selective".

Low-e coatings

Relatively neutral in appearance, low-e coatings reduce heat loss by reflecting long-wave infrared energy (heat) and, therefore decrease the U-value 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. They may also be coupled with solar control coatings. SunGuard® High Selective, HP and ClimaGuard® products all have low-e coatings.

Relative heat gain (RHG)

The total heat gain through glass for a specific set of conditions. This value takes account of indoor/outdoor air temperature differences and the effect of solar radiation.

R-value

A measure of the resistance of the glazing to heat flow. It is determined by dividing the U-value into 1, ($R\text{-value} = 1/U\text{-value}$). 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 referred to here to help understand U-value.



Shading coefficient (SC)

The solar radiant heat admission properties of glasses can be compared by their shading coefficients. The shading coefficient is derived by comparing the properties of any glass with a clear float glass having a total solar heat transmittance of 0.87 (such a glass would be between 3 and 4mm thick). It comprises a short wavelength and long wavelength shading coefficient. The short wavelength shading coefficient (SWSC) is the direct solar heat transmittance divided by 0.87. The long wavelength shading coefficient (LWSC) is the fraction of the absorptance released inwards, again divided by 0.87.

The total shading coefficient is the sum of both the short and long wavelength coefficients.

Shading coefficients are calculated for radiation at near normal incidence.

Solar energy

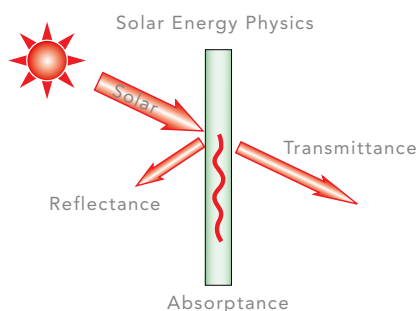
Radiant energy from the sun having a wavelength range of 300 to 4000nm, which includes UV (300 to 380nm), visible light (380 to 780nm) and near infrared energy (780 to 4000nm).

% reflectance out = percentage of incident solar energy directly reflected from the glass back outdoors

% absorptance = percentage of incident solar energy absorbed into the glass

% transmittance = percentage of incident 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 re-radiation of absorbed energy that can be emitted toward both the exterior and interior of the building. Emissivity is controlled through the use of low emissivity, or low-e, coatings.



Solar reflective coatings

Typically, highly reflective coatings that reduce solar heat gain through reflection and absorption. Though very effective at reducing heat gain, visible light transmittance is generally low and U-values are not as energy-efficient as low-e coatings. GUARDIAN offers the SunGuard® Solar range in this product category, which is often combined with a low-e coating on the opposite pane in an insulating glass unit.

Spectrally selective glazing

High-performance glazing that admits as much daylight as possible, while preventing transmission of as much solar heat as possible. By controlling solar heat gain in summer, preventing loss of interior heat in winter and allowing occupants to reduce electric lighting use by making maximum use of daylight, spectrally selective glazing significantly reduces building energy consumption.

Ultraviolet transmission

Percentage of incident ultraviolet energy that is directly transmitted through the glass. Long-term exposure to UV light may result in fabric and pigment fading, plastic deterioration and changes to the appearance of many types of wood. Ultraviolet light is radiant energy from the sun having a wavelength range of 300 to 380 nm with air mass of 1.5.

U-value

A measure of the heat gain or loss through glass due to the difference between indoor and outdoor air temperatures. A lower U-value indicates better insulating properties. The units are W/m^2K .

Visible light

Radiant energy in the wavelength range of 380 to 780 nm with III. D65 and CIE2° observer.

% transmittance = percentage of incident visible light directly transmitted through the glass

% reflectance indoors = percentage of incident visible light directly reflected from the glass back indoors

% reflectance outdoors = percentage of incident visible light directly reflected from the glass back outdoors



The performance values shown are nominal and subject to variations due to manufacturing tolerances. Spectra-photometric values according to EN 410; U-values according to EN 673.

The products in this publication are sold subject to GUARDIAN's standard terms and conditions of sale and any applicable written warranties. It is the responsibility of the purchaser to confirm that the products are suitable for their intended application. Please contact your local GUARDIAN representative to obtain any applicable handling and fabrication guides and for the most current product information.