

The AGC logo consists of the letters 'AGC' in a bold, blue, sans-serif font. The letter 'A' is white with a blue outline, 'G' is solid blue, and 'C' is solid blue.

us.agc.com

BEYOND GLASS™

YOUR GLASS POCKET

Your Glass Pocket

The AGC logo consists of the letters 'AGC' in a bold, blue, sans-serif font. The letter 'A' is white with a blue outline, 'G' is solid blue, and 'C' is solid blue.

BEYOND GLASS™

The AGC logo consists of the letters 'AGC' in a bold, blue, sans-serif font. The letter 'A' is white with a blue outline, 'G' is solid blue, and 'C' is solid blue.

BEYOND GLASS™

© 2013 AGC Glass Company North America, Inc.
All rights reserved.

The logo for AGC (Associated General Contractors of America) is displayed in a white square. The letters 'AGC' are in a bold, blue, sans-serif font. A small red and white flag is positioned between the 'A' and the 'G'.

BEYOND GLASS



I. AGC GLASS COMPANY NORTH AMERICA	4
II. ALL ABOUT GLASS	20
III. CHOOSING A GLASS	106
IV. BRANDS AND PRODUCTS	120
V. LOCATIONS	214
VI. GLOSSARY	218
VII. PERFORMANCE SUMMARY TABLES	246



I. AGC GLASS COMPANY NORTH AMERICA

1 Beyond Glass™	6
2 Committed to North America	8
3 Building Products	10
4 Vertical Integration	18



1 BEYOND GLASS™

As a glass technology driven company, AGC operates on a broader premise that glass is more than just a design element and something to manage light and energy. It's an opportunity.

With more than 200 subsidiaries and affiliates, AGC is the global leader in glass. We've earned the #1 position in many markets by providing our customers with innovative products and individualized solutions. Much of the glass you see and touch every day is supplied by AGC. A proven global partner with a worldwide network of technical knowledge and innovation, AGC is providing a better future through glass.



2 COMMITTED TO NORTH AMERICA

A global leader with strong North American roots, AGC has a steadfast commitment to innovation, expansion, and customer service. Founded in 1956 and headquartered in Alpharetta, Georgia, AGC North America has more than 3,500 employees and 40 locations. New capabilities and facilities continue to advance, creating jobs and investing in communities.

The AGC logo consists of the letters 'AGC' in a bold, sans-serif font. 'A' and 'C' are blue, while 'G' is red. The logo is centered within a white square.

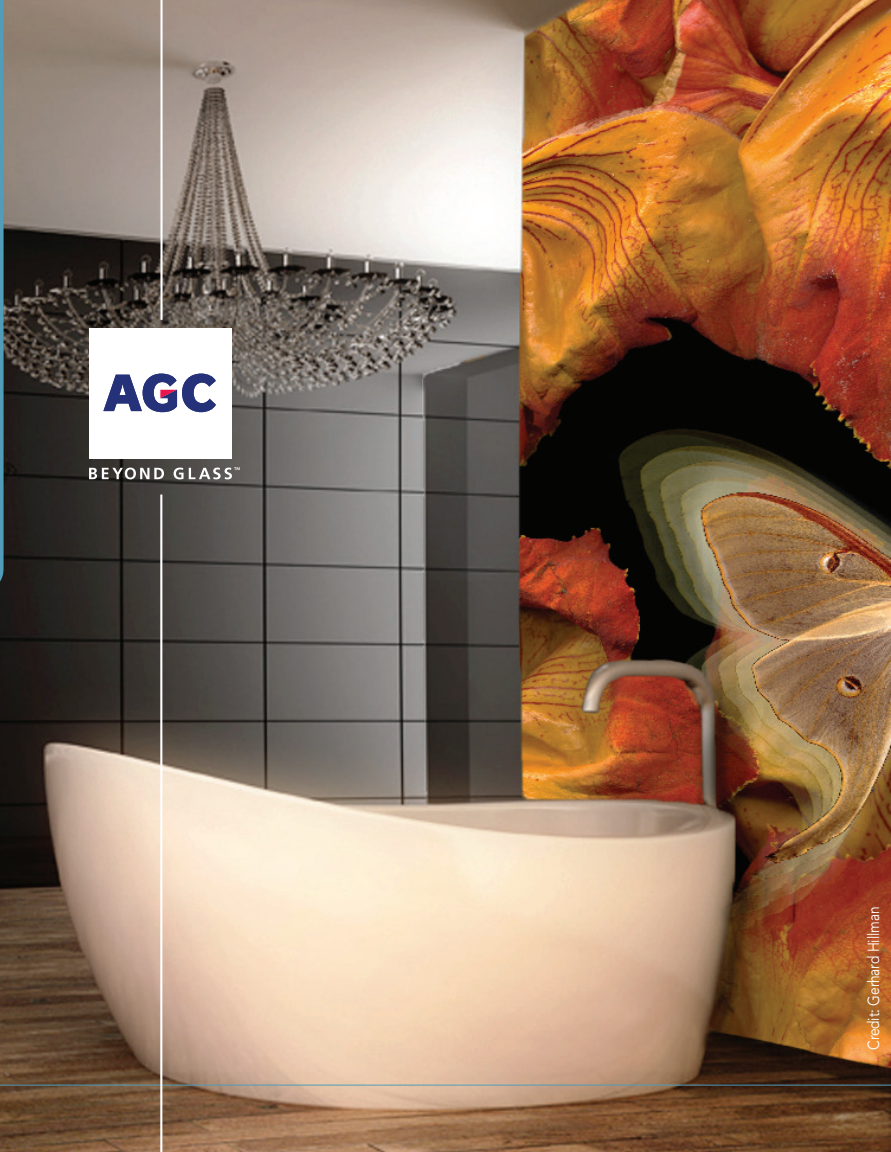
BEYOND GLASS

3 BUILDING PRODUCTS

ARCHITECTURAL

The shortest distance between “what if” and “wow”

Enhancing and expanding the applications of glass requires understanding the needs of every member of the building team, from architect to glazier to building owner. By functioning across the entire manufacturing value chain, AGC is able to control glass production and optimize fabrication processes. Performance is assured, allowing design to be expanded through enhanced solar control, sound control, fire- and impact-protective glazing, and beyond.

**AGC**

BEYOND GLASS™

Credit: Gerhard Hillman

INTERIORS

Experience the new designability of glass

Few materials convey a mood and capture a distinctive aesthetic quite like glass. From back-painted to acid-etched, AGC offers an extensive selection of unique glass products that elevate and distinguish interior applications. Our custom fabrication capabilities assure that your vision is easy to achieve from the time it's ordered through final delivery. Discover our portfolio of glass "designed for designers" with clearer clears, truer colors, distinctive patterns, and custom imaging.



RESIDENTIAL

Adding comfort with a regional approach to residential glass

Through a complete portfolio of products designed for climate-specific performance, AGC offers the right glass for the right region. Our global experience, leading technology, and integrated fabrication systems enable us to deliver efficient products tailored to your needs. The superior thermal performance of AGC residential products has been proven to help homeowners reduce utility costs and add years of comfortable enjoyment.

The AGC logo consists of the letters 'AGC' in a bold, blue, sans-serif font, centered within a white square.

BEYOND GLASS™

FIRE-RATED GLASS

Glass that restricts fire, not design

AGC's Pyrosafe™ family of fire-rated glass and framing systems offers the protection and code compliance your project demands—as well as the ability to bring inspired designs to life.

Ratings of up to 180 minutes can be achieved with glass that is wireless, colorless, and distortion free. So you can be sure your design vision will always come through.



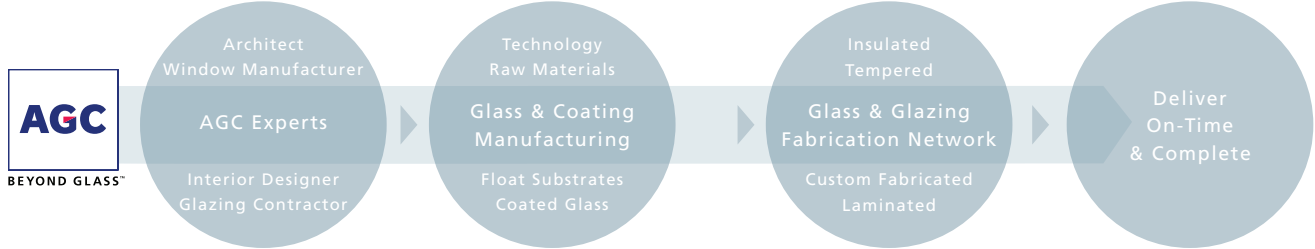
4 VERTICAL INTEGRATION

BETTER PREPARED TO MEET YOUR DESIGN VISION

AGC is a vertically integrated company. As a result, we're able to align all resources to maximize the designability of glass and consistently meet your vision.

Unsurpassed global resourcing and manufacturing innovation enable us to develop leading-edge solutions and deliver them through our fabrication network. The result: Complete accountability, consistent and dependable supply, and value-added solutions.

AGC AT EACH STEP IN THE PROCESS





II.

ALL ABOUT GLASS

1	Glass Products	22
1.1	Composition	23
1.2	Properties	24
1.3	Glass Products	25
2	Properties and Functions	37
2.1	Introduction	38
2.2	Radiation, Light, and Color	39
2.3	Thermal Insulation	46
2.4	Solar Control	56
2.5	Light Control	68
2.6	Sound Insulation	73
2.7	Safety	86

1 GLASS PRODUCTS



Galeo, Issey les Moulineaux, France

1.1 COMPOSITION

Flat glass used in buildings is a soda lime (soda + lime) silicate (silica or sand) obtained by melting the mixture at a high temperature.

Soda lime silicate glass is composed of—

- > Silicate sand, which gives the glass its texture—it is known as the glass former, or SiO_2 network former
- > Calcium carbonate, used as a melting agent to lower the melting temperature of the silica and as a fining agent to homogenize the melting mixture and eliminate bubbles
- > Lime, used as a stabilizer, which gives the glass its chemical resistance
- > Fining agents, which are designed to agitate the melting mixture, release gases, and standardize quality
- > Various metal oxides, which enhance the mechanical characteristics of the glass, increase its resistance to atmospheric agents, and provide any color it might have

There are also other types of glass, for example—

- > Borosilicates, which are used, for example, for laboratory glazing because of their low expansion coefficient
- > Glass ceramics made up of a crystalline phase and a residual glassy phase; they have a linear expansion coefficient of virtually zero and are used, among other applications, in the manufacture of ceramic cook tops
- > Alkaline earth glasses
- > Glasses with a high lead content (approximately 70%), which substantially reduces the transmission of X-rays; these are used for glazed walls in medical or industrial radiology areas
- > Crystal, which is glass containing a minimum of 24% lead oxide, offering special features of clarity and resonance

1.2 PROPERTIES

Main properties of soda lime silicate glass

Density @ room temperature	156 lb/ft ³ 2,500 kg/m ³
Modulus of elasticity	10 x 10 ⁶ psi 69 GPa
Poisson's ratio	0.23
Mohs' hardness	5.5
Melting temperature	≈ 2,700°F ≈ 1,500°C
Softening point	(1,319-1,345)°F (715-729)°C
Coefficient of thermal expansion	5.0 x 10 ⁻⁶ (°F) 9.0 x 10 ⁻⁶ (°C)
Thermal conductivity	1.0 Btu/ft-h-°F 1.7 W/m-K
Specific heat capacity	0.2 Btu/lb _m -°F 840 J/kg-K
Characteristic bending strength*	
Annealed glass	6,000 psi 41.4 MPa
Heat-strengthened glass	12,000 psi 82.7 MPa
Tempered glass	24,000 psi 165.5 MPa
Compressive strength	1,000 N/mm ² 145 x 10 ³ psi
Refraction index	1.5
Emissivity of uncoated glass	0.84
Values below are for 3mm clear	
Total solar transmission	86%
Total visible light transmission	90%
Solar heat gain coefficient	0.88

*Generally accepted values. Glass does not behave like a standard building material. Use appropriate safety coefficient and FEA program when performing mechanical calculations.

1.3 GLASS PRODUCTS

1.3.1 INTRODUCTION

Finished glass is obtained by bringing the soda lime silica mixture to its melting point (approximately 1,600°C), then cooling and processing it. Several types of glass can be made, depending on the process used.

In describing glass products, a distinction is drawn between two types:

- > Base products—i.e., soda lime silicate glass products that undergo no additional processing after leaving the furnace
- > Processed products—i.e., those products obtained by processing base glasses. Among processed glass solutions, a further distinction is made between two types of processing:
 - Primary processing of large sizes (sheets) or, where necessary, standard sizes
 - Secondary processing of standard sizes

These products are described briefly in sections 1.3.2 and 1.3.3 of this chapter.

Base and processed products

Base products		Float glass - Patterned rolled glass - Wired glass - Polished wired glass
Processed products	Primary processing	Low-e coated glass - Surface-treated glass (etched, sandblasted, etc.)
	Secondary processing	Tempered glass - Heat-strengthened glass - Laminated glass - Enameled and silk-screen printed glass - Bent glass - Mirror glass - Insulating glass - Spandrel glass

1.3.2 BASE PRODUCTS

▼ Float Glass (ASTM C-1036)

The float glass product category includes flat, transparent, clear, and colored (e.g., green, grey, bronze, blue) soda lime silicate glass.

Standard thicknesses for architectural applications are—

in.	SGL	LAMI	DSG	1/8	5/32	3/16	1/4	5/16	3/8	1/2	5/8	3/4
mm	2.5	2.7	3	3.1	4	5	6	8	10	12	15	19

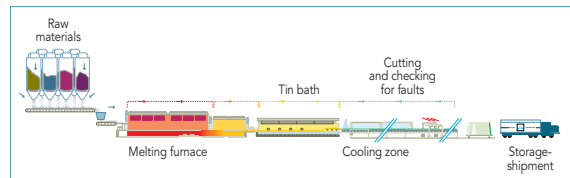
Maximum dimensions are 130" by 204".

Float glass is the base glass used in all subsequent glass processing operations.

The production line for float glass is composed of the following key areas:

- > Area for storing and weighing raw materials
- > The melting and refining furnace, where materials are melted at a temperature of approximately 1,600°C; this process refines and homogenizes the mixture, eliminates gas bubbles, and ensures good thermal conditioning of the molten glass
- > The tin bath, where the molten glass is "floated" to form the sheet of glass; regulating the flow rate of the mixture determines the thickness of the sheet of glass
- > The annealing zone, where the glass is cooled under controlled conditions to eliminate internal stresses
- > Equipment area, where flaws are detected and the continuous strip of glass is cut into smaller sizes
- > Area for storing and shipping end products

Float process



AGC float products: Clear and Solarshield™ tinted glasses, Linea Azzurra (blue tinted) and low-iron Krystal Klear™

▼ Patterned Rolled Glass (ASTM C-1036)

Patterned rolled glass features a design on one or both sides, obtained by passing the sheet of glass between textured rollers during the manufacturing process.

The production line for patterned glass is similar to a float line, except that the stage of floating on a tin bath is replaced by shaping the glass between two rollers. The distance between the rollers determines the ultimate thickness of the glass. Afterward, patterned glass is annealed, or placed in a cooling zone.

AGC patterned product: Krystal Patterns™

▼ Wired Glass (ASTM C-1036)

Wired glass products consist of patterned glass into which a wire mesh is incorporated. This product is laminated between rollers to form a glass "sandwich." The internal wire mesh is designed to hold pieces of glass in place in the event of breakage, but has no impact on mechanical strength.

▼ Polished Wired Glass (ASTM C-1036)

Polished wired glass is a wired glass patterned with a very faint design; this surface design is then softened and polished to achieve the transparency and clarity of float glass. Like wired glass, this product protects against injury in the event of glass breakage; it can also provide fire resistance in certain applications.

AGC polished wired products: Diamond, Square, Kasumi Obscure

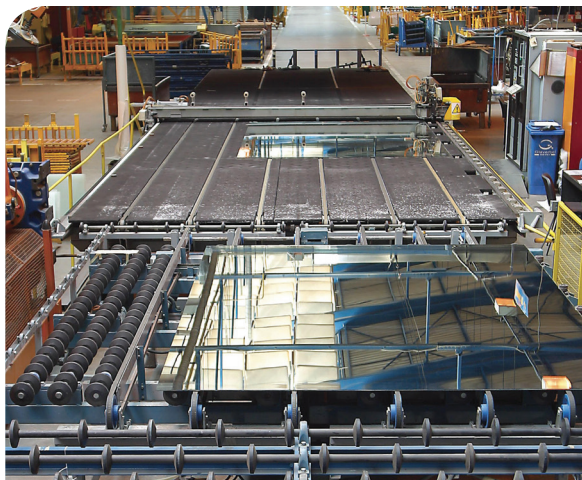
1.3.3. PROCESSED PRODUCTS

▼ Coated Glass (ASTM C-1376)

This popular glass solution is created by applying one or more coatings of inorganic materials to alter the physical properties of the glass—including its solar heat gain coefficient (SHGC), emissivity, color, light transmission, light reflection, and other properties. See Section 2 in this chapter, called “Properties and Functions.”

Coated glass products can be categorized by three main characteristics:

- 1 The method used to apply the coating (pyrolytic or sputter-coated)
- 2 The position of the coated side of the glass when installed in an insulating unit (e.g., position 1, 2, 3, 4)
- 3 The application for which the glass is used (e.g., thermal control or solar control)



▼ Sputter-Coated Glass

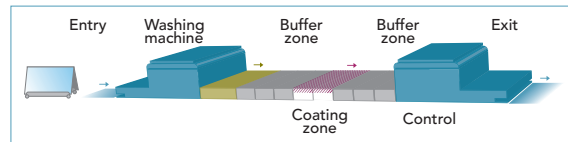
Sputter or “soft” glass coatings are applied through the bombardment of metal atoms onto cooled float glass. This process, which takes place in a low-pressure chamber, is known as magnetic sputter vapor deposition (MSVD). Because it takes place after float manufacturing is complete, sputter coating is often referred to as an “offline” coating method.

In the sputter-coating process, a sheet of annealed glass is placed under a magnetic sputter ring, as well as a plate of the specific metallic material that will be used to coat the glass with a microscopically thin layer. This plate is negatively charged, then bombarded with gas particles that disturb its outermost molecules—depositing them in a “sputter” pattern onto the annealed glass surface beneath.

The specific metal atoms deposited on the glass surface will determine its ultimate performance properties.

In order to protect the integrity of the coating, “soft-coat” products should be installed in position 2 or 3 in a double-glazed unit and 4 or 5 in a triple-glazed unit.

Sputter-coating process



AGC sputter-coated products: Energy Select™ and Comfort Select™.

▼ Glass With Pyrolytic Coatings

Pyrolytic coatings are metallic oxides applied during the float manufacturing process, while glass is still in a semi-molten state—when it has cooled to a temperature of about 1,112°F or 600°C. Because these coatings become a permanent part of the glass itself, they are extremely durable and tough—hence the common name “hard coat.”

After the molten glass has moved through the tin bath—floating on its surface to form a perfectly flat, consistently shaped ribbon—specialized metallic oxide coatings can be applied to the “atmosphere” surface of the glass in order to improve its performance or enhance its appearance. This “online” coating process is known as chemical vapor deposition (CVD).

Glass products that feature a pyrolytic coating have a number of advantages:

- > They offer a high level of solar control
- > They are easy to handle, transport, stack, and store
- > They can be heat treated, laminated, bent, silk screened, and enamelled to meet specialized applications
- > There is no need for edge deletion when incorporating pyrolytic glass in an insulating unit. “Edge deletion” means removing a portion of the coating at the perimeter of the glass to ensure a tight seal
- > Pyrolytic products are durable enough to be used monolithically, though this is seldom recommended by AGC
- > Pyrolytic reflective coatings can be exposed to weather—positioned on the #1 surface—but this is never recommended by AGC Glass Company North America because of increased potential for damage and staining of the coating

AGC hard-coated products: Comfort Select™ 73, Energy Select™ 73, Stopsol®

▼ Mirror Glass (ASTM C-1503)

Mirror is glass to which a coating is applied to reflect images; this coating is then protected by a second coating of paint. The process of manufacturing mirrors is called silvering.

▼ Back-Painted Glass

Painted glass products are coated on one side with a high-quality, durable paint in a range of colors. Painted glass products are for interior use only and should not be used outdoors.

For special applications where personal safety is a concern, painted products can be backed by a polypropylene film, which is applied to the painted side of the glass. This backing minimizes injury and damage if the glass breaks, because splinters adhere to the film. This backing has the added benefit of protecting the painted surface from scratches.

AGC painted products: Krystal Kolours™

▼ Matte-Finish Glass

Acid-etched glass may be wholly or partially matte in appearance. This innovative product is created by applying acid to one or both sides of clear or colored float glass. The acid attacks the surface of the glass, giving it a translucent appearance and a smooth, satiny feel.

AGC acid-etched products: Matelux®

▼ Sandblasted Glass

This decorative product is flat glass which undergoes a sandblasting treatment—i.e., abrasive etching at high pressures. This process can be used to obtain uniform or multi-relief motifs.

> Laminated Glass (ASTM C-1172)

Laminated glass solutions consist of at least two sheets of glass bonded into a “sandwich” configuration by a full-surface plastic interlayer. The plastic interlayer may be one or more plastic films (PVB, EVA, etc.), as well as resin, silicate, or gel. These materials are designed to bond the sheets of glass together while further enhancing the performance of the end product.

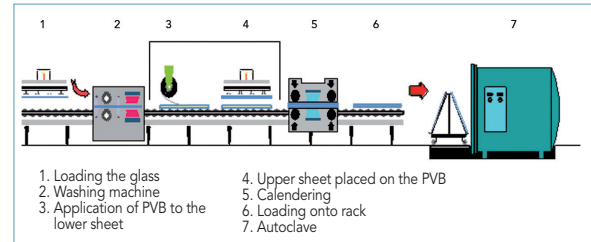
The high performance level of laminated products may provide one or more of these functions:

- > Safety and security of people and property (limiting the risk of injury in the event of glass breakage, or providing protection against hurricanes, defenestration, vandalism, burglary, etc.)
- > Protection against bullets and explosions
- > Protection against fire
- > Sound insulation
- > Decoration

Producing laminated glass solutions with PVB interlayers involves the following processing steps:

- > The glass is loaded and cleaned
- > The PVB film is applied to the first glass, and the second glass is then applied onto the film
- > The glass moves into an oven, where a roller passes over it at a very high temperature to eliminate any air bubbles—as well as ensure preliminary bonding of the glass to the PVB
- > The laminated glasses (not yet transparent) are then stored on racks
- > The racks are placed in a high-pressure, high-temperature autoclave to achieve the product’s ultimate adhesion and transparency properties

Laminating process



Laminated products—which can be visually indistinguishable from monolithic glass—can be fabricated with a variety of annealed, heat-treated, and coated products to create custom-tailored solutions.

In commercial applications, building codes often require the use of laminated safety glass in overhead glazings such as atriums and skylights, and laminated glass can be used as a safety glazing in storefronts and entrance doors.

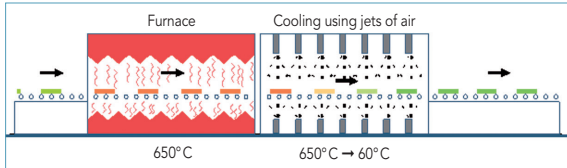
Specific properties provided by laminated products include enhanced UV protection, as well as protection from unwanted noise. In fact, the use of laminated glass can significantly improve the sound transmission class (STC) rating for windows in noisy areas. Compared to traditional single- and double-glazed systems, the difference in STC rating can be dramatic.

See Section 2 in this chapter, called “Properties and Functions.”

▼ Tempered Glass (ASTM C-1048, ANSI Z97.1 & CPSC 16 CFR 1201)

Tempered glass is a flat glass product which has undergone heat treatment; it is heated to approximately 1,112°F (600°C), then cooled rapidly using jets of air.

Tempering process



This rapid cooling locks the surface of the glass in a state of compression. This makes it more resistant to mechanical and thermal stresses and gives it the required fragmentation characteristics.

If the glass breaks, it fragments into small pebble-sized pieces, limiting the risk of personal injury. Tempered glass is considered a safety glass that protects against injury, and it can be used for specific applications where safety is a concern (shower enclosures, skylights, glass doors, display cases, etc.). Tempered glass has a small risk of spontaneous breakage, due to nickel sulfide inclusions.

Many of AGC's high-quality flat glass products can be tempered; consult the AGC Technical Services team for details.

▼ Heat-Strengthened Glass (ASTM C-1048)

Heat-strengthened solutions have undergone heat treatment during which they have been heated to approximately 1,112°F (600°C) and then cooled in a controlled manner using jets of air. In this case, the cooling process is slower than it is for tempered glass.

The surface of the glass is then locked in a state of compression, making it more resistant to mechanical and thermal stresses. However, when broken, heat-strengthened glass splits into large sharp pieces like float glass. For this reason, it is not considered a safety glass.

Many of AGC's flat glass solutions can be heat-strengthened; consult the AGC Technical Services team for details.

▼ Ceramic Frit

To produce high-quality enamelled solutions, the entire surface of the flat glass is covered with a coating of vitreous enamel during the strengthening or tempering process. Enamelled glass is often used in spandrel panels.

▼ Silk-Screen Printed Glass

This decorative product is manufactured in a process similar to enamelling. An enamel coating is applied to part of the glass using a screen and is vitrified during the tempering or strengthening process.

▼ Curved Glass

Curved glass is obtained by bending flat glass—at a high temperature—to fit the shape of a mold on which it is resting.

▼ Insulating Glass (ASTM E-2190)

An insulating glass unit is a glazing which is factory sealed and made up of multiple sheets of glass separated by a spacer and filled with dehydrated air and/or gas.

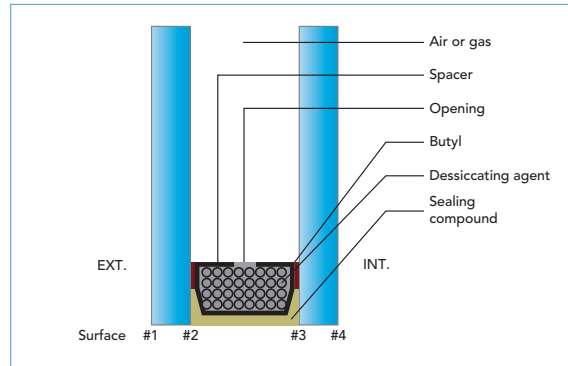
The main purpose of double glazing or triple glazing is to provide a higher level of thermal insulation than single glazing.

The thermal insulation characteristics of insulating glazing can be combined with properties such as solar control, sound insulation, and safety by using the appropriate glass products as components of insulated glazing.

See Section 2 in this chapter, called "Properties and Functions."

The sides of the components in double glazing (including non-laminated glass products) are generally numbered from 1 to 4 (exterior to interior). Units which include laminated glass solutions may be numbered 1 through 8 because they include more individual glass surfaces.

Insulating glazing: components, direction, and numbering of sides



2 PROPERTIES AND FUNCTIONS



2.1 INTRODUCTION

The first glass appeared a little more than 2,000 years ago. It was used to seal off entrances to structures and to perform the main function of glass: letting in light while also providing a minimum level of protection against wind, cold, and rain.

However, the use of glass in buildings did not become widespread until a few centuries ago, and it was not until the 20th century that glass performance began to evolve significantly. In the late 1940s, the concept of double glazing to enhance thermal insulation began to develop, but its real growth came about in the wake of the global energy crisis of the 1970s.

Since then, the development of coated glass, laminated glass, and other innovative products has provided high-quality solutions for functions such as solar energy and luminosity control—while coated glass, laminated glass, tempered and heat-treated glass, and other products have proven effective solutions for sound insulation and safety.

Today, there is increasing demand for all these functions to be combined in a single type of glass.

To provide an insight into the many functions of glass, this chapter of Your Glass Pocket describes the following areas of glass performance in detail:

- > Radiation, light, and color
- > Thermal insulation
- > Solar control
- > Light control
- > Sound insulation
- > Safety
- > Protection against fire

These glass functions are then linked to specific glass types, as well as the product range of AGC Glass Company North America.

2.2 RADIATION, LIGHT, AND COLOR

The concepts of radiation, light, and color are key to understanding the following sections on thermal insulation, solar control, and light control.

2.2.1 DIFFERENT TYPES OF RADIATION

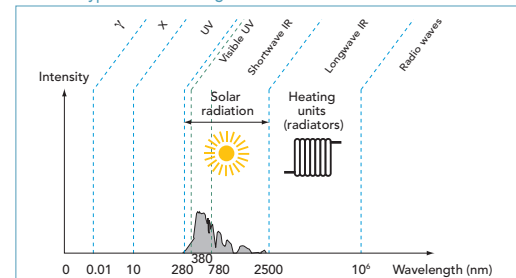
Every day we are subjected to different types of radiation, including radiation from the sun. The table and figure below show how these different types of radiation are classified according to their wavelengths.

Classification of electromagnetic radiation by wavelength

Type of radiation	Wavelengths (nm)**
Gamma rays	0 to 0.01
X-rays	0.01 to 10
Ultraviolet (UV) rays	10 to 380
UV C	10 to 280
UV B	280 to 315
UV A	315 to 380
Visible rays	380 to 780
Infrared (IR) rays	780 to 10 ⁶
Shortwave IR A	780 to 1,400
Shortwave IR B	1,400 to 2,500
Longwave IR C	2,500 to 10 ⁶
Radio waves	10 ⁶ to several km

** 1nm = 1 nanometer = 10⁻⁹m.

Different types of electromagnetic waves



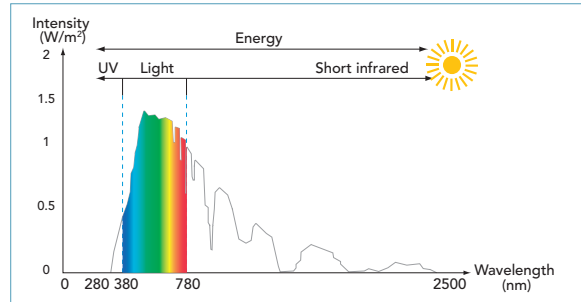
2.2.2 THE SOLAR SPECTRUM

Solar radiation accounts for only a small portion of the spectrum of electromagnetic waves. Its composition is shown in the table and figure below. The spectrum of visible light forms part of the solar spectrum.

Composition of the solar spectrum

Type of radiation	Wavelength (nm)	Percentage of total solar energy
UV	280 to 380	Approx. 5%
Visible	380 to 780	Approx. 50%
IR	780 to 2,500	Approx. 45%

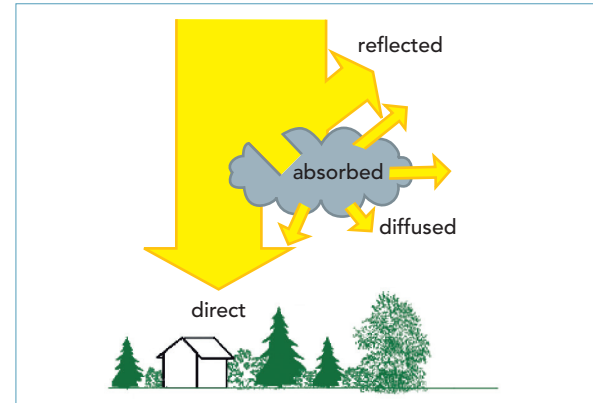
Solar spectrum



The sun is the basis for the solar spectrum. It gives off 66 million W/m^2 of energy produced by nuclear chain reactions. Only a fraction of this energy ends up anywhere near our atmosphere. This fraction— $1,353 W/m^2$ —is called the solar constant.

The energy we receive from the sun is less than the solar constant, since our atmosphere absorbs approximately 15% of solar radiation and reflects another 6% back into space. Total solar radiation is therefore defined as the sum of direct and diffused radiation.

Atmospheric influence on solar radiation



The energy we receive also depends on the season, which changes the angle of incidence of the sun in relation to the earth, as well as latitude, weather conditions (cloud coverage), geographic contours, pollution, the direction our buildings are facing, and other factors.

2.2.3 LIGHT

Light is the part of the solar spectrum—from 380 nm to 780 nm—which is visible to the human eye.

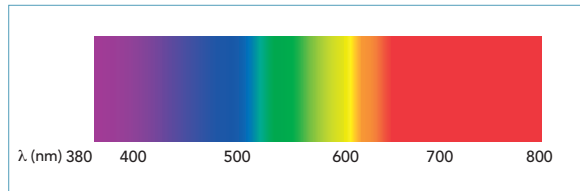
The table and figure below show the composition of light.

Composition of light

Color	Wavelengths (nm)**
Violet	380 to 462
Blue	462 to 500
Green	500 to 577
Yellow	577 to 600
Orange	600 to 625
Red	625 to 780

** 1nm = 1 nanometer = 10^{-9} m

Light



We perceive light visually, but light can also be perceived in the form of heat. Light comprises approximately half of the heat we receive from the sun.

2.2.4 HEAT

The heat we feel comes from two sources:

- > Heat from the solar spectrum and generated by UV rays, light, and short infrared waves
- > Heat emitted by objects (lamps, radiators, etc.) in the form of long infrared waves

2.2.5 PROTECTION PROVIDED BY GLASS AGAINST DIFFERENT WAVELENGTHS OF THE SOLAR SPECTRUM

▼ Introduction

Glass can be used to control most types of radiation; the sections below give a brief outline of the glass solutions available for different types of solar control.

▼ Protection Against UV Radiation

In certain situations, solar radiation can damage the color of objects exposed to it. This change in color is due to the gradual degradation of molecular links caused by high-energy photons. Such damage is caused by ultraviolet radiation and, to a lesser extent, shortwave visible light (in the violet and blue range). Solar radiation also causes the temperature to increase, thus accelerating this process.

Some glass products can combat this discoloration:

- > Laminated glass with PVB interlayers absorbs more than 99% of UV radiation up to 380 nm
- > Colored glass with a predominantly yellow-orange tint partially absorbs violet and blue light
- > Glass with a low solar factor limits temperature increases

That said, no glass product can completely eliminate discoloration. In fact, in some cases, interior artificial lighting can also cause discoloration.

Various indices are used to quantify the protection against UV radiation provided by glass products, as well as the risk of discoloration:

- > UV transmission index (TrUV)
- > The Damage Weighted Index (LBNL Window 5.2=TDW-ISO): this index is defined in ISO 9050 and pertains to the transmission of radiation for wavelengths in the range of 300 nm to 600 nm—i.e., those wavelengths causing objects to discolor

▼ Light Control

Light can be controlled by using tinted, coated, or translucent glass.

For further details, see the section of this chapter entitled “Light Control.”

▼ Protection Against Shortwave Infrared Radiation and Heat

Solar control glass with an appropriate SHGC provides protection against shortwave infrared radiation and heat in general.

When designing a building, it is important to remember that the surfaces of the glazing and their SHGC have a direct impact on the ventilation system used.

For further details, see the section of this chapter entitled “Solar Control.”

▼ Control of Longwave Infrared Radiation

Controlling longwave infrared radiation involves preventing longwaves—i.e., the heat emitted by objects—from leaving buildings in order to enhance thermal insulation.

Low-emissivity coated glass can be used to control longwave infrared radiation.

When designing buildings, it is important to remember that the thermal insulation of the glazings (and of the building in general) will directly affect the heating system used.

For further details, see the section of this chapter entitled “Thermal Insulation.”

2.2.6 COLOR

Objects we can see—whether they are transparent, translucent, or opaque—all have a specific color.

The color depends on several parameters, such as—

- > Incident light (type of illumination)
- > The reflection and transmission properties of the object
- > The sensitivity of the eye of the observer
- > The environment surrounding the object and the contrast between the object and those around it

The color of an object depends on all these factors, and an observer will not always see the object in the same way, depending, for example, on the time of day or the level of natural light.

Clear glass has a slightly green transmission color. The optical qualities of colored glass vary widely depending on their thickness. Bronze, grey, blue, and green float glasses reduce the amount of solar energy and therefore the level of light transmission.

The view through colored glazings is therefore influenced by the color of the glass itself.

2.3 THERMAL INSULATION

2.3.1 TRANSMISSION OF HEAT THROUGH A GLAZING

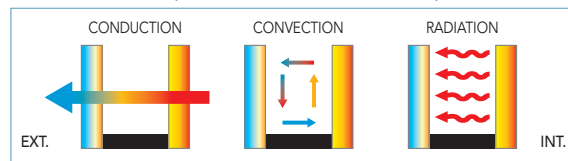
A difference in temperature between two points within any material will result in heat being transferred from the hot point to the cold point.

Heat may be transferred in various ways:

- > By conduction within the material itself: the heat is transferred from one molecule to the next when heated. For example, a metal rod with one end heated up will transfer this heat throughout the rod.
- > By convection in liquids and gases: temperature variations within a liquid prompt differences in density, which cause the molecules to move around. This occurs because the hot parts have a smaller mass and rise, while the opposite is true for the cold parts. These movements balance out temperatures. For example, when heating a saucepan of water, the temperature eventually becomes constant.
- > By radiation: any heated body gives off energy in the form of electromagnetic radiation. This radiation crosses physical spaces more easily and effectively than light waves. By contrast, when light waves meet an obstacle, they release part of their energy to the obstacle—which, in turn, emits heat. This method of heat transmission requires no area and can also take place in a vacuum. For example, in the case of solar radiation or an electric light bulb.

Double glazing is designed to limit heat lost through conduction within the glass by inserting an insulating space of air or gas between the two sheets of glass.

Methods of heat transmission through a glazing
(where the outside temperature is lower than the inside temperature)



2.3.2 THERMAL CONDUCTIVITY AND THERMAL TRANSMITTANCE

▼ Introduction

The heat flow density q (W/m^2) per second passing through the glazing from the warm atmosphere to the cold atmosphere can be expressed by the equation

$$q = \frac{(\theta_i - \theta_e)}{R} = U (\theta_i - \theta_e)$$

where

θ_i and θ_e are the temperatures of the internal and external atmospheres

R is the thermal resistance of the glazing ($m^2 \cdot K/W$)

$U = 1/R$ is the thermal transmittance of the glazing ($W/(m^2 \cdot K)$)

▼ Thermal Transmittance U (Formerly k)

Thermal transmittance is defined as the amount of heat passing through the glazing, in a steady state, per unit of surface area, for a difference in temperature of 1.8°F (1°C) on each side of the glass between the atmospheres.

The amount of heat per second Q (W) passing through a glazing with surface area S (m^2) from the hot atmosphere to the cold atmosphere is therefore

$$Q = S U (\theta_i - \theta_e)$$

For a solid isotropic material, thermal resistance R is defined as the relationship between its thickness e (m) and its thermal conductivity λ ($W/(m \cdot K)$):

$$R = \frac{e}{\lambda}$$

▼ Thermal Conductivity λ

Thermal conductivity is defined as the amount of heat passing per second through a pane 1 m thick and with a surface area of 1 m² where there is a temperature difference of 1°C between two surfaces.

The thermal conductivity of the glass is 1 W/(m.K). It is therefore not an insulating material, since insulating materials are those with a thermal conductivity of less than 0.065 W/(m.K).

To minimize energy loss and therefore ensure maximum thermal insulation, the thermal transmittance or U Factor of the glazing must be as low as possible (i.e., the thermal resistance R of the glazing must be as great as possible).

NFRC 100 Standard details the method used to calculate the U Factor of glazings. The value obtained using this calculation is the U Factor at the center point of glazings—excluding edge effects due to the presence of the spacer.

The table below shows the U Factor for different types of insulating glazings. The most widely used spacers are between 1/4 inch (6 mm) and 1/2 inch (12 mm) thick.

U Factor (thermal transmittance values) for different types of glazings

Space mm (inches)	Standard IGU 1/8" clear 1/8" clear			Low-e IGU*** 1/8" Comfort Select™ 36 1/8" clear		
	Air	90% Argon	90% Krypton	Air	Argon	Krypton
1/4" (6)	0.550	0.507	0.455	0.406	0.331	0.234
3/8" (10)	0.502	0.468	0.443	0.323	0.260	0.224
1/2" (12)	0.480	0.455	0.448	0.294	0.248	0.234
5/8" (15)	0.482	0.458	0.452	0.303	0.256	0.240
3/4" (19)	0.486	0.462	0.452	0.311	0.263	0.240

*** coating on surface #2 of IGU

As a comparison, an uninsulated cavity wall has a U Factor of approximately 1.5 W/(m².K); that of an insulated wall is less than 0.6 W/(m².K).

2.3.3 DIFFERENT TYPES OF INSULATING GLAZING

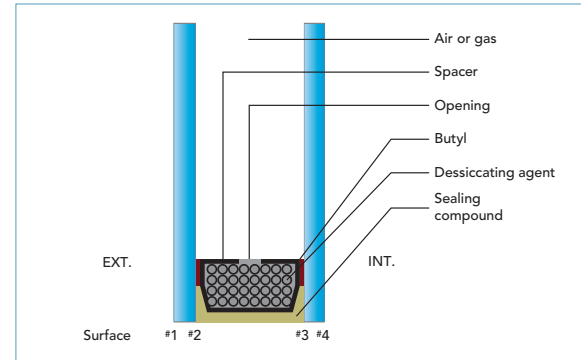
▼ Introduction

Single-pane glazing is not a high-performance solution in terms of thermal insulation. Various solutions have been developed to enhance the insulating properties of glazings, primarily in the wake of the energy crisis of the 1970s.

▼ Double Glazing

The first type of thermally insulating glazing was double glazing, which is composed of two sheets of glass separated by a spacer to provide a space filled with dry air. Since the air has a thermal conductivity of 0.025 W/(m.K) (at 50°F or 10°C), while that of glass is 1 W/(m.K), the layer of air enhances the insulating properties and reduces the U Factor of the glazing.

Double glazing: components and numbering of glass surfaces



The glass surfaces in double glazings are generally numbered from 1 to 4 (outside to inside). For laminated glass products, the surfaces may be numbered 1 to 8.

▼ Noble Gases

Another improvement in thermal insulation was achieved by replacing air with noble gases—which have both a lower thermal conductivity, to limit heat conduction, and a greater volumic mass, to restrict convection and make molecular movement more difficult.

Noble gases lower the U Factor and are used only in coated insulating glazings. In practice, argon and krypton are generally used.

▼ High-Performance Double Glazings

> Principle

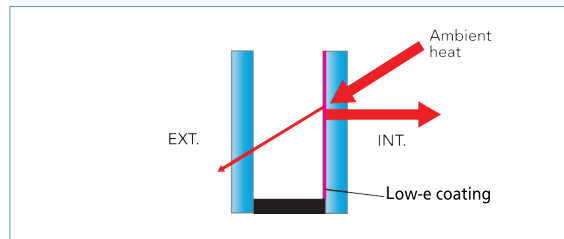
The development of techniques for applying metallic coatings to glass has been a decisive step forward in improving the thermal insulation of glazings. Applying a metallic coating to a glass makes it “high-performance” (also called “low-emissivity” or “low-e”).

These coatings are generally

- Sputter coatings applied inside a vacuum chamber, which must be positioned inside a double glazing unit (“soft” coatings)
- Pyrolytic coatings, which are applied as part of the float manufacturing process (“hard” coatings)

In a typical dual glazing with surfaces numbered 1 through 4, low-emissivity coatings are generally applied in position 2 or 3. Placing them in position 2 does not affect their insulation properties, but rather their reflection properties—and therefore the overall solar heat gain and look of the glazing.

Low-emissivity glazing



> Emissivity

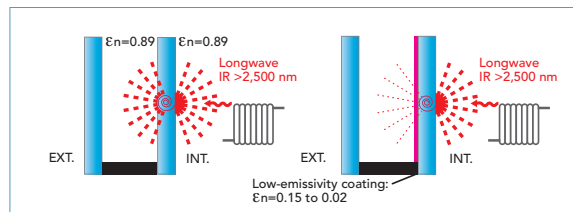
Objects located inside buildings radiate heat in the form of longwave infrared radiation (over 2,500 nm). Since glass transmits virtually none of this type of radiation, it will absorb longwave infrared radiation, heat up, and then emit this heat back.

Clear glass (with no coating) will generally emit heat to the colder side. In winter months, this heat would be emitted to the exterior of a building and lost.

Low-emissivity glass coatings are designed to increase the reflection of the heat absorbed by the glazing to the interior of the building. In contrast to clear glass, low-emissivity coated glass ensures that heat is retained in a building, enhancing thermal comfort.

The emissivity of a glass can therefore be interpreted as its heat absorption level; the lower the emissivity (absorption), the greater the reflection—and the more heat is retained.

Double glazing and high-performance double glazing



An emissivity rating of 0.2 means that 80% of the heat flow absorbed by the glazing is reflected back into the building.

The mathematical formula is

$$\epsilon = AE = 1 - TR - RE = 1 - RE \quad (\text{because } TR = 0)$$

In scientific terms, emissivity is defined as the relationship between the energy emitted by a given surface at a given temperature and that of a perfect emitter (i.e., a black body which has an emissivity of 1, at the same temperature).

Standard NFRC 300 describes the method used to measure normal emissivity ϵ_n ; in practice, the corrected emissivity value ϵ is used in heat transfer calculations. This corrected value is achieved by multiplying normal emissivity by a numerical factor that considers the angular distribution of the emissivity.

A sheet of clear glass has a normal emissivity of 0.840, while “hard” or pyrolytic coatings (Comfort Select™) result in emissivity values of between 0.148 and 0.298 respectively. “Soft” or sputter-coated products, including the Energy Select™ family, result in lower emissivity values, generally between 0.06 and 0.03.

▼ Warm-Edge Spacers

The latest development to enhance thermal insulation for facades and glazing is the warm-edge spacer. The conventional metal spacer, made of aluminum or steel, is replaced with a plastic spacer—which can be reinforced by a metallic structure in some cases. The thermal conductivity of plastic materials is far superior to that of steel or aluminum, and the resulting spacer reduces heat loss around the edges of the glass—hence the name “warm edge.”

Using a warm-edge spacer does not alter the U Factor in the center of the glass—but rather it improves the U_w value, which is the thermal insulation of the window as a whole (glass + spacer + frame).

▼ Triple Glazing

Since thermal insulation is increased by the presence of an air space, the next stage is triple glazing—i.e., glazings made up of three sheets of glass separated by two spaces.

This solution is used when a low U_w value is required by the specific application. However, there are challenges associated with triple glazings—for example, the resulting thickness and weight of the insulating unit can make it difficult to install.

▼ Notes

> Solar control

Emissivity affects longwave infrared radiation; however, it has virtually no effect on solar radiation.

To combine thermal and solar control, certain types of spectrally selective (solar control) low-e coatings must be used which combine these two functions.

2.3.4 AGC GLASS COMPANY NORTH AMERICA BRANDS: BASE GLASSES

AGC Glass Company North America offers a complete range of low-emissivity coated glass—both hard-coat pyrolytic and soft-coat sputter solutions—to provide excellent thermal insulation.

Some of these coatings are used solely for thermal insulation and are ideal for passive solar applications where it is important to capture the “free” energy of the sun to reduce annual heating costs. Comfort Select™ 73 and Energy Select™ 63 are two types of AGC coated products that deliver these thermal benefits.

Other low-emissivity solar control solutions are engineered to combine high levels of solar control with outstanding thermal insulation. AGC’s Energy Select™ family of soft-coat glasses is perfect for applications where a high level of solar-blocking performance is required—but thermal insulation is also important.

The table on page 46 summarizes the different coatings available from AGC Glass Company North America.

AGC brands of high-performance glass

	"Soft" or sputter coatings	"Hard" or pyrolytic coatings
Passive solar low-e glass	Energy Select™ 63	Comfort Select™ 73
Solar control low-e glass	Energy Select™ R42 Energy Select™ 28 Energy Select™ 36 Energy Select™ 40 Energy Select™ 25	
Solar control glass		Stopso® (used in combination with a low-e coated glass)

Note: Sputter or "soft" glass coatings must always be positioned inside a double glazing unit on surface #2 or #3.

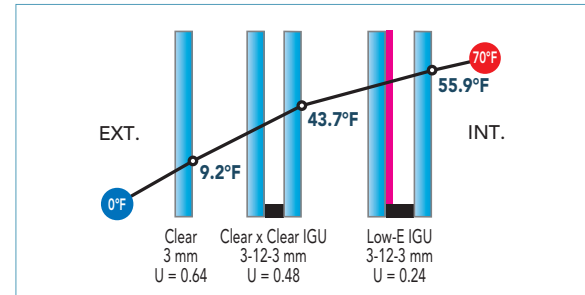
2.3.5 TEMPERATURE OF GLAZINGS AND COMFORT

Feeling comfortable in any given location depends not only on the ambient air temperature, but also on the proximity of cold surfaces. The human body—with a skin temperature of approximately 82.4°F (28°C)—acts as a "radiator" when, for example, it is placed near a window which provides little thermal insulation from low outdoor temperatures. The heat energy dissipated from the skin results in an uncomfortable feeling of coldness.

The figure on page 47 shows the temperature of the internal side of a single glazed unit, as well as various other insulating glazings, under internal and external temperature conditions ranging from 20°F to 68°F (0°C to 32°C) in a steady state.

This demonstrates that using high-performance glazings can help limit energy loss, lower U-factor, and reduce overall cost associated with heating.

Change in temperature of the internal side of the glazing depending on the U Factor



2.3.6 CONDENSATION

Condensation is the process by which atmospheric water vapor liquefies to form fog, clouds, or water droplets on objects. Three types of condensation are likely to occur on glazings (all surface positions are for a dual-glazed, non-laminated unit):

- > Surface condensation on the internal side (position 4): this occurs if internal relative humidity is high and/or the temperature of the internal side of the glazing is low. Under normal internal conditions (e.g., heated buildings with no specific source of humidity), this type of condensation very rarely occurs with high-performance double glazings.
- > Surface condensation on the external side (position 1): this can sometimes occur at dawn on high-performance double glazings, but only following clear, still nights. Under these conditions, given the high-performance thermal insulation of double glazing, the external pane cools to the point that condensation forms on the outside. This is temporary and only proves the insulating efficiency of the glazing.
- > Condensation inside the double glazing unit (position 2 or 3): this can be caused by a failed window seal. How effectively the desiccant and the waterproof barriers work determines the lifespan of the glazing. If the desiccant becomes ineffective or if the seal is no longer hermetic, condensation will form inside the glazing unit and it will need to be replaced.

2.4 SOLAR CONTROL

2.4.1 ENERGY AND LIGHT FACTORS

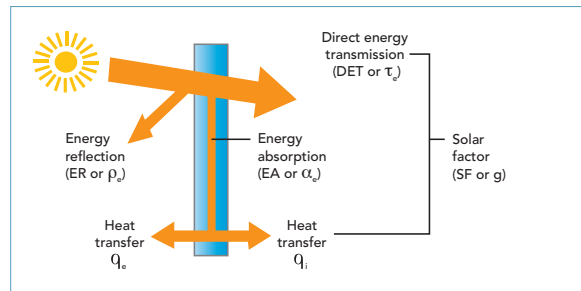
Energy and light factors (or spectrophotometric factors) determine the transmission, absorption, and light and energy reflection properties of glazings.

▼ Energy factors

When the sun's rays hit a glazing, the total incident solar radiation (between 300 nm and 2,500 nm) ϕ_e is split up into—

- > A fraction $\rho_e \phi_e$ reflected outward, where ρ_e (or ER) is the direct energy reflection of the glazing
- > A fraction $\tau_e \phi_e$ transmitted through the glazing, where τ_e (or DET) is the direct energy transmission of the glazing
- > A fraction $\alpha_e \phi_e$ absorbed by the glazing, where α_e (or EA) is the direct energy absorption of the glazing; the energy absorbed by the glazing is then divided up into—
 - A fraction $q_i \phi_e$ emitted back to the inside, where q_i is the secondary internal heat transfer factor
 - A fraction $q_e \phi_e$ emitted back to the outside, where q_e is the secondary external heat transfer factor

Energy factors



These different factors are linked by the formulae

$$\rho_e + \tau_e + \alpha_e = 1 \quad \text{or} \quad ER + DET + EA = 100$$

and

$$\alpha_e = q_i + q_e$$

The SHGC represents the total energy transmitted through the glazing; it is therefore the sum of the radiation transmitted directly and that which is absorbed and emitted back to the inside.

$$SHGC = \tau_e + q_i$$

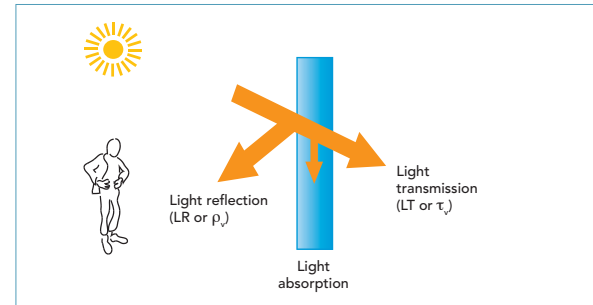
▼ Light Factors

Similar to energy factors, light factors are defined solely on the basis of the visible part of the solar spectrum (between 380 nm and 780 nm).

Light transmission τ_v (LT) and light reflection ρ_v (LR) factors are defined, respectively, as the fractions of visible light transmitted and reflected by the glazing.

The radiation absorbed by the glazing is not visible and is not generally taken into account.

Light factors



As an example, the table below gives the SHGC and VLT values of clear single and double glazing units.

SHGC and VLT values of clear single and double glazing units

	Solar Heat Gain Coefficient	Visible Light Transmission
Clear glass: 6 mm	0.84	0.88
Clear insulating glazing: 6 mm /12 mm /6 mm	0.73	0.78

The National Fenestration Rating Council (NFRC) has developed a uniform national rating system for the energy performance characteristics of fenestration products. NFRC 100, NFRC 200, NFRC 303, NFRC 304, and NFRC 500 are guidelines developed by the NFRC to meet the need for a uniform and accurate means of rating the thermal and related performance of fenestration systems.

▼ Selectivity or LSG (Light-to-Solar-Gain Ratio)

The heat entering a given room comes entirely from solar radiation—i.e., visible light, ultraviolet rays, and infrared radiation.

The amount of heat entering a building can be limited without reducing light levels by using high-performance coated glass, which prevents UV and infrared radiation from passing through but allows visible light in. Such glass is called selective.

The selectivity LSG of a glazing is the relationship between its visible light transmission (VLT) and its SHGC.

The higher the value, the more selective the glazing.

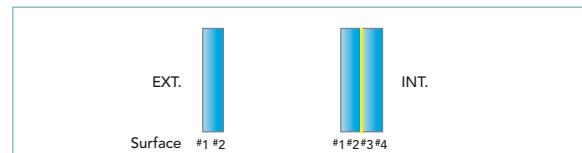
In the United States, the Department of Energy defines a spectrally selective glazing as a glazing with a Light to Solar Heat Gain Ratio (LSG) of 1.25 or greater.

Type	Configuration		VLT	SHGC	LSG
	Outboard	Inboard			
Uncoated	Bronze	CLR	0.48	0.50	0.95
Passive Solar (pyrolytic)	Comfort Select™ 73	CLR	0.74	0.72	1.03
Passive Solar (sputter)	Energy Select™ 63	CLR	0.76	0.55	1.38
Solar Control (sputter)	Energy Select 36	CLR	0.63	0.36	1.75

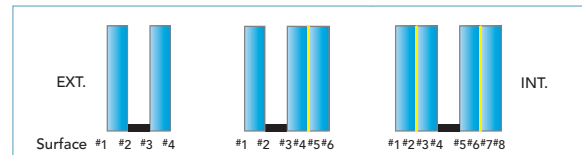
▼ Conventions in Coating Positions

The North American conventions are shown below.

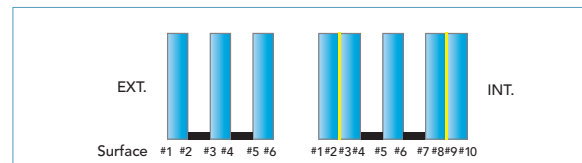
- > Monolithic glass (numbered 1 and 2 for non-laminated glass, numbered 1 through 4 for laminated)



- > Double glazing (1 through 4 for non-laminated, up to 8 surfaces for laminated solutions)



- > Triple glazing (1 and 6 for non-laminated, up to 12 surfaces for laminated solutions)



2.4.2 SOLAR CONTROL

▼ Introduction

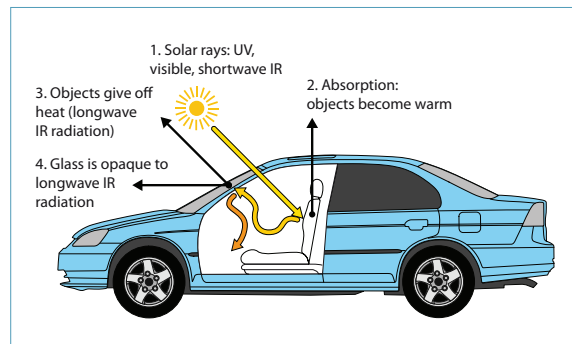
> Heating rooms: the greenhouse effect

The sun can introduce too much heat into buildings with substantial glazed areas. Heat from the sun penetrates rooms via direct or indirect transmission after being absorbed by the glazing. This solar radiation penetrating a building reaches walls, floors, and furniture, which partially absorb it and then heat up. They then return this heat, in the form of infrared heat radiation with a wavelength in excess of 2,500 nm (longwave infrared radiation). However, glass is virtually impervious to this high-wavelength radiation—and so it is radiated back to the interior. This causes room temperatures to rise gradually; this is how the “greenhouse effect” works.

A body-tinted glass or one with solar control coatings allows less heat to pass through the glass, which reduces the level of interior warming.

The figure below shows the greenhouse effect in a car parked in the sun. The temperature inside the vehicle rises significantly, and the seats and the steering wheel also heat up considerably.

The greenhouse effect



> Passive solar: free solar energy

The greenhouse effect is desirable in homes in the northern regions of North America during cold periods of the year since it saves heating energy. By contrast, it is undesirable in office buildings in which the high numbers of employees, electrical equipment, and artificial lighting all cause interior temperatures to rise. In such cases, the greenhouse effect means increased air-conditioning costs. For these commercial buildings, protection against solar energy transmission results in lower annual energy costs.

> Direction of windows

Clearly, the amount of solar transmission depends on the direction a window faces. In the northern hemisphere, north-facing windows generate less passive solar energy. South-facing windows receive a lot of sun in the winter and little sun in the summer. West- and east-facing windows receive passive solar energy throughout the year. West-facing windows also have the disadvantage of receiving high solar energy levels toward the end of the day when the building has already had time to heat up—making west-facing windows the most critical when trying to guard against passive solar energy transmission.

> Desired performance of glazings

Solar control needs in North America are generally determined by geographic region.

Residential—In the southern region of the United States, a low SHGC is desirable. This type of high-performance window will greatly reduce the amount of solar heat energy entering the home.

In the northern region of the United States and throughout Canada, a high SHGC and a low U Factor is the best combination to allow passive solar heat in while still ensuring excellent thermal insulation to keep heat in.

Commercial—In contrast to residential, geographic region is less important than the internal heat levels generated by people and machinery. In light of this fact, throughout North America, low-SHGC glazing is generally used to reduce the amount of solar heat energy entering the building.

When choosing a glazing, it is critical to consider the energy, light transmission, and thermal insulation requirements of the overall project. For help in balancing these needs, please consult the Technical Services team at AGC Glass Company North America.

▼ Solar Control Glass

Three types of solar control glass are currently available: absorber glass, low-e coated, and reflective coated glass. These functions can also be combined in the same glazing.

> Absorbent (tinted) glass

This type of solar control glass is body-tinted (bronze, grey, green, blue, etc.) by adding metal oxides. Depending on the color and the thickness of the glass, the SHGC varies between 40% and 80%. AGC's Solarshield® family of tinted products is an example of a high-performing tinted glass.

Tinted glass absorbs some of the energy from solar radiation before emitting it back inside and out.

Absorbent tinted glass



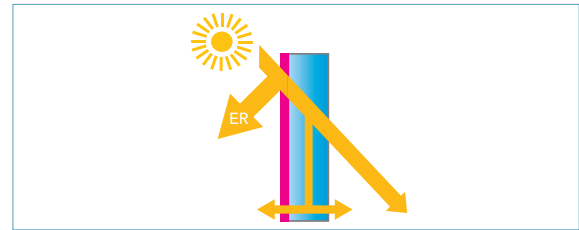
The amount of energy emitted to the outside and the inside depends on wind speed as well as external and internal air temperatures. To dispatch the heat radiated to the outside as efficiently as possible, the absorbent tinted glass must be installed as close to the front of the facade as possible. In flat facades, the heat absorbed can escape more easily, and the level of radiation emitted to the inside is lower.

Absorbent tinted glasses warm up more quickly than conventional clear glass. In most cases, a study should be conducted into the risk of breakage by thermal stresses prior to installing tinted glass; consult AGC Technical Services for more information.

> Low-e coated glass

Although there are many coated glass products, this section refers specifically to coated glass solutions which reflect some solar energy.

Coated glass



There are several types of coatings designed for solar control:

- Sputtered solar control low-e glasses (Energy Select™ family) are produced using metal- or metal oxide-based sputtered coatings on the surface of the glass. Since these coatings are placed on the surface of the glass, they should be used in position 2 or 3 (depending on the application). Soft coatings must be used on the inside of a double glazing unit.
- The sputter coating process can be used to create spectrally selective coatings to meet a wide range of aesthetic and spectrally performance needs. They can also be applied to a wide range of tinted substrates to achieve customized performance levels. (Energy Select glasses on Solarshield® tints).
- Pyrolytic solar control coated glasses are produced using metal oxide-based coatings applied to a clear or colored substrate during the float glass production process. These coatings can be either low-emissivity or reflective (Stopsol®).

Like tinted absorbent glasses, coated solutions also carry a risk of thermal breakage when subjected to high levels of solar energy. In some cases, a study should be conducted into the risk of breakage by thermal stresses before installing coated glass products. Consult AGC Technical Services to learn more.

> Notes

- It is important to always use the same type of glazing (in terms of thickness, color, coatings, etc.) side by side in order to ensure the uniform appearance of a facade.
- Coated glass with a high reflectance rating reflects light from the “brightest” area at any given time. When it is dark outside and artificial light is used to light rooms, this interior light will be reflected into the building and it will no longer be possible to see out. For this reason, careful attention must be paid to the selection of coated glass solutions with low interior reflectance ratings.

▼ Spandrel Panels

Positioned on the exterior of commercial buildings, spandrel panels are used to mask opaque sections as well as the structural elements of facades. Used in conjunction with vision glazings, they have given rise to “curtain wall” facades.

Depending on the products and colors used, either complete harmony or contrasting effects can be achieved when specifying spandrels and vision glass.

From an aesthetic point of view, choosing the ideal spandrel for a particular vision glazing is not always easy. AGC Glass Company North America recommends that architects, specifiers, building owners, and glass professionals work together to choose the most appropriate solution using actual glass samples and prototypes. AGC has an expert team of architectural and Technical Services consultants to support this decision-making process.

Spandrels can be combined with thermal insulation, sound insulation, and fire protection functions depending on the specific customer application.

A number of different types of spandrels are available:

- > Single-pane, ceramic frit enamelled glass: this is clear or colored glass which is coated with a ceramic frit and then tempered or heat strengthened
- > An insulating glazing made of the same glass as vision glass (as an external glass) and spandrel glass (as an internal glass)
- > An insulating glazing enamelled in position 4
- > A shadow-box: this is a spandrel made up of vision glazing combined with an opaque background (metal sheet, etc.) in order to produce an opaque glass section in harmony with the building

Except in special cases where a preliminary study has been carried out, spandrels are heat strengthened or tempered. For spandrels in insulating glazing positioned in front of a structure built out of concrete or an insulating material, a thermal study is required to ascertain the glazing's durability.

▼ Risk of Breakage Due to Thermal Stresses

Breakage caused by thermal stresses occurs if the temperature difference between two areas of annealed glass is too great. If the temperature of the glass rises, the glass expands—which causes no problems if the temperature remains uniform throughout the glazing. However, if part of the glazing remains cool, it will prevent the warm section from expanding freely. This creates tensile stress, which can exceed the permitted level of stress in the glass. If there is any risk of this happening, the glass must be tempered or heat strengthened.

Except where a preliminary study is carried out, spandrels must be tempered or heat strengthened.

2.4.3. AGC BRANDS

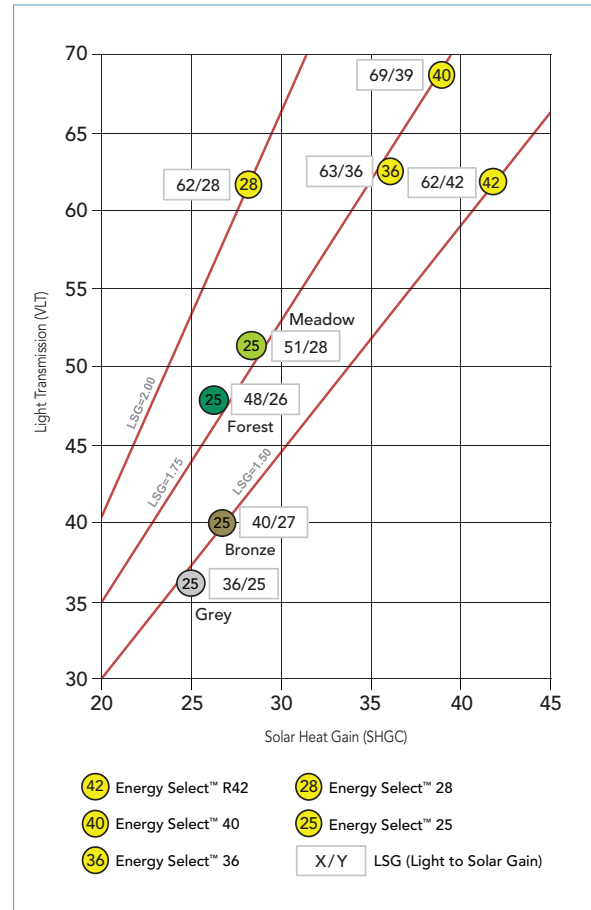
AGC offers a full range of solar control glass: colored glass, glass with pyrolytic (hard) coatings, and glass with sputter (soft) coatings. The table below sums up the range.

AGC solar control glass brands

Type	Pyrolytic coatings	Sputter coatings	Uncoated
Reflective	Stopsol®	Energy Select™ R42	—
Solar Control		Energy Select™ 25 Energy Select™ 28 Energy Select™ 36 Energy Select™ 40	Solarshield™ Tinted Glass
Passive Solar	Comfort Select™ 73	Energy Select™ 63	Clear Float

The graph on page 67 gives an overview of the position of the different families of AGC solar control glass in double glazings (6-12-6 configuration). Passive solar products can be combined with reflective or tinted glass to achieve solar control properties.

Performance ranges of AGC solar control glazings in double-glazed units



2.5 LIGHT CONTROL

2.5.1 LIGHT CONTROL

The location of a building has a substantial impact on its requirements in terms of light control. In very sunny regions, the general aim is to limit light transmission (and solar heat gain). By contrast, in regions with less sunshine, it is important to make the most of the natural light available.

Modern glazings are designed to meet all these requirements, since light transmission levels ranging between a very low percentage (for applications designed to reduce glare) and 90% (for extra clear glass) can be achieved.

Moreover, depending on the type of coating or glass used, these levels of light transmission can be combined with more or less equivalent (low selectivity) or more high-performance (high selectivity) SHGC ratings.

While light transmission is an important consideration, in specifying a glazing—determined through SHGC levels, which impact a building's HVAC requirement—it is typically the decisive factor.

2.5.2 LIGHTING ROOMS

▼ Introduction

When designing a building, the surface of glazings and their level of light transmission have a direct impact on the level of artificial lighting required.

Natural lighting of rooms is a complex process. In *Your Glass Pocket*, AGC Glass Company North America discusses only a few general rules in relation to private homes rather than office buildings—where artificial lighting is always present.

For each project, the architect must adapt the position and the size of the openings to the direction the building faces, as well as its location—and must choose the appropriate glazing based on these considerations.

To learn more about how specific glazing choices can impact natural lighting levels, please consult AGC Technical Services.

▼ Natural Lighting

The amount of natural light available depends on weather conditions, the season, the time of day, and any physical obstacles close to the building's openings (e.g., trees).

As with energy transmission, light transmission depends on the direction each window is facing. In the northern hemisphere, north-facing windows receive virtually no sun, and most of the light available there is natural light. By contrast, east- and west-facing windows receive direct transmission of light; this is also true of south-facing windows during winter months.

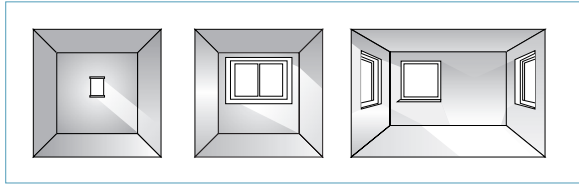
▼ Position of Openings

Since light travels in a straight line, the upper parts of openings are a room's main light source. It is advisable to position glazings so that their upper edge is at least halfway up the wall. Roof openings are also a good idea.

Even distribution of light is also the key to high-quality lighting. It is not enough to allow light into interior spaces; it also has to be distributed harmoniously. Since light is reflected by ceilings, floors, and walls, care should be taken to avoid dark colors which absorb light and cause "dark corners."

Where this is not possible, reflective surfaces should be used inside rooms, which act as secondary light sources. An imbalance between the intensity of several light sources can also be offset by an appropriate choice of light transmission levels.

Distribution of light depending on the size and position of windows



Finally, although it is nice to have plenty of light, care should be taken to ensure that the intensity is not so great that it causes glare. Glare is caused by the presence of overly intense light sources in the field of vision. Reducing the surface area of openings is not a viable solution since this accentuates the contrast between the window and the wall in which it is set, thereby further increasing discomfort. On the other hand, glare can be lessened by using coated glass with reduced levels of light transmission.

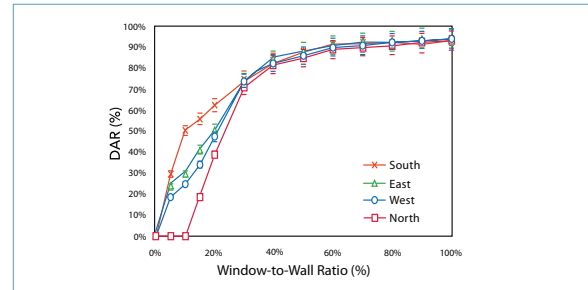
▼ Surface Area of Glazings

To provide good natural lighting in rooms, the surface area of the openings must be large enough and the proportion of non-transparent elements (for example, frame subdivisions) must be limited. In fact, the glazed surface area is always smaller than the surface area of the opening.

2.5.3 DAYLIGHTING AND VISIBLE TRANSMITTANCE

The emphasis on daylighting (the practice of designing structures to maximize the use of natural light) continues to increase in step with the movement toward greater sustainability. The benefits of daylighting include reduced energy consumption and increased indoor environmental quality. As such, the merits of daylighting are recognized by the USGBC and its LEED® certification program. Studies have shown that daylighting can also increase the productivity of building occupants and improve the test scores of students.

Daylighting Availability Ratio vs. Window-to-Wall Ratio



It's natural to assume that the more sunlight, the better. But this isn't entirely true. Research by A. Tzempelikos indicates that window-to-wall ratios in excess of 60% provide very little additional daylighting benefits. The ideal upper limit ratio is in the 40%–50% range.

The reason for the diminishing benefits of daylight is the issue of sunlight glare. The fact is, poor glare control can completely defeat the intended purpose of daylighting. As a result, it is critical to account for proper glare control when designing structures with daylighting in mind.

For more information on how to maximize the benefits of daylighting in your design, contact the AGC Technical Services department at 1-800-251-0441.

2.5.4 VISION PROTECTION

In some specific instances, it is important to maintain privacy by preventing people from looking into a room. Several types of glass products offer solutions:

- > Coated glass: this partially obscures a room from prying eyes, provided that the room in question has a lower light level than the environment outside
- > Translucent and/or colored glass: patterned glass, laminated glass with translucent or colored PVB, acid-etched or sand-blasted glass, or glass blocks can provide privacy and obscurity
- > Silk-screen printed or enameled glass also offers vision protection
- > Two-way mirrors: these are glazings which allow vision in one direction only, to enable those inside to see out while preventing those outside from seeing in (appropriate in airports, large retail stores, etc.). Two conditions are required for high-quality two-way mirrors:
 - A coated glass must be used, which has a low level of light transmission
 - The glass used must have a much lower level of luminosity on the viewing side than on the viewed side

Please see the “Brands and Products” section of *Your Glass Pocket* for many AGC products which can provide visual protection and privacy—including Krystal Patterns™ glasses, Matelux® acid-etched glasses, and Krystal Kolours™ premium painted glass.

2.6 SOUND INSULATION

2.6.1 SOUND CONCEPTS

▼ Sound, Pressure, and Frequency

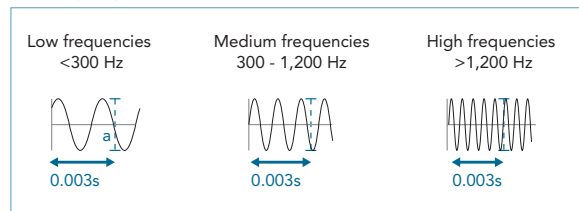
The movements of a vibrating body disturb the environment around it. These disturbances gradually spread in all directions from the source to the reception body—for example, the ear. The speed at which they move depends on the physical properties of the environment. In air at a temperature of 68°F (20°C), this speed is 1,115 feet/second (340 m/s). They do not spread in a vacuum.

Under certain conditions, these disturbances can be perceived by the ear causing what we call “sound.” The sound heard by the ear is a variation in pressure on the eardrum transmitted by movement in an environment, generally the air. The eardrum harnesses this change in pressure, and the ear’s neuro-acoustic system transforms it into a sound sensation.

Two values are required to measure a sound:

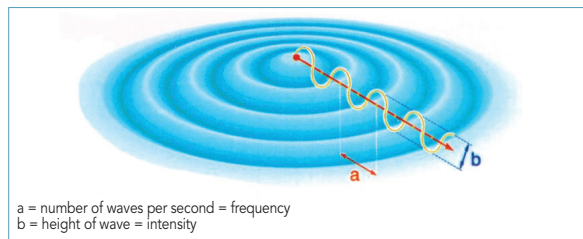
- > Its level of pressure, expressed in Pascal—or, more generally, the level of sound pressure, expressed in decibels
- > Its frequency, which depends on the duration of a complete vibration, measured by taking the number of vibrations per second expressed in Hertz (Hz). The higher the frequency, the more high-pitched the sound

Frequency ranges



The movement of sound through the air can be likened to waves on the surface of water.

Frequency and intensity



The hearing threshold for the human ear is a pressure of 2.10^{-5} Pa; it can withstand pressures of up to 20 Pa undamaged, while the pain threshold is approximately 200 Pa. The human ear is therefore so sensitive that the minimum audible change in pressure is over 10 million times less than that of its pain threshold.

In terms of frequencies, the ear can, on average, hear sounds ranging from approximately 20 Hz up to 16,000–20,000 Hz.

▼ Acoustic Pressure

In practice, acoustic pressure is not used to measure the intensity of a sound because—

- > The pressure range is too great: from 2.10^{-5} to 20, or even 100 Pa
- > The relationship between the human ear and acoustic pressure is not linear, but logarithmic. The level of acoustic pressure L_p of a sound is therefore calculated using the formula

$$L_p = 10 \log \frac{p^2}{p_0^2} = 20 \log \frac{p}{p_0} \text{ (dB)}$$

where: p is the sound pressure (Pa) of the sound wave in question, and

p_0 is the reference pressure equivalent to the hearing threshold of 2.10^{-5} Pa

This value is expressed in decibels (dB).

Example: if a sound has a sound pressure of 10 Pa, its acoustic pressure will be

$$L_p = 10 \log \frac{10^2}{(2.10^{-5})^2} = 114 \text{ dB}$$

The table below shows the correlation between acoustic pressure (Pa), levels of acoustic pressure (dB), and details of physiological effects and examples of corresponding sounds.

Sound pressure and level of acoustic pressure

Effect	Example	Sound pressure p (Pa)	Acoustic pressure L_p (dB)
Blackout		200,000	200
		20,000	180
		2,000	160
Pain threshold		200	140
	Aircraft engine		130
Danger	Klaxon horn	20	120
	Lawn mower		110
	Metro train arriving	2	100
	Heavy traffic	0.2	80
	Loud voices	0.02	60
	Normal voices	0.002	40
	Whispers	0.0002	20
Hearing threshold	Total silence	0.00002	0

▼ Decibels in Practice

When several independent sources produce sound pressures p_1 , p_2 , p_3 ,... at the same time, the resulting pressure p is calculated using the formula $p^2 = p_1^2 + p_2^2 + p_3^2 + \dots$, and the resulting acoustic pressure using the formula

$$L_p = 10 \log \frac{p_1^2 + p_2^2 + p_3^2 + \dots}{p_0^2}$$

This means that it is incorrect to add together all acoustic pressure values expressed in dB.

Two sounds with the same acoustic pressure combine to produce a noise measuring 3 dB higher than that of each constituent part.

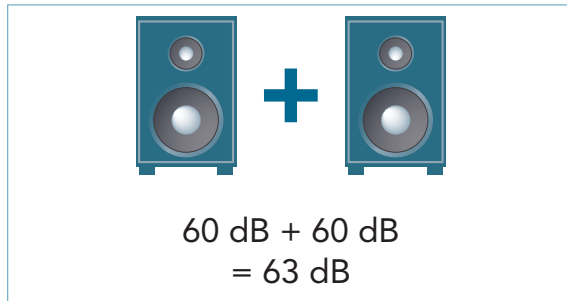
For example, if a noise has a sound pressure of 0.2 Pa, its acoustic pressure is calculated using the formula

$$L_p = 10 \log \frac{0.2^2}{(2 \cdot 10^{-5})^2} = 60 \text{ dB}$$

If two sounds measuring 60 Pa are combined, the acoustic pressure is calculated using the formula

$$L_p = 10 \log \frac{0.2^2 + 0.2^2}{(2 \cdot 10^{-5})^2} = 63 \text{ dB}$$

Example of combining acoustic pressure



An important note: even if a difference of 3 dB in the insulation between two products is equivalent to a 50% reduction in sound intensity, the same does not apply to the sound heard by the ear. In this way, to the ear, a difference of—

- > 1 dB is virtually inaudible
- > 3 dB is barely audible
- > 5 dB is clearly audible
- > 10 dB is equivalent to a 50% reduction in the perception the sound intensity
- > 20 dB is equivalent to a 75% reduction in the perception of sound intensity

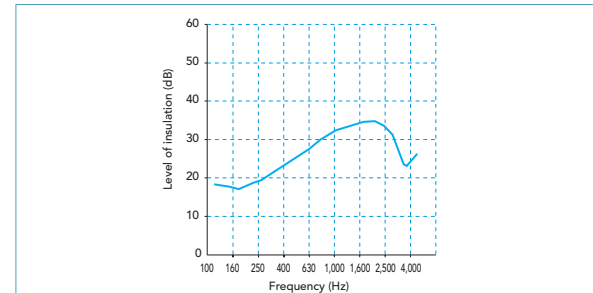
▼ Sound Spectrum

In reality, the sounds we hear are not made up of repeated

frequency cycles and identical pressure levels, but of different frequencies and sound pressures superimposed on each other, which creates a continuous spectrum containing all the frequencies.

To represent a sound comprehensively, it is therefore necessary to show it in a diagram called a sound spectrum, which expresses the level of pressure (or sound insulation) depending on the frequency. The table below gives an example of a sound spectrum.

Example of a sound spectrum



▼ Sound Reduction Index

> Sound Transmission Loss (TL) and Sound Transmission Class (STC)

In North America, the sound resistance of a building material is referred to as Sound Transmission Loss (TL). The Sound Transmission Class (STC) performance of materials is a single number which rates the materials' airborne sound transmission loss across 16 one-third octave bands between 125 Hz and 4,000 Hz, as measured in an acoustical laboratory under carefully controlled conditions.

TL measures the ability of a building material to resist the transmission of sounds at different frequencies (Hz). While TL is a measured value, the STC is a single number rating a given material's calculated value. Both these parameters are determined in accordance to ASTM E90 "Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements."

TL and STC performance data for many glazing configurations is available to architects and designers to help them in selecting the

best sound reduction glazing for a given application. While STC is a good parameter to use in selecting a glazing, the designer must also examine the TL performance of the glazing at the frequency of the noise that needs to be isolated.

2.6.2 SOUND INSULATION OF GLAZINGS

▼ Single-Pane (Float) Glass

In terms of sound insulation, single-pane glass acts as a simple partition and, as such, it respects two acoustical laws that apply to all single-pane partitions, regardless of the material they are made out of:

- > The law of frequencies
- > The law of masses

The law of frequencies states that, in theory, for thin partitions of any size, sound insulation increases by 6 dB by doubling the average frequency.

In practice, this law is not always respected, and there are three frequency zones within a sound spectrum:

- > In the first zone, the law of frequencies is respected in most cases, and insulation increases with frequency. However, partitions are of a specific size and have a muffling effect, which means that the insulation gains achieved are only as much as 4 or 5 dB at most when the average frequency is doubled—i.e., up to approximately 800 Hz
- > In the second zone, the level of sound insulation drops due to the critical frequency of the pane of glass. The critical frequency f_{cr} of a thin pane of glass is the frequency at which the free-bend speed on the partition and the air speed are equal—i.e., the frequency at which a pane of glass spontaneously vibrates following a wave

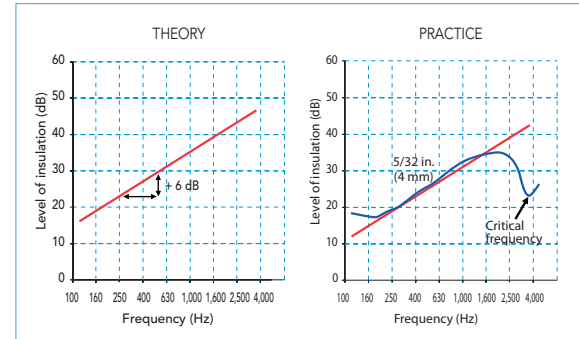
At ambient temperature, critical frequency is equivalent to approximately

$$f_{cr} = \frac{12,800}{e}$$

where e is the thickness of the pane of glass expressed in mm. The site of this zone depends on the elasticity of the material; the more rigid it is, the closer the coincidence zone is to the low frequencies

- > In the third zone, following coincidence, insulation increases rapidly by doubling the frequency—in theory, by 9 dB, but in practice the increase is less

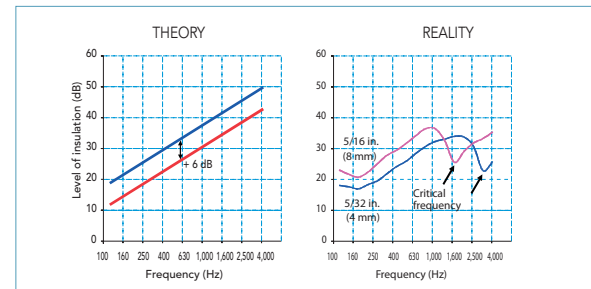
The law of frequencies: in theory and in practice



The law of masses states that, in theory, if the mass of a partition is doubled, then the sound insulation it provides increases by 6 dB at a constant frequency.

In practice, this law is respected in most cases, except in the coincidence zone. However, increasing the thickness of a single-pane glazing also pushes the critical frequency into a lower frequency area (per the law of frequencies).

The law of masses: in theory and practice



The table below shows the critical frequency of single-pane glazings according to their thickness.

Critical frequency (coincidence) of single-pane glazings

Thickness in. (mm)	Critical frequency (Hz)
5/32 (4)	3,200
3/16 (5)	2,560
1/4 (6)	2,133
5/16 (8)	1,600
5/8 (10)	1,280
1/2 (12)	1,067

Conclusions—

- > In light of the law of frequencies, all materials naturally provide better sound insulation against high frequencies than against low ones. However, the noise against which buildings require sound insulation often contains low frequencies
- > Increasing the thickness of a single-pane glass—which, in theory, enhances the glass's sound insulation—has the disadvantage of shifting the critical-frequency trough toward lower frequencies, thereby weakening the insulation provided against low-pitched sounds. However, for low frequencies, increasing the thickness of the glass can improve performance to some extent

▼ Laminated Glass

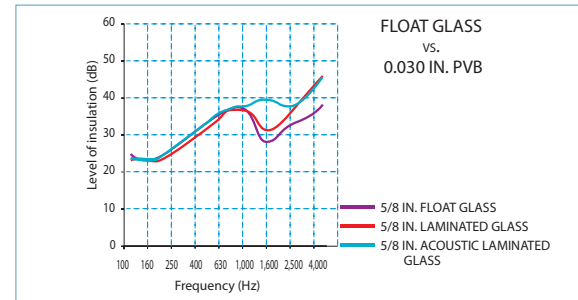
In terms of sound insulation, there are two types of laminated glass:

- > Glazings with a PVB (polyvinyl butyral) interlayer: the main function of this type of glazing is to protect against burglary and to ensure safety; however, such glazings also offer enhanced sound insulation
- > Glazings with acoustic PVB: this type of PVB interlayer is more supple than the "safety" PVB described above. It was developed to provide better sound insulation while providing the same level in terms of safety and burglary-resistance properties

Given their elasticity, acoustic PVBs can separate the two glasses making up the laminated glass and prevent it from acting as a monolithic glass. The critical-frequency trough is less and is shifted toward the high frequencies.

The table below shows the spectra for float glass, as well as these two types of laminated glass, with the same total thickness.

Spectra of sound insulation for a single-pane glass and laminated glass of the same thickness



Conclusions—

- > For a laminated glass of equal mass, sound insulation generally increases in the zone in which it coincides with the critical frequency. The sound-insulation trough is restricted by the muffling of the vibrations by the interlayer. This effect is more marked for acoustic PVB. In addition, in some cases the resonance trough is shifted toward the high frequencies
- > Laminated glasses have STC performance levels of approximately 34 dB for 1/4" up to 39 dB for 1/2"
- > Laminated glass with acoustic PVB typically improve STC performance by 1 dB regardless of glass thickness

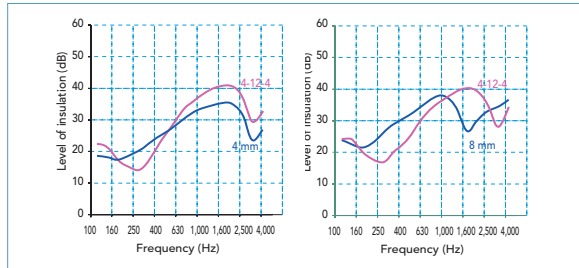
Note: Dissymmetrical laminated glass does not improve the sound insulation.

▼ Double glazing

The performance levels of symmetrical double glazings are often lower than those of a single-pane glazing with the same total glass thickness.

The table below shows the sound insulation spectra of a 4 mm/12 mm/4 mm (5/32"/1/2"/5/32") double glazing as compared with that of single-pane glazing with a thickness of 4 mm (5/32") and 8 mm (5/16").

Spectra of sound insulation for a single-pane glass and laminated glass of the same thickness



This table demonstrates—

- > A logical reduction in sound insulation of approximately 3,200 Hz for double glazing equivalent to the critical frequency of 4 mm (5/32") panes of glass
- > In relation to single-pane glazing, a lower level of insulation at low frequencies. This trend can be explained by the fact that double glazing acts as a mass-spring-mass (m-r-m) system. This mass-spring-mass system has a resonant frequency (entire system) located in the low-frequency zone of approximately 200 to 300 Hz, depending on the thickness involved. Sound insulation is significantly reduced in this zone
- > Between the resonance trough due to the mass-spring-mass system and the critical-frequency trough of the individual panes of glass, the sound insulation increases sharply (in theory, increases of 18 dB by doubling the frequency)

To provide the building with efficient sound insulation, the resonant frequency of the mass-spring-mass system must be below 100 Hz. This condition is not met by double glazing made up of two panes of glass of the same thickness and air space of 12 or 15 mm, and the sound insulation of double glazing in the low- and medium-frequency zone is limited.

To eliminate the mass-spring-mass effect, the air space between the panes of glass must be widened, in order to make the spring created by the air space more flexible. However, this could result in glazings which are too thick and which require equally wide frames, which would add significant weight to the unit. This would also increase convection within the air or gas space, which would be detrimental in terms of thermal insulation. For these reasons, insulating glazing is not widely used in practice for sound reduction.

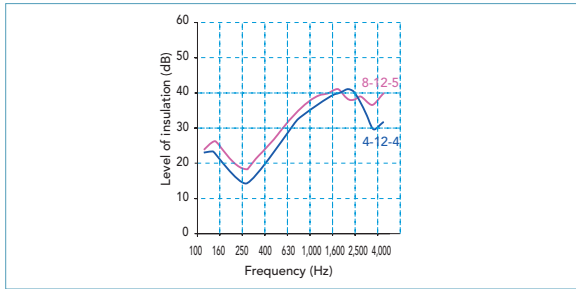
Conclusions—

- > The acoustic performance of symmetrical double glazing is limited
- > One might draw the conclusion that when renovating an older building, replacing single-pane glazing with double glazing is not a viable option. This is an incorrect assumption for two reasons:
 - Replacing a single-pane glazing with double glazing generally also means replacing the frame, which will also provide a greater level of sound insulation than the old frame. The level of sound insulation provided by the entire window will therefore be higher
 - In terms of thermal insulation, the gain afforded by double glazing in relation to single-pane glazing means that it is the only viable solution
- > The level of sound insulation provided by double glazing can easily be enhanced (see next sections) by using dissymmetrical forms or laminated glass

▼ Dissymmetrical Double Glazing

To enhance the level of sound insulation provided by double glazing, the first step is to use glasses with sufficiently different thicknesses in order to ensure that each can compensate for the weaknesses in the other when the unit reaches its critical frequency. This produces a coincidence trough in a broader frequency zone—but one in which the peaks are less marked. (In the figure on page 76, the trough around 3,200 Hz disappears). In this case, the increase in mass in relation to 4 mm /12 mm/4 mm (5/32"/1/2"/5/32") double glazing also helps to reduce the trough at low frequencies.

Sound insulation spectra for 4mm/12mm/4mm (5/32" /1/2" /5/32") and 8mm/12mm/5mm (5/16"/1/2"/3/16") double glazings



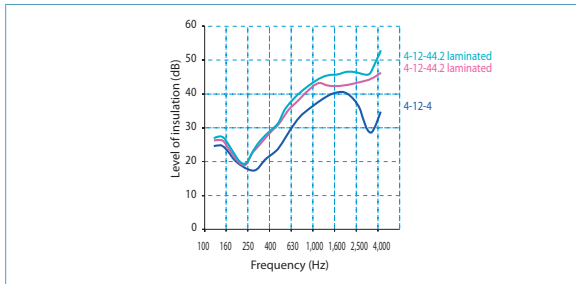
Conclusion—

- > Using two glasses of different thicknesses in a double glazing unit significantly improves performance in relation to symmetrical solution

▼ Double Glazing Units With Laminated Glass

Laminated glass can also be used in double glazing. The figure below shows the improvement in performance when laminated glass is used. The gain can be seen primarily in the high-frequency zone since it flattens out the critical-frequency trough.

Sound insulation spectrum for conventional 4-12-4, double glazing, a double glazing with laminated glass, and a double glazing with acoustic laminated glass



The direction in which dissymmetrical double glazings and/or double glazings with laminated glass are installed has no effect on the acoustical performance of the glazing. It is advisable to position any laminated glazing with PVB on the inside to ensure safety in the event of any breakage.

Conclusions—

- > If the performance levels of dissymmetrical double glazings are insufficient, better results can be achieved by replacing one or both of the two single panes with a laminated glass or an acoustic laminated glass
- > Improvements are generally seen at the high-frequency level

▼ Triple glazings

Triple glazings are of no particular value in terms of sound insulation because of the multiple resonance which occurs in the cavities between the glass panes.

▼ Conclusion

The factors that affect the levels of sound insulation provided by various glazings can be summarized as follows:

- > Single-pane glazing
 - Increased thickness provides slight improvement
 - Using laminated glass and acoustic laminated glass provides significant improvement in performance levels
- > Double glazing
 - Always use dissymmetrical glazing
 - Use a substantial air space
 - Use thick glass in most instances
 - Use a laminated glass (conventional PVB or safety) in place of one of the two monolithic glasses
 - Use a laminated glass with acoustic PVB for high levels of sound disturbance

2.7 SAFETY

2.7.1 SAFETY GLASS PRODUCTS

▼ General

Safety is a wide-reaching concept, covering many areas:

- > Protecting individuals against the risk of injury from
 - Sharp, broken glass
 - Falling glass (defenestration)

In trying to avoid the risk of injury only, it is the breakage pattern of the glass which is significant. It is important to ensure that, if the glass breaks, it does not produce pieces which are likely to cause injury. If the aim is to provide protection against falling glass as well, care must be taken to ensure that the glazing is not obliterated

- > Protecting people and property against burglary and vandalism of private homes, shops, and offices: in this context, the glazing should remain in place and should prevent anyone or anything penetrating it
- > Protection against firearms
- > Protection against explosions

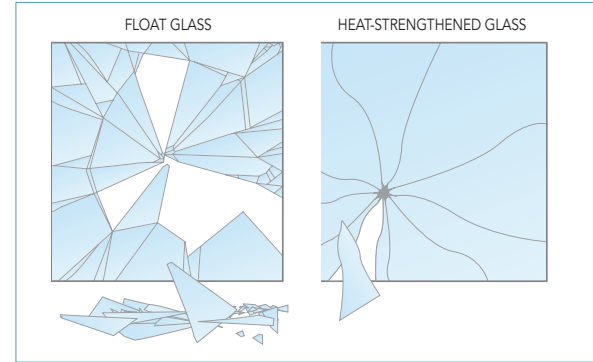
Only a small number of glass products meet the breakage pattern, defenestration, and resistance criteria described above: these are tempered and laminated glass. Other glass products—including float, heat-strengthened, and wired glass, among others—are not considered safety glasses.

The properties of these products are described briefly in this section.

▼ Float, Heat-Strengthened, and Wired Glass

In view of its breakage pattern of large sharp pieces, float glass cannot be considered a safety glass. The same applies to heat-strengthened glass, which has a similar breakage pattern.

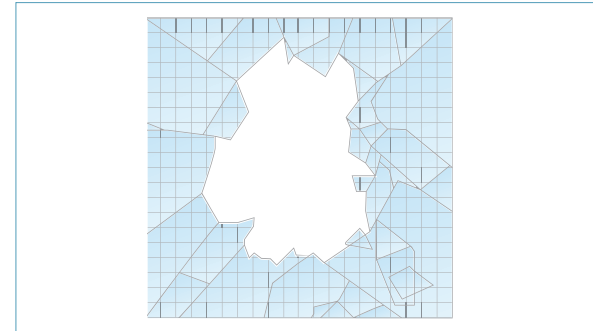
Breakage patterns of float and heat-strengthened glass



Wired glass (flat or profiled) has a metallic wire mesh built into it during the manufacturing process, designed to hold pieces of glass together in the event of breakage. However, if wired glass suffers an impact, the pieces of glass and the wire mesh may come apart, increasing the risk of injury.

For this reason, this type of glazing may not be used as a safety product, designed to prevent injury or protect people falling through it.

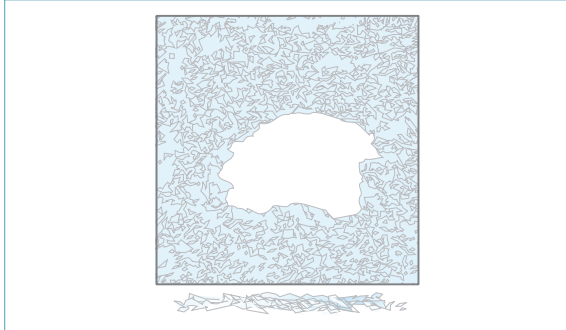
Breakage pattern of wired glass



▼ Tempered Glass (ASTM C-1048)

Because of the high internal stresses tempered products are subjected to during the manufacturing process, they shatter into small, blunt pieces upon impact.

Breakage pattern of tempered glass



Tempered glass is considered to be a safety glass if it meets the relevant breakage pattern criteria; these criteria are set out in the standards ANSI Z.97.1 and CPSC 16 CFR 1201—which also describes the test that must be implemented in order for a glazing to meet these safety requirements.

For reference, the main advantages of tempered glass over float glass are that tempered products—

- > Exhibit much greater characteristic bending resistance: 120 N/mm² (24,000 psi) as compared with 45 N/mm² (6,000 psi)
- > Have a higher level of resistance to impacts
- > Are four times stronger than annealed float glass
- > Have a higher level of resistance to thermal shock (approximately 392°F or 200°C)

- > Break into small, blunt pieces
- > Cannot be cut or processed after tempering
- > Exhibit a different anisotropy of the material: in natural lighting conditions, the refraction properties vary from point to point—and the superficial aspect of the glass pane may have differently colored designs due to interference

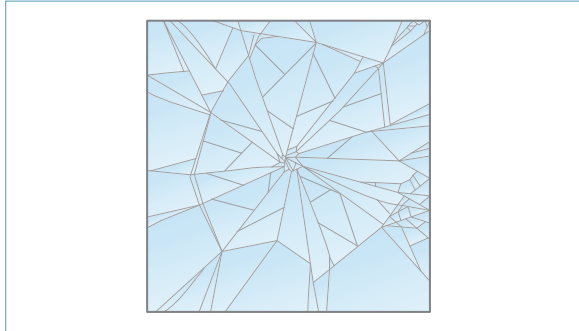
Comparing the impact resistance of an 11.8 inches by 11.8 inches (30 cm x 30 cm) piece of float glass to a similar-sized piece of tempered glass—

- > Float glass measuring 1/4 inch (6 mm) in thickness resists a ball weighing 0.55 pound (250 g) falling from a height of 11.8 inches (30 cm)
- > Tempered glass measuring 1/4 inch (6 mm) resists a ball weighing 0.55 pound (250 g) falling from a height of 9.8 feet (3 m)
- > Tempered glass measuring 5/16 inch (8 mm) resists a ball weighing 1.1 pounds (500 g) falling from a height of 6.6 feet (2 m)

▼ Laminated Glass (ASTM C-1172)

A laminated glass is an assembly composed of at least two panes of glass bonded together across their entire surface by an interlayer. For laminated safety glass, the most widely used interlayer is a plastic PVB (polyvinyl butyral) film, but EVA (ethylene vinyl acetate) films or a safety resin may also be used. In the event of breakage, the bond between the glass and the interlayer ensures that the broken pieces remain in place—at least for a certain period, or up to a specified load level.

Breakage pattern of laminated glass



According to standard ANSI Z97.1, a laminated glass may be considered a safety glass if it meets the requirements of a specific resistance class following the pendulum impact test detailed in this standard.

In some specific cases, tempered or heat-strengthened glasses are used to manufacture laminated glass.

As such, in specific applications requiring a high level of compression, a laminated glass composed of tempered and heat-strengthened glass is sometimes used. The former provides mechanical strength, while the latter gives adequate residual stability if the glass breaks and cannot be immediately replaced.

Heat-strengthened laminated glass is sometimes used when a higher level of wind load resistance is required than that offered by annealed float glass—as well as to prevent the risk of breakage due to thermal shock.

▼ Glass With a Self-Adhesive Film

A self-adhesive film may be applied to a glass to keep fragments in place in the event of breakage.

These films are generally used for applications such as mirrors and opaque painted glass.

Please note that these films are effective only if they are applied to the glazing before it is placed in the glazing channel of the frame. Adhering a film to the visible part of a glazing already in the channel is not effective if the glass breaks. In addition, some films applied in-situ can cause problems in terms of breakage due to thermal shock.

2.7.2 STANDARDS AND TESTS

▼ Introduction

In North America, there are a number of industry standards that products must meet in order to be considered safety glass solutions. These requirements are described in this section.

▼ Impact Resistance—ANSI Z97.1

Impact resistance standards for North America include both federal and voluntary standards, such as the U.S. Consumer Products Safety Commission's CPSC 16 CFR 1201 ("Glass Standard for Architectural Glazing Materials") and ANSI Z97.1 ("American National Standard for Safety Glazing Materials Used in Buildings—Safety Performance Specifications and Methods of Test").

ANSI Z97.1 establishes the test methods for safety glazing materials designed to promote safety as well as reduce or minimize the likelihood of cutting and piercing injuries when the glazing materials are broken by human contact in their use in architectural buildings.

The related impact test utilizes a leather punching bag filled with 100 pounds (45.4 kilograms) of lead shot to simulate the impact created by a running person. The standard divides safety glazings into two groups: Category I/Class B, and Category II/Class A, as shown in the table below.

Classes and categories of safety glazings, based on impact resistance

CPSC 16 CFR 1201 Category/ANSI Z97.1 Class	Weight of Impactor—lbs. (kg)	Height of drop—in. (cm)	Energy (ft.-lb.)	Minimum required PVB thickness—in. (mm)	Maximum Glazing Area—sq. ft. (m ²)
Cat. I / B	100 (45.4)	18 (46)	150	0.015 (3.8)	9 (2.7)
Cat. II / A	100 (45.4)	48 (122)	400	0.030 (7.6)	Unlimited

In the event that breakage occurs, the two fragmentation methods accepted by the ANSI Z-97.1 standard for these criteria are—

- > Numerous cracks appear, but no shear or opening is allowed within the test piece through which a 3-inch (76 mm) diameter sphere can pass when a maximum force of (18 N) is applied (in accordance with annex A). In addition, if particles are detached from the test piece up to 5 minutes after impact, they shall, in total, weigh no more than a mass equivalent to 10 square inches (640 mm²) of the original test piece
- > When breakage occurs, the 10 largest crack-free particles shall be selected within 5 minutes subsequent to the impact and shall weigh no more than the equivalent weight of 10 square inches (640 mm²) of the original specimen. For purposes of impact test evaluation when breakage occurs, the average thickness of a tempered glass specimen containing grooves, bevels, or other thickness-altering fabrication shall be considered the average of the thinnest measurement of each of the 10 geometrically largest crack-free particles. This average thickness will then be used to determine the maximum allowable weight of the 10 largest crack-free particles

NOTE: The weight in ounces of 10 square inches of glass is equal to 14.5 times the glass thickness in inches. The weight in grams of 10 square inches of glass is equal to 412 times the glass thickness in inches (16.18 grams/mm). (From ANSI Z-97.1)

> A tempered glass is classified as 1C2 if it resists an impact from a fall height of 17.7 inches (450 mm) without breaking and if it falls from a height of 47.25 inches (1,200 mm) and fragments in accordance with tempered glass.

▼ Hurricane Impact Resistance Glazings— ASTM E-1886/E-1996, Florida Building Code TAS 201 and 203, or AAMA 506

Building codes in the coastal counties of the United States require that, in wind-borne debris regions, glazing in buildings shall be impact-resistant or protected with an impact-resistant covering meeting the requirements of SSTD 12, ASTM E 1886 and ASTM E 1996, Florida Building Code TAS 201 and 203, or AAMA 506.

In accordance with the wind-borne debris provisions of these building codes, glazed openings located within 30 feet (9.144 m) of grade must meet the requirements of the ASTM E 1996 Large Missile Test. This test simulates the effects of large wind-driven debris that can impact the glazing during a hurricane—such as broken roof tiles, branches, patio furniture, etc. The weight and speed of these large missiles are defined according to the basic wind speed, as per the following table.

Standards of the ASTM Large Missile Test

Large Missile			
	Basic Wind Speed	Basic Protection	Enhanced Protection
Wind Zone 1	110 to 120 mph	4.5 lb. @ 40 ft./sec.	9.0 lb. @ 50 ft./sec.
Wind Zone 2	120 to 130 mph	4.5 lb. @ 40 ft./sec.	9.0 lb. @ 50 ft./sec.
Wind Zone 3	130 to 140 mph	9.0 lb. @ 50 ft./sec.	9.0 lb. @ 80 ft./sec.
Wind Zone 4	Greater than 140 mph	9.0 lb. @ 50 ft./sec.	9.0 lb. @ 80 ft./sec.

To meet these large-missile standards, laminated glasses are offered in a variety of interlayer thicknesses and types.

Glazed openings located more than 30 feet (9.144 m) above grade must meet the provisions of the ASTM E 1996 Small Missile Test. This test simulates small wind-driven debris that can impact the glazing during a hurricane—such as roof gravel and other small debris.

To meet the requirements of the ASTM E 1996 Small Missile Test, laminated glasses typically include a PVB interlayer with a thickness of 0.06 inch (1.5 mm).

Standards of the ASTM E 1996 Small Missile Test

Small Missile			
	Basic Wind Speed	Basic Protection	Enhanced Protection
Wind Zone 1	110 to 120 mph	2 g steel ball @ 130 ft./sec.	9.0 lb. @ 50 ft./sec.
Wind Zone 2	120 to 130 mph	2 g steel ball @ 130 ft./sec.	9.0 lb. @ 50 ft./sec.
Wind Zone 3	130 to 140 mph	2 g steel ball @ 130 ft./sec.	9.0 lb. @ 80 ft./sec.
Wind Zone 4	Greater than 140 mph	2 g steel ball @ 130 ft./sec.	9.0 lb. @ 80 ft./sec.

In addition to meeting the wind-borne debris requirements included both in the ASTM large and small missile tests, fenestration systems are subjected to a static cyclic pressure load test that simulates the extended force of the wind during a hurricane. Since hurricanes rotate in a counterclockwise direction, glazings in a building structure will be subjected both to positive and negative forces. These forces are simulated at different pressure cycles as indicated in the following table.

Standards of the ASTM E 1996 Cyclic Static Air Pressure Loading Test

Cyclic Static Air Pressure Loading			
Loading	Basic Wind Speed	Basic Protection	Enhanced Protection
1	Positive	0.2 to 0.5 Ppos	3,500
2	Positive	0.0 to 0.6 Ppos	300
3	Positive	0.5 to 0.8 Ppos	600
4	Positive	0.3 to 1.0 Ppos	100
5	Negative	0.3 to 1.0 Pneg	50
6	Negative	0.5 to 0.8 Pneg	1,050
7	Negative	0.0 to 0.6 Pneg	50
8	Negative	0.2 to 0.5 Pneg	3,350

Pass/Fail Criteria

Window systems are certified if three similar specimens pass in accordance with the following criteria, after completion of the impact and cycling portions of the ASTM E 1996 testing.

- All test specimens must resist the large or small missile impacts, or both, without penetrating the pane of glass
- Test specimens must resist the large or small missile impacts, or both, with no tear formed longer than 5 inches (130 mm) or no opening formed through which a 3-inch (76 mm) diameter solid sphere can pass freely

▼ Burglar-Resistant Glass—ANSI/UL 972

Laminated glasses provide an element of security against “smash and grab” thefts. Whether protecting merchandise in a store display or guarding a homeowner’s porch door or window against intruders, laminated glass provides the needed security. Laminated glass protects against forced entry by resisting repeated blows from hammers, bricks, or other weapons—and deterring burglars from perpetrating the crime.

ANSI/UL 972 Testing

ANSI/UL 972 test standards define the specific methods that are used to classify glasses in terms of their resistance to burglary. This testing uses the impact of a steel ball as a surrogate for a variety of burglary tools such as hammers, bricks, or crowbars.

Testing consists of dropping a 3.25-inch (82 mm) 5-pound (2.26 kg) steel ball across a designated vertical distance at glazing specimens conditioned at different temperatures. The test specimens should measure 24 inches x 24 inches (610 mm x 610 mm) in size. There are five impacts per specimen.

Pass/Fail Criteria

In order for glazings to qualify as burglary resistant under these standards, the steel ball must not penetrate the laminate during all five impacts.

ANSI/UL 972 test requirements for burglary-resistant glazings****

Test Requirements Burglary-Resistant Glazing Material					
UL 972 Tests ¹	Impacts per Sample	Impact Energy		Temperature	
		ft.-lb.	Joules	°F	°C
Multiple Impact	5	50	68	70-80	21-27
Outdoor Use	5	40	54	14	-10
Indoor Use ²	5	40	54	120	49
	5	50	68	95	35
High Energy Impact ³	5	50	68	55	13
	1	200	271	70-80	21-27

****Charts provided by Solutia Saflex in its "Security Design Guide"

Note—

- 1 Tests consist of dropping 3.25 inches (82 mm) 5-pound (2.26 kg) steel ball through a designated vertical distance; sample size 24 inches x 24 inches (610 mm x 610 mm)
- 2 The steel ball shall not penetrate the laminate on any five impacts for nine of the 10 samples tested
- 3 The steel ball shall not penetrate the laminate on any of the three samples tested

▼ Bullet Resistance—ASTM F-1233 and UL 752

There are many standards used in North America for the testing and classification of bullet-resistant glasses. These standards make a distinction between the resistance that glazings demonstrate against various types of weapons and ammunition. There are various classes or levels reflecting various weapon and ammunition types. For each category of weapons that are tested, glass products are considered bullet resistant if they stop all the bullets on a set of different rounds fired from a specified distance.

The various classes and levels of bullet-resistant glass may include products that offer a number of levels of protection. A glass meeting the requirements stipulated for a given class of weapons also meets those of the classes below it. However, there is no correlation between classes/levels for different weapon types.

The table below and on page 98 provide more details about the weapons, ammunition, and test conditions for the different classes of bullet-resistant glazings under ASTM F-1233 and UL 752.

Classes of bullet resistance according to standard ASTM F-1233****

ASTM F1233 Ballistic Criteria				
Class/Level	Weapon Description	Caliber	Bullet Mass ¹ / Type ²	Velocity ³ (ft./sec.)
HG1	Handgun - Low	.38 Special	158 gr/lead	875 (± 25)
HG2	Handgun - Medium, Soft Point	.357 Magnum	158 gr/JSP	1,400 (± 50)
HG3	Handgun - Medium, Jacketed	9 mm	124 gr/FMC	1,250 (± 50)
HG4	Handgun - High	.44 Magnum	240 gr/FMC	1,425 (± 25)
SMG	Submachine gun	9 mm	124 gr/FMC	1,450 (± 50)
R1	Rifle - Light	.223 (5.56 mm)	55 gr/M193 ball	3,100 (± 100)
R2	Rifle - Heavy, Soft Point	0.30-06	180 gr/SP	2,925 (± 75)
R3	Rifle - Heavy, Jacketed	.308 Winchester (7.62 mm)	147 gr/M80 ball, FMC	2,750 (± 50)
R4-AP	Rifle - Armor Piercing	.30-06	164 gr/M2-AP	2,800 (± 50)
SH1 ⁴	Shotgun - Buckshot	12-gauge, 3 in. Magnum	OO buckshot, 15 pellets	1,200 (± 50)
SH2	Shotgun - Slug	12-gauge	1 oz. rifle slug	1,650 (± 50)

****Charts provided by Solutia Saflex in its "Security Design Guide"

Notes—

- 1 gr denotes grain as a unit of mass; 1gr = 1.426 x 10⁻⁴ pound (0.0647981 g)
- 2 FMC = Full Metal Coating, JSP = Jacketed Soft Point, LGC = Lead Gas Check, and SP = Soft Point
- 3 Velocity measured at a distance of 10 feet (3 m) from the strike face of the sample. Muzzle of the barrel is positioned at a distance of 25 feet (7.6 m) from the strike face of the sample
- 4 This ammunition is to be used as an adjunct to the primary test to further evaluate the ability of designed assembly details to resist fragmentary threats

- 5 The shotgun load includes 15 pellets of 59 grains each. Each pellet has an energy of approximately 227 feet-pound (308 joules)
- 6 This test standard requires the sample to resist three (3) rounds fired at 25 feet (7.6 m) range and 120° spacing around an 8-inch diameter (203 mm) target circle. Spall is measured using a 0.001 inch (0.03 mm) = thick aluminum foil witness panel 6 inches (152 mm) behind the glazing
- 7 The small differences between the weapon characteristics defined in Figure 2.8 for UL 752 and those presented for ASTM F1233, as well as the differences in required shot patterns and methods for measuring spall, can make a difference in whether a specimen will pass or fail

Classes of bullet resistance according to standard ASTM F-1233****

Rating	Typical Weapon	Ammunition	Bullet Mass ¹ / Type ²	Velocity ³ (ft./sec.)
Level 1	9 mm Gun	Full metal copper jacket with lead core	1,175/124	3
Level 2	.357 Magnum Revolver	Jacketed lead soft point	1,250/158	3
Level 3	.44 Magnum Revolver	Lead semi-wadcutter gas checked	1,350/240	3
Level 4	.30 Rifle	Lead core soft point	2,540/180	1
Level 5	7.62 mm Rifle	Lead core full metal copper jacket, military ball	2,750/150	1
Level 6	9 mm Gun	Full metal copper jacket with lead core	1,400/124	5
Level 7	5.56 mm Rifle	Full metal copper jacket with lead core	3,080/55	5
Level 8	7.62 mm Rifle	Lead core full metal copper jacket, military ball	2,750/150	5
Supplementary	12-Gauge Shotgun	12-gauge rifled lead slug	1,585/437	3
Supplementary	12-Gauge Shotgun	12-gauge lead buck-shot (12 pellets)	1,200/650	3

****Charts provided by Solutia Saflex in its "Security Design Guide"

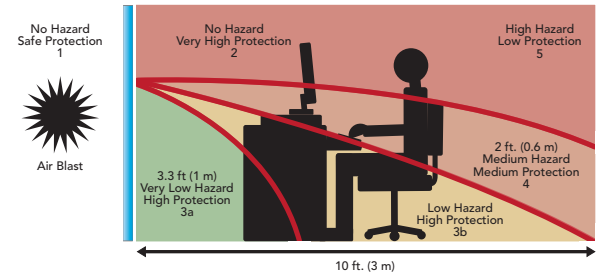
▼ Explosion Resistance—GSA "Standard Test Method for Glazing and Window Systems Subject to Dynamic Overpressure Loadings" and ASTM F-1642

To resist explosions, laminated glass products can be designed to meet the requirements of the U.S. General Services Administration (GSA) "Standard Test Method for Glazing and Window Systems Subject to Dynamic Overpressure Loadings" as well as ASTM F-1642 "Standard Test Method for Glazing and Glazing Systems Subject to Air Blast Loadings." These test methods are designed to measure the performance criteria of glazings subjected to air blast loads similar to those of an explosion.

The GSA and ASTM F-1642 test standards can be performed using shock tube or field arena blasts to create overpressure. When glass is exposed to a blast event, broken glass shards fly into the inhabited space, potentially causing personal injury and loss of life. These test methods measure the performance of the glazings in their ability to retain the broken shards of glass and restrain them from flying into the inhabited space.

The levels of explosion protection range from a "no break" safety level to a low protection level, where the glazing cracks and the window system fails catastrophically. Glass fragments enter the inhabited space, impacting a vertical witness panel located 9.8 feet (3 m) from the window at a height of 2 feet (0.6 m) above the floor.

Performance conditions for explosion-resistant glazings



Department of Defense Criteria

The United States Department of Defense (DoD) Unified Facilities Criteria UFC 4-010-01 “DoD Minimum Antiterrorism Standards for Buildings” sets minimum design guidelines for windows and doors designed to resist explosions. This standard requires that a 1/4-inch (6 mm) nominal laminated glass be used, at a minimum. The 1/4-inch (6 mm) laminated glass should consist of two nominal 1/8-inch (3 mm) annealed glass panes bonded together with a minimum of a 0.03-inch (0.75 mm) polyvinyl-butylal (PVB) interlayer.

For insulating glass units, the DoD design criteria requires the use of 1/4-inch (6 mm) laminated glass for the inboard pane, at a minimum. The required thickness for the laminated glass and PVB interlayer is determined based on the appropriate explosive weight and standoff distance defined in ASTM F-2248, “Standard Practice for Specifying an Equivalent 3-Second Duration Design Loading for Blast Resistant Glazing Fabricated With Laminated Glass,” as well as ASTM E-1300 “Standard Practice for Determining Load Resistance of Glass in Buildings.”

Protection level vs. hazard level comparison

GSA Condition	Protection Level		Hazard Level	
	GSA	DoD	GSA	DoD
1	Safe	High	None	No Hazard
2	Very High	Medium	None	Minimal Hazard
3a	High	Low	Very Low	Very Low Hazard
3b and 4	High/Medium	Very Low	Low/Medium	Low Hazard
5	Low	Below AT Standards	High	High Hazard

2.7.3 SAFETY GLASS APPLICATIONS

▼ Introduction

The following section provides general information on the use of safety glass; the list of applications is not exhaustive.

While this section includes general guidelines, the application of safety glass in a specific glazing project should always be considered on a case-by-case basis according to specific site requirements and local regulations.

In all cases, the actual glass thicknesses should be adapted to the real-world glazing sizes and loads for each project—as well as the specific glazing framing system. The thicknesses corresponding to a particular safety glass class are merely a minimum level defined for testing purposes only.

AGC customers should consult the company’s Technical Services team for more information about applications and requirements for safety glass products.

▼ Safety of Individuals Against Injury and Falling

> Introduction

There are two distinct aspects that must be considered when protecting the personal safety of individuals:

- > Preventing the risk of injury caused by sharp pieces of glass upon glass breakage
- > Preventing the risk of falling through glass (defenestration)

In the case of the first risk, both tempered and laminated glass products can be used. However, only laminated glass may be used for protection against defenestration.

Although it displays some impact resistance, annealed float glass is never considered to be a safety glass.

> Protection against injury

To limit the risk of personal injury resulting from shattered pieces of glass, glazings should include tempered or laminated glass with a minimum 0.015-inch (0.38 mm) PVB film interlayer for Class B, and a 0.03-inch (0.75 mm) PVB interlayer for Class A Drop Height Classification.

Such glass can be used in the following applications:

- > Retail store windows (if the bottom of the glass is close to ground level)
- > Internal partitions (if the bottom of the glass is close to ground level) where there is no difference in the level on either side
- > Doors and windows in public places
- > Street furniture: bus shelters, telephone booths, etc.
- > Shower cubicles, shelves, furniture, etc.
- > In the case of roof glazings, the use of laminated glass is vital in order to protect people standing beneath the glazed opening against the risk of injury from glass shards which have become detached—dislodged, for example, by falling objects. Since there is no guarantee that objects will not fall through the glass, roof glazings will be completely effective only if the stresses produced by such impacts are within the performance levels of the specific glazing products.

In safety applications where the edges of a glass are visible, they should be ground—and in some cases, the glass should also be tempered.

> Protection against falling

To limit the risk of injuries caused by falling through glass, laminated glass—with a minimum 0.03-inch (0.75 mm) PVB interlayer—should be used in the following applications, among others:

- > Internal windows and doors (if the bottom of the glass is close to ground level) where there is a difference in level
- > Railings and balustrades
- > Floors and staircases

> Position of safety glass

In order to protect individuals, double glazings should position the laminated glass on the side on which impacts are most likely to occur.

Two safety glasses may be used in a double glazing assembly if the impact may occur on both sides—for example, in the case of double glazings fitted in an entry door to a public place. The permissible combinations in double-glazed safety units are tempered-tempered, tempered-laminated, and laminated-laminated.

Double glazings composed of float and tempered glasses provide no safety protection. If the two glasses break at the same time, there is a risk of personal injury.

For double glazings installed in roofs, the internal glass should be laminated.

▼ Burglary Resistance

Only laminated glass may be used to protect against vandalism and burglary—or escape, e.g., in prisons or hospitals.

The fabricator of the laminated glass must determine the number of PVB films to be used, as well as the glass composition, depending on the level of protection required. Whether the aim is to provide protection against vandalism or to protect homes and retail stores from theft, the laminated glass should be composed of two panes of glass and an increasing number of PVB films—depending on the level of security required and/or insurance requirements. For very high levels of security, multi-laminated glass should be used, potentially incorporating polycarbonate.

In the case of burglary-resistant safety glass assembled in a double glazing unit, the laminated glass should be positioned on the inside of the unit.

▼ Bullet and Explosion Resistance

Laminated or multi-laminated glasses, sometimes containing polycarbonate, are resistant to bullets and explosions.

Using glass as a source of resistance to bullets and explosions is a highly specialized field. It is the responsibility of the glazing professional to determine the level of protection required. AGC customers should contact a blast security consultant when deciding which glass products provide the level of performance required—which will depend on the specific nature of the project and the type of protection needed.

▼ Frame Quality

In all cases, safety glasses are useful only if the accompanying framing system has the same resistance qualities. The level of resistance of the weakest component determines the resistance of the assembly as a whole.

▼ Installation Instructions for Safety Glass

When fitting safety glass products, general installation instructions—as well as those specific to safety glass—should be followed.





III. CHOOSING A GLASS

1	Exterior Glazing	108
1.1	Considerations in Choosing a Glass	109
1.2	Size of Panes	113
1.3	Energy Performance	115

1 EXTERIOR GLAZING



Palacruceros Terminal, Barcelona, Spain - Architect: Ligi Vicini, Andrea Piazza

1.1 CONSIDERATIONS IN CHOOSING A GLASS

1.1.1 INTRODUCTION

When choosing a glass for any application, a number of factors should be taken into account—including its thermal insulation, solar control, light transmission, color, sound insulation, and safety properties.

Aesthetics are also a concern—for example, when specifying spandrel panels, architects need to ensure that the entire facade of a building has a unified, harmonious appearance.

Because there are so many factors to consider when choosing a glass, it is important to plan a thorough decision-making process that investigates all these various aspects. Depending on the type of building in which the glass will be installed—e.g., residential versus commercial—not all of these glass characteristics may be relevant in every application.

1.1.2 GLASS STRUCTURE AND THICKNESS

A mechanical calculation should be used to determine the minimum structure, or glass thickness, required to ensure that the glass is stable—in view both of its overall dimensions and the loads to which it will be subjected.

This calculation should be performed in accordance with ASTM E-1300 “Standard Practice for Determining Load Resistance of Glass in Buildings.”

1.1.3 SOUND INSULATION PROPERTIES

Acoustic performance levels also have a direct impact on the structure and thickness of the glass: the higher the level of acoustic performance required, the greater the mass of the glass. At a certain level of sound performance, insulating glass units with laminated glass, or acoustic laminated glass, may be needed to ensure adequate insulation.

Glazing requirements in terms of structure and sound insulation are interrelated issues and should always be considered in parallel.

1.1.4 GLASS APPEARANCE AND COLOR, REFLECTIVITY, TRANSMISSION, SOLAR CONTROL, AND THERMAL INSULATION

Glass appearance and color are always important criteria when choosing the appropriate type of glass for any application. Modern glass technology has provided a range of options in glass tints and colors, as well as innovative coating options, making this decision more complicated than ever.

In residential applications, the general trend is toward glass solutions which are neutral both in color and appearance.

In commercial applications, a wide range of tints, reflectivity levels, and coating options can help architects bring their unique aesthetic vision to life. Glass samples and project mock-ups can provide an accurate idea of how products will look in the finished structure and support well-informed architectural decisions.

In curtain-wall glazing, it is important to choose a spandrel which either blends or contrasts with the vision glazing. Fortunately, the broad range of architectural glasses available today can help make this visual harmony much easier to achieve.

In addition, today's wide variety of hard- and soft-coat products, low-emissivity glasses, and other options make it easy for glass professionals to choose the unique combination of light transmission, solar control, and thermal insulation properties that are right for their specific application.

To learn more about the science behind each of these categories of glass performance, see Chapter 2, "All About Glass."

Glazing professionals can achieve the exact glass appearance that meets their high aesthetic standards—without having to sacrifice the energy efficiency or comfort of interior spaces.

There is one important performance aspect that must always be considered when specifying glass for a commercial application: the risk of breakage due to thermal stress. Glass products subject to high thermal loads may need to be tempered or heat-strengthened in order to minimize this risk and maximize safety. Consult AGC's Technical Services team to learn more about calculating thermal stress when choosing a glass.

1.1.5 SAFETY PROPERTIES

Safety considerations—including the risk of personal injury, protection against burglary, security against firearms or explosions, and hurricane and fire protection—should always be taken into account when choosing a glass. In certain situations where safety is a concern, tempered or laminated glass solutions represent the best choice. Glass professionals should consult safety organizations such as ASTM when specifying safety glass products and ensure that they are meeting all relevant industry standards.

1.1.6 MISCELLANEOUS CONSIDERATIONS

> Multiple functions

Often, today's complex glazing applications require that glass products perform more than one function.

To meet this growing demand, it is possible to combine various properties and functions—such as thermal insulation, solar control, safety, sound insulation, and decoration—in a single glazing. In order to accomplish this, glass specifiers should carefully choose each component of the finished glazing system.

> Feasibility

While glass manufacturing offers more flexibility and more choices than ever, architects should always check that their specific glass solution is available in the required thicknesses and sizes they need, as well as in the appropriate weight for their application.

The AGC Technical Services team can help ensure the feasibility and appropriateness of a specific glazing system for the desired application.

> Handling

It is important to remember that glass solutions will need to be handled and positioned on the job site, and their size and weight may prove problematic if these characteristics are not considered up front.

In addition, glazing installations should be planned for accessibility in the future, in the event that the glass may need to be replaced or repaired at a later date.

1.2 SIZE OF PANES

The architect and/or the mechanical engineer should determine the correct thickness for each glass pane, as well as any double- or triple-glazed insulating units that will be installed in a building.

This will depend, among other things, on the location of the building, the size of the units, and how they are installed.

Architects and designers must follow the guidelines of the American Society of Civil Engineers Standard ASCE 7 “Minimum Design Loads for Buildings and Other Structures” as well as ASTM E-1300 “Standard Practice for Determining Load Resistance of Glass in Buildings.”

Glass thicknesses should also be adapted to fit relevant sizes and stress levels in accordance with local building code regulations. Glazing units need to be protected against the effects of thermal stress, mechanical breakage, water penetration and condensation, and natural forces such as high winds and heavy snow loads.

It is important during the initial study phase to determine the minimum thicknesses required for a facade in order to—

- > Select the final structure of the glazing (coated glasses available, sound structure needed, etc.) in view of these minimum thicknesses
- > Reduce the size of the sealed units where necessary by using thinner glass panes or framing systems

It is always important to remember safety considerations—such as hurricane and explosion protection—when selecting a glass thickness, since these requirements will have a direct impact on the structure of the glass.

- > Installation—how it is supported
- > Size of the sealed unit
- > Wind load
- > Dead load (i.e., snow load)
- > Deflection requirement (if known)
- > Building location (urban, rural, etc.)
- > Dimensions of the building
- > Location of building where glass will be installed
- > For roof glazings: the slope of the roof



Torre Gas Natural, Barcelona, Spain

1.3 ENERGY PERFORMANCE

In North America, the energy performance requirements of a glazing are dictated by the energy code requirements of local regulations, as well as voluntary programs such as the Department of Energy's ENERGY STAR® initiative and the U.S. Green Building Council Leadership in Energy and Environmental Design (LEED) Green Building Rating System.

With a range of high-performance coatings and other glass options available today, new levels of energy efficiency are possible, whether annual energy needs are focused more on heating or air conditioning costs. The AGC Technical Services team can help customers calculate their annual energy requirements and make well-informed product choices.

1.3.1 RESIDENTIAL APPLICATIONS

For residential applications where a neutral glass color is usually a priority, there are a range of pyrolytic ("hard coat") and sputter-coated ("soft coat") product options that combine color neutrality with customized annual energy performance.

Depending on where North American homes are located, the priority is either on minimizing annual heating costs by choosing a glass with passive solar properties or reducing year-round air conditioning usage by selecting a solar control product.

There are a number of energy-efficiency programs that can help window makers and consumers make the best glass choice for their region, including the ENERGY STAR program.

AGC's expert Technical Services team has an in-depth understanding of the unique challenges in specifying residential window systems and can help customers make the best choices that minimize up-front costs while maximizing long-term energy-efficiency gains.

1.3.2 COMMERCIAL APPLICATIONS

When specifying energy-efficient glazings for architectural applications, the following key factors should be considered:

- > Solar heat gain coefficient (SHGC)
- > Visible light transmission (VLT)
- > Level of external visible light reflection (LR)
- > Color

Detailed information about the building's projected annual energy usage, desired interior temperature, and, where appropriate, the level of air conditioning in the building will determine the maximum permissible solar heat gain for any given façade—i.e., the solar energy that passes through the glazing in the form of heat. The level of light desired inside the building, the visual comfort of occupants and likelihood of glare, and the type of lighting will all help determine the correct LT level. The color and reflectivity of the façade—whether it has a transparent, matte, or mirror effect—are aesthetic choices that can be determined by the architect.

The glass performance characteristics above are all interrelated. Choosing certain values for one criterion may restrict the choices available in other areas. For example, achieving a very low SHGC—which means excellent solar heat blocking—may require choosing a tinted or slightly reflective glass.

In terms of solar and light performance, colored or coated glasses, in general, achieve higher levels of performance.

To deliver customized performance for its customers, AGC Glass Company North America uses two coating technologies:

- > Pyrolytic or “hard” coatings: Energy Select™ 73 and Stopsol®
- > Sputter or “soft” coatings: Energy Select™ 25, Energy Select™ 28, Energy Select™ 36™, Energy Select™ 40, Energy Select™ R42, and Energy Select™ 63.

Depending on the type of coating, the glass thicknesses available will vary. The main features of these coatings are detailed in the table below.

	Stopsol®	Energy Select™ (ES) ES73, ES63	Energy Select™ (ES) ES25, ES28, ES36, ES40, ESR42,
Use in single glazing	Yes (surface #1)	No	No
Use in double glazing	Yes (surface #1 or 2)	Yes (surface #2 or 3)	Yes (surface #2 or 3)*
External light reflection	Medium (surface #2) to high (surface #1)	Low	Low to medium (ESR42)
Solar heat gain coefficient	Low to high	High	Low to medium
Spectral selectivity	Poor	Medium	High
Processing options	Tempered	Tempered	Tempered
	Bent	Bent	Bent
	Laminated	Laminated†	Laminated†
Thermal insulation (U value)	Low	Medium to high	High

* AGC Energy Select solar control low-e coatings are engineered to be installed on the #2 surface of an insulated glass unit. If the coatings are installed on the #3 surface of an IGU, it is recommended that a facade does not mix the annealed and temperable coat in the same elevation.

† Please note that sputter or “soft” coatings must not come into contact with the PVB interlayer during the laminating process. This would result in a loss of the thermal insulating properties provided by the low-e coating.

In some special cases, silk-screen printed glasses, coated laminated glasses, or glasses with colored interlayers can also provide a degree of solar control in commercial applications. To choose the correct product, the specifier should consider the following criteria:

- > Reflectivity and color required
- > Level of thermal insulation required—it may be necessary to combine a solar-control coating with a spectrally selective low-e coating to achieve the desired thermal performance level
- > Required solar heat gain coefficient (SHGC)
- > Desired level of visible light transmission

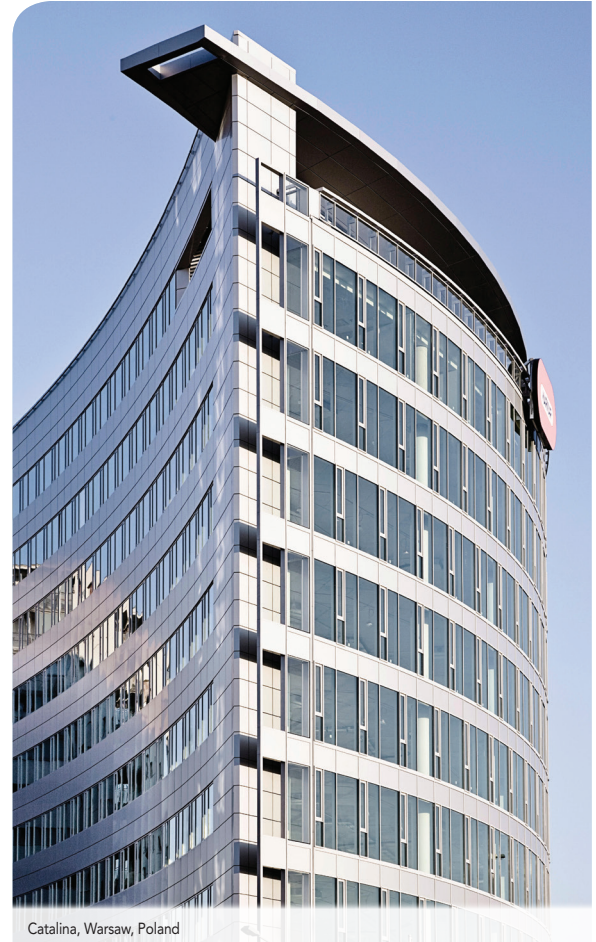
- > Type of product used—e.g., glass with pyrolytic or sputter coatings—this is more of a direct consideration during processing rather than during the design stage. But note that pyrolytic glasses are more durable and therefore easier to handle, transport, stack, and store

The performance summary section at the back of this book will help you choose the most appropriate product for a specific application. These tables include most of the glasses available in the AGC product range, and the performance values indicated apply ¼-inch/½-inch/¾-inch (6 mm/12 mm/6 mm) double glazing.

Each table details the solutions' performance for thermal insulation and for solar control. Other performance levels may be achieved by varying the thickness of the glass, primarily in the case of colored glasses.

For more information about the performance of AGC glass products, please consult the Technical Services team at AGC Glass Company North America. (800) 251-0441.

Breakage due to thermal shock occurs if there is too great a temperature difference between two areas of the same annealed glass. As the temperature of the glass rises, the glass expands—which is not problematic if the temperature increase is uniform across the entire sheet of glass. However, if part of the glass remains cold, it will prevent the warm part from expanding freely. This gives rise to tensile stress, which may exceed the mechanical resistance of the glass. If there is a risk of this happening in a given commercial application, the glass should always be tempered or heat strengthened to minimize the risk of breakage. To assess the risk of thermal shock and whether heat treatment is required, contact AGC Technical Services at (800) 251-0441.



Catalina, Warsaw, Poland



Square Brussels-Meeting Centre, Brussels, Belgium – Architect: A.2R.C

IV.

BRANDS AND PRODUCTS

1. CLEAR FLOAT GLASSES

1.0 Introduction

1.1 Clear

KRYSTAL KLEAR™
Linea Azzurra®

122

123

124

126

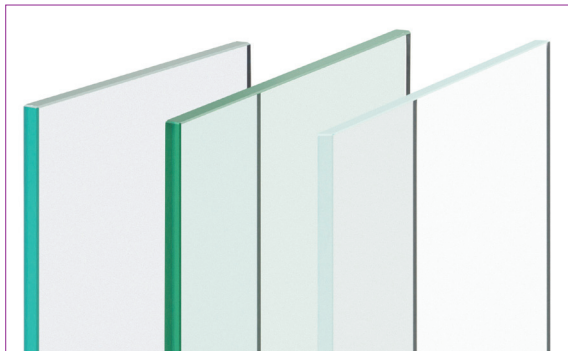
1.0 INTRODUCTION

To meet its customers' needs for float glass, AGC Glass Company North America offers a range of high-quality solutions. Versatile float glass products from AGC can be processed in many ways for use in numerous applications, including construction, decoration, automotive, and high-tech industries. AGC clear float products offer these benefits—

- > Perfectly flat parallel surfaces due to “float” manufacturing process
- > High levels of transparency and light transmission
- > An excellent base for further processing, such as coating
- > Available in three tints: Clear, KRYSTAL KLEAR™ and Linea Azzurra® (blue)
- > Strength and flexibility to support single glazing, insulating glazing, laminating, tempering, enamelling, silk screening, sandblasting, and bending

AGC also offers a family of tinted Solarshield® float glass solutions that control solar energy; see the Exterior Glazing section to learn more.

AGC offers three types of float glass: Clear, KRYSTAL KLEAR™, and blue-tinted Linea Azzurra®



1.1 CLEAR FLOAT PRODUCTS

CLEAR



Clear float glass is a beautiful, versatile choice when specialty glass is not needed—and AGC Glass Company North America has built a reputation as a leader in this product category. Clear solutions from AGC offer a wealth of product benefits, including outstanding clarity, excellent color neutrality, and high levels of visibility and light transmission.

In residential and commercial applications alike, AGC's Clear reduces the need for interior lighting by flooding interior spaces with light—while its strength and durability are valued in the automotive and specialty glass markets. From doors and windows to furniture and other household items, Clear from AGC is a trusted and reliable performer that supports a wide range of processing options.

KRYSTAL KLEAR™ LOW-IRON GLASS

Outstanding Light Transmission, Clarity, and a Colorless Appearance

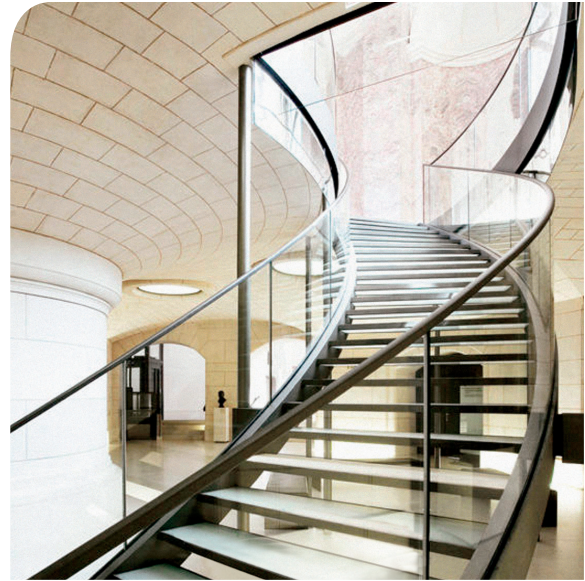
New KRYSTAL KLEAR™ from AGC is the most transparent low-iron glass available today—delivering remarkable clarity and a virtually colorless appearance. Ultratransparent KRYSTAL KLEAR is ideal for commercial interior, residential, and specialty applications. With a visible light transmission of 91%, KRYSTAL KLEAR floods interior spaces with light and provides outstanding visibility for a range of applications.

With its low iron content, KRYSTAL KLEAR delivers all the benefits of traditional float glass while offering the highest level of glass clarity and transparency available today. Used in insulating units or as storefront, vision, entrance, security, skylight, or spandrel glass, AGC's KRYSTAL KLEAR combines a virtually invisible appearance with unparalleled levels of daylighting and views. Its sparkling crystalline appearance and beautifully neutral edge color make KRYSTAL KLEAR a natural choice for interior and specialty applications—including frameless shower doors, partitions, railings, furniture, appliances, framing, shelving, and display cases.

Because KRYSTAL KLEAR is a strong, durable float glass product, it lends itself to easy fabrication and processing. KRYSTAL KLEAR can be tempered, bent, silk-screened, and insulated to meet many specific customer needs.

In applications where personal safety or security is a concern, KRYSTAL KLEAR can be laminated to provide additional strength—without sacrificing light transmission. In testing, a 1³/₈" laminated KRYSTAL KLEAR glazing allowed 18% more light to shine through than a similar unit composed of traditional float glass.¹

¹Based on a simulation performed using LBNL Optics 5.1 and Windows 5.2 software, which compared multiple layers of KRYSTAL KLEAR and clear polyvinyl butyral (PVB) interlayers with conventional float glass and clear PVB interlayers.



Key Attributes

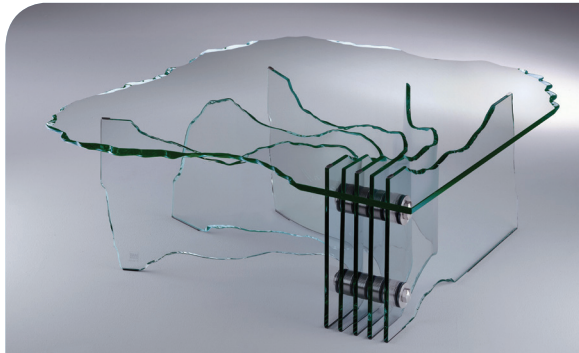
- High light transmission
- Outstanding clarity
- Colorless appearance
- Easy to fabricate and process

LINEA AZZURRA®



Linea Azzurra float glass from AGC is prized for its blue tint, the intensity of which varies according to the thickness of the glass. It is also valued for its high light transmission.

Available in a 3/4-inch (19 mm) thickness, Linea Azzurra is an outstanding option for many applications, including the large glazing areas needed for facades, atriums, furniture, and other decorative uses. The high quality of this blue-tinted float glass makes additional processing easy, particularly cutting and bending.



> Float Product Attributes

Performance Data

Single Glazing: 1/4" (6 mm)					
Product	Thickness	VLT	LR	SHGC	LSG
Krystal Klear™	6 mm	91%	8%	0.91	1.00
Clear	6 mm	88%	8%	0.84	1.05
Linea Azzurra®	19 mm	81%	7%	0.66	1.23

Processing Options

Tempering and heat strengthening	Yes
Laminating	Yes
Bending	Yes
Silkscreening and enamelling	Yes

Uses

Monolithic glazing	Yes
Insulating glazing	Yes

Applications

Interior	Yes – all furniture and partition applications
Exterior	Yes

Standard Thickness

Inches (mm)	1/8 (3)	5/32 (4)	3/16 (5)	1/4 (6)	5/16 (8)	3/8 (10)	1/2 (12)	5/8 (15)	3/4 (19)
Krystal Klear™	✓			✓	✓	✓	✓		
Clear	✓	✓	✓	✓	✓	✓	✓		
Linea Azzurra®									✓



IV.

BRANDS AND PRODUCTS

2. EXTERIOR GLAZING ARCHITECTURAL

2.0	Introduction	130
2.1	Low-emissivity Glass	133
	2.1.1 Hard-Coat	134
	Energy Select™ 73	134
	2.1.2 Soft-Coat	136
	Energy Select™ 63	137
	Energy Select™ R42	139
	Energy Select™ 40	141
	Energy Select™ 36	143
	Energy Select™ 28	145
	Energy Select™ 25	147
2.2	Reflective Glass	148
	Stopsol®	148
2.3	Tinted Glass	153
	Solarshield® Tints	153

2.0 INTRODUCTION

AGC Glass Company North America offers a full range of glass for exterior glazing applications, for use both in commercial and residential buildings. Supported by this broad family of products, AGC customers can meet their exacting performance specifications while also achieving their unique aesthetic vision.

AGC products that combine outstanding performance with an attractive appearance for exterior applications include—

- > Low-emissivity hard- and soft-coat glass solutions that maximize year-round energy efficiency while adding a range of aesthetic options
- > Reflective products that minimize solar heat gain while maximizing aesthetics
- > Tinted glasses which combine low reflectivity and outstanding aesthetics with high solar-blocking properties

▼ INSULATING GLAZING: MAXIMIZING THE POTENTIAL OF AGC PRODUCTS

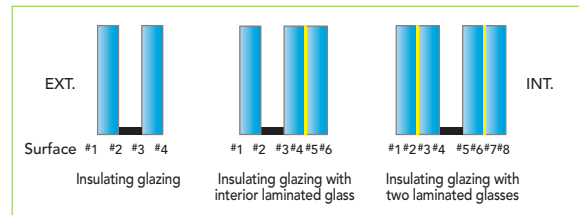
While designed to deliver outstanding energy performance, AGC glasses achieve their full potential when they are installed as part of an energy-efficient insulating glass unit. This section provides a brief overview of the typical insulating glass (IG) unit. AGC recommends consulting with its Architectural and Technical Services teams to maximize the energy performance of its innovative products. For more information, see “Properties and Functions” in Section II, All About Glass.

IG assemblies are sealed units composed of two or three panes of glass which, having been assembled and sealed in the factory, are separated by a closed hermetic space containing air or an insulating gas. The main benefit of insulating assemblies is using the insulating properties of the air or gas space to lower the thermal transmittance (U-value) of the overall unit. The unit’s insulating properties can be further enhanced in various ways—by specifying a glass with a low-emissivity coating, by choosing a specific gas filling such as argon or krypton, by installing a

“warm-edge” spacer system between the glass panes, or by using special moisture barriers and desiccants in the unit’s construction to minimize condensation.

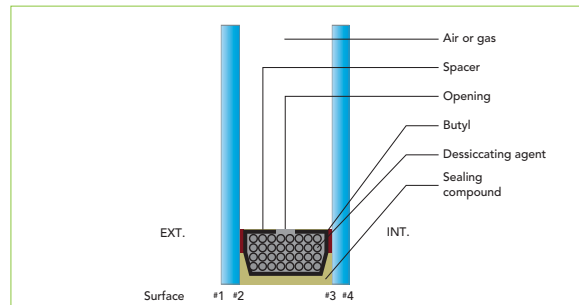
The sides of a typical dual-paned IG unit are numbered 1 to 4 from the exterior to the interior, with the exterior being on the left in the diagram below. As multiple panes of glass are added, each surface is assigned a number; the IG assembly with laminated glass below would have eight different surfaces, numbered accordingly.

Numbering of the sides of insulating glazing



The sides of insulating glazing are generally numbered positions 1 to 4 from the outside in, the outside being on the left in the diagram below.

Insulating glazing: components and numbering of the sides



The composition of a sealed unit is shown by three figures (generally expressed in mm) representing the following thicknesses:

- > The pane of external glass
- > The air or gas space
- > The internal pane of glass

For example, a unit designated “6-12-6” indicates that it includes a pane of external glass that is 1/4 in. (6 mm) thick, a spacer measuring 1/2 in. (12 mm), and an internal pane of glass that is 1/4 in. (6 mm) thick.

In keeping with its “Beyond Glass” approach, AGC Glass Company North America consults with customers to make the right glasses choices, matched with the ideal IG unit configuration to achieve their performance and aesthetic needs.

In the performance tables found in this section, AGC demonstrates the light and energy properties that can be achieved by installing its products in a typical IG assembly. All performance tables include the IG specifications used to obtain these specific performance levels.

2.1 LOW-E GLASS

2.1 INTRODUCTION

AGC Glass Company North America offers a wide range of Architectural low-emissivity products that combine outstanding energy efficiency with the highest aesthetic standards to help customers achieve their specific goals.

With versatile manufacturing capabilities, AGC produces hard-coat (pyrolytic) and soft-coat (sputter-coated) glass solutions to meet a broad spectrum of customer needs—and to deliver highly customized energy performance for every region of North America.

The AGC Energy Select™ family of low-emissivity glasses is designed to meet real-world needs and geographic energy challenges. As a supplier/partner in the U.S. and Canadian ENERGY STAR® programs, AGC’s low-e products have established new standards for energy efficiency and year-round value. AGC’s extensive low-e family is the industry benchmark—representing new levels of product innovation, day-to-day comfort, and year-round energy performance.

Whether customers are focused on annual energy usage, views, daylighting, or glass appearance, Energy Select low-e products deliver highly customized value. These spectrally selective glasses allow architects, designers, specifiers, and window fabricators to customize their solar heat gain, insulating value, and visible light transmission levels—while also realizing their own aesthetic vision.

Which Energy Select low-e product is right for your application? Hard- and soft-coat glasses each have distinct advantages, and these products should be chosen based on individual customer needs. Please consult with your AGC representative or AGC’s Technical Services experts to make the low-e glass choice that delivers the right combination of benefits for your application needs.

ENERGY *Select*™

2.1.1 HARD-COAT LOW-E GLASS

With a durable low-emissivity coating that is applied during the float manufacturing process—becoming an integral part of the glass—AGC’s hard-coat (pyrolytic) products are tough enough to withstand the real-world demands of glass transportation and handling.

These versatile glass solutions are easy to stack, store, and fabricate—as well as standing up exceptionally well to special processes such as tempering, laminating, and insulating. Hard-coat products from AGC do not require edge deletion when assembled in an IG unit.

▼ ENERGY SELECT™ 73

Low-emissivity hard-coated glass to provide thermal insulation with passive solar gain.

> Description

Energy Select 73 from AGC is a hard-coat low-e product that combines excellent year-round energy efficiency with hard-coat durability. For homes and commercial buildings alike, Energy Select 73 saves energy costs by reflecting heat back into the room during colder months—while also allowing free solar energy into interior spaces. During warmer months, Energy Select 73 reduces direct sunlight and blocks re-radiated solar heat.

> Benefits

Versatile and durable, Energy Select 73 provides the following benefits:

- > High levels of light transmission and superior passive solar gain
- > Meets stringent energy-efficiency building codes for colder regions
- > Neutral colorless appearance

- > High levels of daylighting
- > Excellent interior comfort as a result of high thermal insulation and a warm glass surface that eliminates “draft” sensations
- > Low levels of indoor reflectivity
- > Worry-free transportation, handling, stacking, and storing
- > Easily processed—including tempering, laminating, and insulating

Performance

Double Glazing: 1/4" - 1/2" air - 1/4" (6-12-6)						
Configuration	Color	VLT	LR	U	SHGC	LSG
Energy Select™ 73 #2/Clear	Neutral	74%	16%	0.33	0.63	1.17
Clear/Energy Select™ 73 #3	Neutral	74%	16%	0.33	0.69	1.06

Processing Options

Tempering and heat strengthening	Yes
Laminating	Yes
Bending	Yes
Silk-screening and enamelling	Yes

Standard Thickness

1/4 in. (6 mm)

Uses

Monolithic glazing	Yes
Insulating glazing	Yes—Energy Select 73 can be positioned on the #2 or #3 surface and does not require edge deletion

Applications

Interior	Yes
Exterior	Yes

2.1.2 SOFT-COAT LOW-E GLASS

AGC Glass Company North America applies “soft” or sputter coatings by subjecting float glass to extreme low pressures in a vacuum chamber and using a sophisticated process to deposit specific metal atoms onto the glass surface. The unique combination of atoms determines the ultimate performance properties of each AGC low-e glass solution.

Unlike pyrolytic coatings, sputter coatings do not become a permanent part of the glass. For this reason, they are considered “soft” coatings. However, sputter coatings deliver a wide range of benefits. They can be applied to any glass substrate and cover the full range of performance and aesthetic requirements.

AGC’s sputter-coated products also feature post-temperable technologies that allow them to be heat treated and laminated for special customer applications. (Please consult AGC’s Architectural or Technical Services team before specifying laminated soft-coat glass products.)

Since its introduction, the Energy Select™ soft-coat product family from AGC Glass Company North America has become an established industry leader in innovation and energy efficiency—setting new standards for year-round comfort, energy savings, visible light transmittance, and color neutrality. AGC offers an Energy Select solution for every region and every code in North America.

▼ ENERGY SELECT™ 63

Low-emissivity soft-coated glass that captures passive solar energy in cooler regions.

> Description

In colder climates, Energy Select 63 from AGC capitalizes on free solar energy to maximize heat gain and minimize annual heating costs.

The ideal choice for the northern regions, Energy Select 63 enables free solar heat gain during winter months while also retaining radiant energy within the building’s interior—resulting in more comfortable interior spaces.

When used in a commercial structure, Energy Select 63 maximizes heating system efficiency in those geographic regions where heating is the greatest energy concern. With outstanding insulating performance and neutral color, this AGC solution means that even cold-climate building owners can install large, attractive windows that let the view in while keeping cold temperatures at a distance.

> Benefits

For applications in colder regions, hard-working Energy Select 63 delivers these benefits:

- > Attractive neutral glass color
- > High levels of visible light transmission and daylighting
- > Maximizes heating system efficiency due to high levels of passive solar heat gain
- > Low levels of indoor reflectivity
- > Meets energy codes for colder regions

Performance

Double Glazing: 1/4" - 1/2" air - 1/4" (6-12-6)						
Configuration	Color	VLT	LR	U	SHGC	LSG
Energy Select™ 63 #2/Clear	Neutral	76%	11%	0.30	0.55	1.38
Clear/Energy Select™ 63 #3	Neutral	76%	11%	0.30	0.59	1.29

Processing Options

Tempering and heat strengthening	Yes, using the post-temperable coating
Laminating	Yes, under certain conditions—consult AGC Technical Services
Bending	No
Silkscreening and enamelling	No

Uses

Monolithic glazing	No
Insulating glazing	Yes, the Energy Select 63 coating can be placed in position #2 or #3

Applications

Interior	Yes
Exterior	No

Standard Thicknesses

1/4 in. (6 mm)

▼ ENERGY SELECT™ R42

Low-emissivity reflective soft-coated glass that blocks solar energy and maximizes cooling system efficiency.

> Description

With its low SHGC and high reflectivity, Energy Select R42 from AGC is the perfect choice for air-conditioned environments, including residential and commercial spaces.

Energy Select R42 represents the ideal solution for those regions where air conditioning costs represent the majority of year-round energy usage. Energy Select R42 is an outstanding solar blocker, making it the natural choice for those ENERGY STAR® regions where air conditioning is used most of the year. To meet the highest aesthetic needs, Energy Select R42 offers excellent light transmission and a neutral reflectance level.

> Benefits

Energy Select R42 offers a range of benefits for AGC customers:

- > Neutral glass color that complements a spectrum of designs
- > Ability to combine with Solarshield® tinted glass in an IGU for even greater design flexibility
- > Maximizes air conditioning efficiency due to high levels of solar heat blocking
- > Glare reduction and enhanced visual comfort

- > Meets energy codes in regions dominated by air conditioning usage
- > A touch of reflectivity makes Energy Select™ R42 the product of choice for high-rise residential and commercial facades
- > Low levels of indoor reflectivity

Performance

Double Glazing: 1/4" - 1/2" air - 1/4" (6-12-6)						
Configuration	Color	VLT	LR	U	SHGC	LSG
Energy Select™ R42	Neutral Reflective	62%	26%	0.30	0.42	1.46

Processing Options

Tempering and heat strengthening	Yes, using post-temperable coating
Laminating	Yes, under certain conditions—consult AGC Technical Services
Bending	No
Silkscreening and enamelling	No

Uses

Monolithic glazing	No
Insulating glazing	Yes, the Energy Select R42 coating can be placed in surface #2 or #3 with a Solarshield® tinted outboard

Applications

Interior	Yes
Exterior	No

Standard Thicknesses

1/4 in. (6 mm)

▼ ENERGY SELECT™ 40

Low-emissivity soft-coated glass providing moderate solar heat blocking in moderate climates.

> Description

The ideal solution for regions with moderate climates, AGC's Energy Select 40 leads the industry in delivering energy savings, comfort, natural light transmission, and a stunning neutral appearance.

With an impressively low emissivity rating and excellent solar heat blocking performance, Energy Select 40 is the premier solution for commercial buildings in warm regions. With a unique sputter coating, Energy Select 40 provides excellent insulation that maximizes air conditioning efficiency and interior comfort levels while minimizing annual energy costs.

Perfect for commercial buildings where annual air conditioning usage is a concern, this balanced performer can be combined with other AGC products in an insulating glass unit to create a truly customized solution.

> Benefits

AGC Glass Company North America has designed Energy Select 40 to deliver many benefits for applications in moderately warm climates:

- > Exceptionally attractive neutral glass color
- > High levels of visible light transmission
- > Low levels of indoor reflectivity
- > Maximizes air conditioning efficiency due to high levels of solar heat blocking

- > Provides good thermal insulation for balanced year-round performance
- > Low reflectivity that complements many aesthetic needs
- > Meets energy codes for regions where annual air conditioning usage is a concern
- > Can be combined with Solarshield® tints to increase solar protection

Performance

Double Glazing: 1/4" - 1/2" air - 1/4" (6-12-6)						
Configuration	Color	VLT	LR	U	SHGC	LSG
Energy Select™ 40/Clear	Neutral	69%	12%	0.29	0.39	1.79

Processing Options

Tempering and heat strengthening	Yes, using post-temperable coating
Laminating	Yes, under certain conditions—consult AGC Technical Services
Bending	No
Silkscreening and enamelling	No

Uses

Monolithic glazing	No
Insulating glazing	Yes, the Energy Select 40 coating can be placed in position #2 or #3 with a Solarshield tinted outboard

Applications

Interior	Yes
Exterior	No

Standard Thicknesses

1/4 in. (6 mm)

▼ ENERGY SELECT™ 36

Low-emissivity soft-coated glass that blocks solar heat in warm climates.

> Description

With an impressive emissivity rating, Energy Select 36 provides the warm-weather energy efficiency, beautiful appearance, and high light transmittance levels to meet the needs both of architects and homeowners.

The Energy Select 36 low U-value means excellent thermal insulation and lower annual energy bills in warmer climates where air conditioning is used most of the year. Energy Select 36 is an outstanding solar heat blocker, designed for those ENERGY STAR® regions where air conditioning is the primary energy component. With high levels of light transmittance and a neutral appearance—despite its hard-working coating—Energy Select 36 is a beautiful choice both for commercial and residential buildings.

By combining Energy Select 36 with a tinted Solarshield® substrate, architects can achieve a unique aesthetic design while enhancing the solar-blocking properties of the glass and providing even greater glare reduction.

> Benefits

Designed for warm regions, Energy Select 36 offers these significant customer benefits:

- > Neutral glass color that complements many designs
- > Flexibility to combine with Solarshield tints for even greater design freedom
- > High levels of visible light transmission
- > Low exterior reflectance levels

- > Low levels of indoor reflectivity
- > Solar protection that maximizes year-round air conditioning efficiency
- > Meets energy codes for regions dominated by air conditioning usage

Performance

Double Glazing: 1/4" - 1/2" air - 1/4" (6-12-6)						
Configuration	Color	VLT	LR	U	SHGC	LSG
Energy Select™ 36/Clear	Neutral	63%	12%	0.29	0.36	1.75

Processing Options

Tempering and heat strengthening	Yes, using post-temperable coating
Laminating	Yes, under certain conditions—consult AGC Technical Services
Bending	No
Silkscreening and enamelling	No

Uses

Monolithic glazing	No
Insulating glazing	Yes, the Energy Select 36 coating can be placed in position #2 or #3 with a Solarshield® tinted outboard

Applications

Interior	Yes
Exterior	No

Standard Thicknesses

1/4 in. (6 mm)

▼ ENERGY SELECT™ 28

Low-emissivity soft-coated glass providing solar control in warm climates.

> Description

The combination of excellent solar control, a neutral appearance, and low reflectivity make Energy Select 28 an obvious choice for buildings in warmer regions of the ENERGY STAR® map.

In areas where air conditioning costs are the primary concern, Energy Select 28 provides impressive solar blocking performance while maintaining a high level of light transmission—translating into year-round energy savings.

> Benefits

Due to its low level of interior and exterior reflectance and its neutral color, Energy Select 28 offers solid solar performance without compromising natural aesthetics.

- > Appealing neutral color
- > Low levels of interior and exterior reflectivity
- > High visible light transmission
- > Meets energy codes for regions where cooling is the main energy concern

Performance

Double Glazing: 1/4" - 1/2" air - 1/4" (6-12-6)						
Configuration	Color	VLT	LR	U	SHGC	LSG
Energy Select™ 28 #2/Clear	Neutral	62%	10%	0.29	0.28	2.21

Processing Options

Tempering and heat strengthening	Yes, using the post-temperable coating
Laminating	Yes, under certain conditions—consult AGC Technical Services
Bending	No
Silkscreening and enamelling	No

Uses

Monolithic glazing	No
Insulating glazing	Yes, the Energy Select™ 28 coating can be placed on the #2 surface

Applications

Interior	Yes
Exterior	No

Standard Thicknesses

1/4 in. (6 mm)

▼ ENERGY SELECT™ 25 ON SOLARSHIELD® TINTS

To deliver customized energy performance on a tinted substrate, AGC Glass Company North America can also combine Solarshield with its low-emissivity, energy-efficient Energy Select coatings. The resulting glass features both excellent solar control and superior aesthetics—available in Meadow Green, Forest Green, Pure Bronze, and Pure Grey. Please consult your AGC architectural representative or the AGC Technical Services team to learn more about this customized product option.

Performance

Double Glazing: 1/4" - 1/2" air - 1/4" (6-12-6)						
Configuration	Color	VLT	LR	U	SHGC	LSG
ES 25 Pure Grey (2) Clear	Grey	36%	6%	0.29	0.25	1.40
ES 25 Pure Bronze (2) Clear	Bronze	40%	7%	0.29	0.27	1.47
ES 25 Meadow Green (2) Clear	Green	51%	10%	0.29	0.28	1.86
ES 25 Forest Green (2) Clear	Green	48%	9%	0.29	0.26	1.87

Processing Options

Tempering and heat strengthening	Yes, using post-temperable coating
Laminating	Yes, under certain conditions—consult AGC Technical Services
Bending	No
Silkscreening and enamelling	No

Uses

Monolithic glazing	No
Insulating glazing	Yes, the Energy Select 25 coating can be placed in position #2

Applications

Interior	Yes
Exterior	No

Standard Thicknesses

1/4 in. (6 mm)

2.2 REFLECTIVE GLASS

▼ STOPSOL®

Hard-coated architectural glass with a medium-performance reflective coating.

> Description

Ideal for many types of commercial buildings, AGC's medium-performance Stopsol coated glass product is an attractive choice when a reflective appearance is part of the architectural vision. This innovative glass combines a beautiful reflective appearance with excellent solar control properties.

Available in Clear, Green, Grey, Bronze, and Blue substrate colors, Stopsol is also offered in a range of thicknesses to meet a spectrum of architectural and performance needs. The Stopsol family offers three coating options: Classic (amber look), Supersilver (silvered look), and Silverlight (bluish look).

Stopsol provides a unique combination of benefits, including high levels of light transmission, low heat absorbency, and customized levels of reflectance. This innovative product also provides privacy and visual comfort for building occupants.

A pyrolytic "hard-coat" product, Stopsol also offers worry-free transportation, handling, and fabrication. It can be laminated, bent, and used both monolithically and as part of a sealed insulating unit.

With a variety of substrate colors and coating options, Stopsol offers architects a highly customized look. This innovative product can also be combined with other AGC products in an IG unit to deliver custom-tailored energy performance that meets specific regional needs.

> Benefits

Stopsol coatings can also be applied to Matelux® acid-etched glass to achieve a unique aesthetic effect; see section 3.2.

AGC's exclusive Stopsol products provide these customer benefits:

- > High reflectivity for privacy and visual comfort
- > Outstanding flexibility—customers can select from multiple combinations of solar-control and light-transmission levels, as well as a variety of colors
- > Limitless creativity because architects can use one product family for all applications
- > A long coating lifespan identical to that of float glass
- > Durable hard coating means worry-free handling, stacking, storage, and transportation
- > Easily processed in a variety of ways
- > Can be combined with other AGC products to deliver specialized performance and design effects
- > Stopsol® coatings are not low-emissivity. However, they can be combined with Energy Select™ low-e products in an IG unit
- > AGC recommends using the same glass thickness throughout a facade, especially when the Stopsol coatings are installed in position 2

Varying the position of Stopsol in an IG unit will change the appearance of the glass; please consult the table below when specifying Stopsol or contact AGC Technical Services

	Position #1	Position #2
Finish	On clear glass: always reflective	
	On colored glass: very reflective	On colored glass: less reflective
	In position #1 for heat-strengthened, tempered, or enamelled Stopsol, optical distortions due to thermal treatment are more visible than would be the case with nonreflective glasses	
Look	Look of the glass stands out	Color of the base glass stands out
Absorption	Higher if the coating is applied in #2 and if the base glass is colored Can be tempered if necessary	
Maintenance	Maintain regularly; contact AGC Glass Company North America Technical Services for details	

Below is a chart showing the performance of all Stopsol products in a 1" IGU.

Performance

Double Glazing: 1/4" - 1/2" air - 1/4" (6-12-6)						
Configuration	Color	VLT	LR	U	SHGC	LSG
Stopsol® Classic Clear #2 Clear	Neutral	38%	27%	1.02	0.58	0.65
Stopsol Classic Green #2 Clear	Green	31%	20%	1.02	0.43	0.73
Stopsol Classic Grey #2 Clear	Grey	19%	10%	1.02	0.47	0.39
Stopsol Classic Bronze #2 Clear	Bronze	21%	12%	1.02	0.49	0.44
Stopsol Classic Dark Blue #2 Clear	Dark Blue	24%	14%	1.02	0.42	0.58
Stopsol Supersilver Clear #2 Clear	Neutral	62%	33%	0.99	0.68	0.91
Stopsol Supersilver Green #2 Clear	Green	51%	24%	0.99	0.48	1.06
Stopsol Supersilver Grey #2 Clear	Grey	29%	11%	1.00	0.51	0.57
Stopsol Supersilver Dark Blue #2 Clear	Dark Blue	42%	15%	1.00	0.50	0.83
Stopsol Silverlight PrivaBlue #2 Clear	Intense	27%	8%	1.02	0.39	0.69



Torre Gas Natural – Barcelona, Spain

▼ STOPSOL®

Processing Options

Tempering and heat strengthening	Yes
Laminating	Yes
Bending	Yes
Silkscreening and enamelling	Yes, but not on Supersilver coatings

Uses

Monolithic glazing	Yes
Insulating glazing	Yes, the Stopsol® coating can be positioned on the #1 or #2 surface and does not require edge deletion
Combined in an IG unit with a low-e glass	Yes—the Stopsol coating is applied in position #1 or #2, and the low-e coating is applied in position #3

Applications

Interior	Yes, see Matelux® Stopsol for specific applications
Exterior	Yes, see Matelux Stopsol for special spandrel applications

Standard Thicknesses

1/4 in. (6 mm)

2.3 TINTED GLASS

▼ SOLARSHIELD®

Tinted float glasses offering solar protection in monolithic or dual glazings.

> Description

AGC's exclusive Solarshield product family offers high-quality tinted products for the commercial and residential markets as well as the automotive sector. Available in Solarshield Pure Bronze™, Solarshield Pure Grey™, Solarshield Pure Green™, Solarshield Meadow Green™, Solarshield Forest Green™, Solarshield Sky Blue™, Solarshield Pure Blue™, and Solarshield Midnight Blue™ colors, these tinted glass solutions from AGC Glass Company North America create an attractive, beautiful exterior appearance while increasing air conditioning efficiency and comfort, reducing glare, and offering unobstructed views.

Made using the float process, Solarshield tinted solutions offer perfectly flat parallel surfaces and lend themselves to many processing options, including single glazing, insulating glazing, tempering, and enamelling.

> Benefits

AGC's Solarshield tinted products offer these customer benefits:

- > Tinted to absorb energy from the visible light spectrum
- > Supports year-round energy efficiency in regions that rely on air conditioning
- > Increases interior comfort and reduces visual glare

▼ SOLARSHIELD®

- > Low levels of light reflection
- > Available in a range of colors to meet many application needs
- > Can be tempered, laminated, heat-strengthened, bent, and otherwise processed just as traditional float glass
- > Designed for monolithic installations or as part of a sealed insulating unit
- > Ideal for use in atriums, skylights, spandrels, windows, entrances, and storefronts
- > Can be combined with Energy Select™ products to deliver customized energy performance
- > Because Solarshield tints absorb a high level of solar energy, these glasses may require tempering, depending on the application
- > AGC advises against mixing Solarshield tinted glasses of different thicknesses in a single facade, since the look will be different as the thickness changes. The thicker the Solarshield glass, the darker the color

Performance

Double Glazing: 1/4" - 1/2" air - 1/4" (6-12-6)						
Configuration	Color	VLT	LR	U	SHGC	LSG
Pure Grey Clear	Grey	40%	7%	0.48	0.47	0.85
Pure Bronze Clear	Bronze	48%	8%	0.48	0.51	0.94
Pure Green Clear	Green	68%	11%	0.47	0.50	1.37
Meadow Green Clear	Green	63%	11%	0.47	0.43	1.45
Forest Green Clear	Green	58%	10%	0.47	0.40	1.45
Sky Blue Clear	Blue	65%	11%	0.47	0.50	1.31
Pure Blue Clear	Blue	50%	8%	0.47	0.46	1.09
Midnight Blue Clear	Blue	31%	6%	0.47	0.29	1.05



Klinika Svietlost – Zagreb, Croatia



IV. BRANDS AND PRODUCTS

3. DECORATIVE GLASS

3.0	Introduction	158
3.1	Patterned Glass Krystal Patterns™	159
3.2	Matte-Finish Glass Matelux®	166
3.3	Krystal Kolours™	171
3.4	Krystal Images™	178
3.5	Polished Wired Glass	180

3.0 INTRODUCTION

AGC Glass Company North America manufactures a wide variety of solutions for interior and decorative applications. These specialty glass products—including patterned and heavy patterned glass, colored laminated, high-definition imagery, matte-finish glass, back-painted glass, and polished and obscured wired glass—lend both strength and beauty in a broad range of commercial and residential settings.

No other glass manufacturer offers the same depth and breadth of decorative glass solutions, and AGC Glass Company is committed to remaining the industry leader and innovator in this product category.

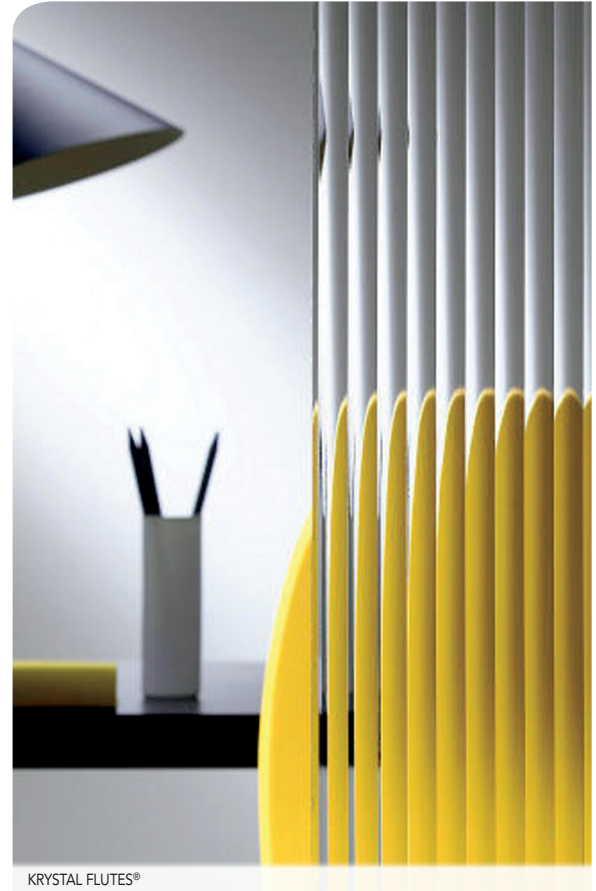
Perfect for a variety of interior and exterior applications, AGC decorative glass products can be used in—

- > Partitions and wall systems
- > Bath and shower enclosures
- > Sliding or fixed doors for furniture
- > Entrance doors
- > Tabletops and shelving
- > Railings and balustrades
- > Floors and staircases
- > Ceilings and atriums
- > Cabinets
- > Wall cladding

Depending on the desired application and specific building standards, decorative products from AGC may need to be tempered, laminated, or backed by a safety film. They may also need to include fire-resistance properties.

Available in a variety of color choices and design options, decorative products from AGC Glass Company North America answer a wide range of aesthetic needs. A full range of transparent, translucent, and opaque glass solutions ensures that AGC customers will be able to beautifully combine form with function.

3.1 PATTERNED GLASS



KRYSTAL FLUTES®

Rolled patterned glass solutions from AGC Glass Company North America are perfect for a range of residential and commercial applications, enabling architects, builders, and specialty manufacturers to create translucent works of art. The industry leader in this category for patterned glass solutions, AGC offers

> **Krystal Patterns™** exclusively on ultraclear low-iron glass. Versatile and beautiful, Krystal Patterns have the unique ability to separate space while sharing light. Patterned glass solutions from AGC are used in shower doors and tub enclosures—including frameless shower doors—as well as interior partitions, translucent door and window treatments, foyers, and vestibules. These high-quality solutions also have applications in patio furniture, shelving, decorative furniture, and lighting fixtures.



Krystal Patterns™ Citrus

▼ **KRYSTAL PATTERNS™ GLASS**

Decorative patterned glass with a low iron content for excellent clarity and colorlessness.

> **Description**

With a low-iron glass formula, Krystal Patterns™ from AGC deliver a beautiful, colorless glass appearance that is ideal for many decorative applications. To meet the needs of commercial, residential, and specialty customers, AGC Glass Company North America offers a broad family of Krystal glass products that will bring many different aesthetic visions to life.

> **Krystal Textured Flutex™**

Featuring a distinctly beautiful linear pattern and a subtle texture, Flutex is the perfect complement to many modern designs.



> **Krystal Flutes®**

The fluted linear design of this patterned glass makes it an attractive option for many residential and commercial applications.



> Krystal Pixels™ (P-73)

Beautiful and practical, Krystal Pixels multiple-prism pattern offers high levels of obscurity while allowing light to flood through.



> Aqua

A classic, understated pattern from AGC, Aqua offers obscurity and light diffusion, allowing architects and designers to achieve their unique aesthetic vision.



> Citrus

A longtime favorite of AGC customers, Citrus combines an attractive appearance with obscurity and light transmission capabilities.



> Krystal Delta Sandblasted™

The dramatic patterning of Krystal Delta Sandblasted is ideal for separating space, while still allowing the transmission of light.



> Krystal Delta™

Krystal Delta makes a statement with its cool, ice-like effect, which also features a high level of light transmission.



> Bamboo™

A subtle and fluid pattern, Bamboo adds a unique combination of light transmission and visual effect to any architectural space.



> Krystal Pebbles™

Krystal Pebbles creates a uniform and monolithic pattern to allow the passage of light with a degree of visual obscurity.



> **Benefits**

- > A variety of contemporary patterns to bring many design visions to life
- > A unique combination of privacy, obscurity, and subtle light transmission
- > Excellent glass clarity and colorlessness as a result of low-iron composition
- > Easily processed in a variety of ways

Processing Options^{††}

Tempering and heat strengthening	Yes
Laminating	Some
Bending	Yes
Silkscreening and enamelling	Yes

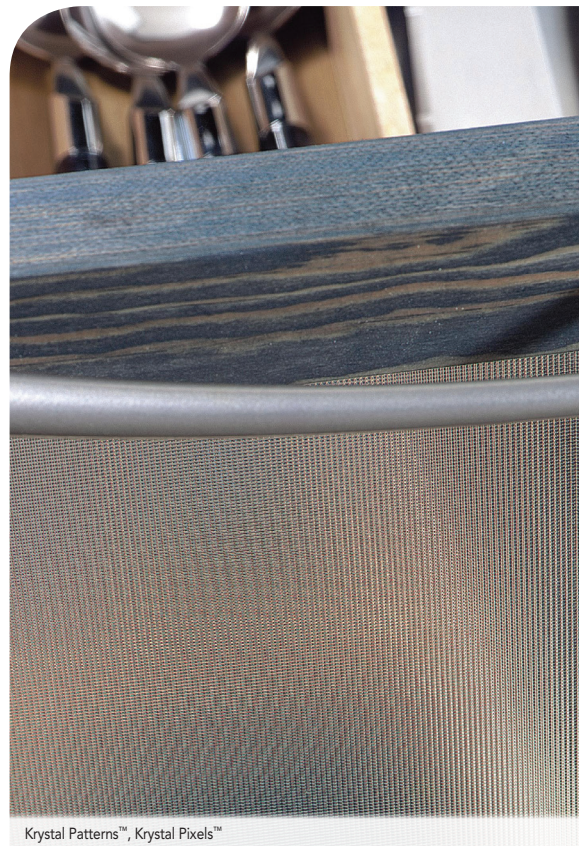
Uses^{††}

Monolithic glazing	Yes
Insulating glazing	Yes—In general, the rolled design can be applied to face either the inside or the outside of the IG unit

Applications

Interior	Yes
Exterior	Yes

^{††}For details on processing or insulating Krystal Patterns™ glass, please contact AGC Technical Services.



Krystal Patterns™, Krystal Pixels™

3.2 MATTE-FINISH GLASS

With a smooth, satin appearance, matte-finish glass from AGC Glass Company North America creates a distinctive look that responds to current design trends toward minimalism and simplicity. By acid-etching its high-quality float glass, AGC creates a slightly opaque solution that filters light softly, creating a degree of privacy and obscurity that is ideal for many decorative applications. Matte-finish glass lends a stylish accent both in interior and exterior applications.

▼ MATELUX®

Acid-etched glass offering obscurity and a satin finish.



Acid-etched partitions - Matelux Light

> Description

Versatile and attractive, Matelux glass from AGC Glass Company North America is an acid-etched product that combines a satin finish with a neutral translucent appearance. It filters light, smoothes visual contours, and provides obscurity and privacy.

Matelux satin-finish glass is the perfect choice for a broad spectrum of interior and exterior installations. Architects can also specify Matelux acid-etched glass as a double glazing for exterior facades, as well as for balconies, exterior doors, and

other architectural features. Interior applications include shelving, partitions, doors, counters, floor tiles, stair tiles, shower screens, lighting fixtures, tabletops, and other furniture.

Though its appearance has been enhanced, Matelux® retains all the mechanical and thermal properties of float glass. It can be tempered, laminated, assembled into a double glazing, bevel-cut, and otherwise processed—just as float glass can.



Matelux Clear

> Matelux® Clear and Colored Options

Matelux uses high-quality AGC Clear float glass as a foundation for Matelux® Clear, Matelux Light, and Matelux Double-Sided.

Four colored substrates can also be etched to create these attractive options: Matelux Bronze, Matelux Green, Matelux Grey, and Matelux PrivaBlue.

> Matelux Stopsol®

A float glass with one reflective surface and one acid-etched surface, Matelux Stopsol is an exclusive offering from AGC Glass Company North America. During the manufacturing process, AGC's proprietary Stopsol reflective coating is applied to the base side of the float glass. This attractive product is available in three tints: Matelux Stopsol Supersilver Clear, Supersilver Green, and Supersilver Dark Blue.

In architectural applications, Matelux Stopsol is designed to combine seamlessly with corresponding Stopsol vision glasses. There is a lovely contrasting aesthetic effect created by the use of vision glass, which is neutral or reflective, along with satin-finish Matelux Stopsol spandrels. Buildings will have a unique, dynamic appearance that varies with the weather. In rainy weather the wet Matelux Stopsol spandrel is shiny and reflective, while in sunny weather the glass has a satiny, metallic look.

Stopsol Supersilver Dark Blue vision glass

Matelux Stopsol Supersilver Dark Blue spandrel



> Benefits

- > Acid-etched for a unique satin finish with a fine grain
- > Translucent appearance ensures obscurity and privacy
- > Offers high light transmission—up to 90% depending on glass thickness
- > Retains all the mechanical and thermal properties of float glass
- > Can be tempered, laminated, assembled into a double glazing, bevel-cut, and otherwise processed
- > Low maintenance and stain resistant
- > Ideal for a range of interior, exterior, and special applications



Clear



Grey



Double-Sided



Bronze



Linea Azzurra®



PrivaBlue



Green



Stopsol® Supersilver Dark Blue



Stopsol® Supersilver Clear



Stopsol® Supersilver Green

Maintenance

Acid-etched Matelux® is easy to maintain and should be cleaned with clear water.

Uses

Single glazing	Matelux: Yes, the acid-etched surface may or may not be positioned externally, depending on the required look Matelux Stopsol®: Yes, the Stopsol coating generally faces the unexposed side
Insulating glazing	Yes—ensure that the etched side faces into the double-glazing unit, and use silicone for the double-glazing joints when the etched surface is in #2 or #3

Processing Options

Tempering and heat strengthening	Yes
Laminating	Yes—The acid-treated side should not be positioned against the PVB layer (to retain the unique matte appearance of Matelux®)
Bending	Yes
Silkscreening and enamelling	Yes, on both sides
Safety backing possible	No

Cutting and Finishing

Special shapes (e.g., circles, rectangles)	Yes—can be cut like conventional float glass
Edge-grinding, treatment, drilling, notches	Yes—can be cut like conventional float glass

Stress Resistance

Heat resistance	Same as float glass
Moisture resistance	Yes, when the etched side of the Matelux glass is exposed to water, the etching becomes less visible—but it recovers its uniform appearance when dry
UV resistance	Yes, may be exposed to the sun and to artificial light
Bending resistance	Matelux offers the same bending resistance as float glass

Applications

Interior	Furniture: partitions, tables, shelves, fixed and sliding doors for cupboards and wardrobes, display cases, and glass bases Specific applications: Matelux® Double-Sided: doors Matelux Antislip: stairs and floors
Exterior	Yes, for all construction and renovation applications Matelux Stopsol® glass is well suited for spandrel panels

3.3 KRYSTAL KOLOURS™

Back-painted glass products from AGC Glass Company North America offer a colorful opaque glass appearance that is perfect for a range of decorative interior applications. By applying a high-quality paint to the back of its float glass, AGC creates a product that beautifully combines form with function.



Krystal Kolours™ Rich Aluminum

Krystal Kolours™ premium painted glass from AGC brings interior decorative glass applications to vivid, colorful life. The glass can be used in a wide variety of furniture applications and also installed as a wall covering. AGC's back-painted glass products are for interior use only and should not be used outdoors.

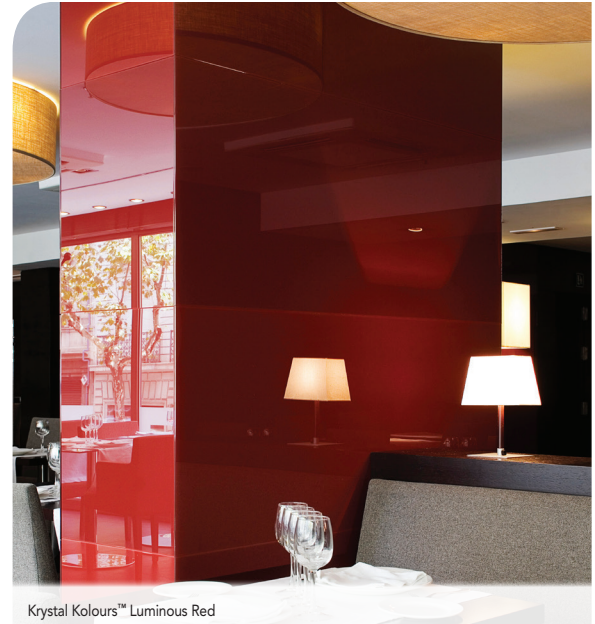
For special applications where personal safety is a concern, these painted products can be backed by a polypropylene film which is applied to the painted side of the glass. This backing minimizes injury and damage if the glass breaks, because splinters adhere to the film. This backing has the added benefit of protecting the painted surface from scratches.



Krystal Kolours™ Luminous Red

KRYSTAL KOLOURS™

Painted glass for interior applications



Krystal Kolours™ Luminous Red

> Description

Durable and beautiful, Krystal Kolours is an innovative painted float product offered by AGC Glass Company North America. Available in 10 standard colors, Krystal Kolours combines the high-end look of varnish with the strength and durability of float glass. Designed for interior applications, Krystal Kolours is an ideal accent in commercial environments such as offices, restaurants, and retail spaces, as well as residential kitchens and bathrooms. It is also perfect for furniture applications, including tabletops, shelving, and cupboard doors.

Krystal Kolours offers a bright, colorful opaque surface with a unique sense of depth and light. Whether specified in a vivid or subtle shade, it provides a striking contemporary accent and supports a wide range of aesthetic viewpoints.

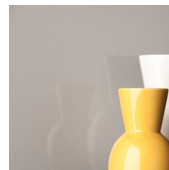
This exclusive back-painted glass product can be processed in a variety of ways, including cutting, grinding, drilling, notching, sand-blasting, and edge grinding. If required by the application, safety backing film is available for added safety and strength.

> **Benefits**

- > Painted on only one side for extreme durability when mounted
- > Features a bright, shiny opaque surface
- > Available in 10 standard colors
- > Can be processed just as mirror glass—including cutting, grinding, drilling, notching, sand blasting, and edge grinding
- > Low maintenance and environmentally friendly
- > Resists both moisture and UV light
- > Designed for a spectrum of interior applications, including wall coverings and furniture

> **Notes on Installation**

To protect it against damage, the back of the glass, with the layer of paint, should always be positioned against the surface to be covered. Positioning Krystal Kolours™ in this way also preserves the color and appearance of the glass.



Rich Aluminum



Luminous Red



Mocha



Pure White



Metal Grey



Deep Blue



Black



Pastel Green



Luminous Yellow



Turquoise Blue

Some of the shades shown in photographs may differ from the actual color of Krystal Kolours™ glass. For this reason, AGC recommends that you view a Krystal Kolours sample for an accurate idea of color when making your product choice.

Processing Options

Tempering and heat strengthening	No
Laminating	No
Bending	No
Silkscreening and enamelling	No
Safety backing available	Yes

Cutting and Finishing

Special shapes (circles, rectangles)	Yes, can be cut like conventional float glass
Edge-grinding, treatment, drilling, notches	Yes, can be cut like conventional float glass

Stress Resistance

Heat resistance	Krystal Kolours™ paints can withstand temperatures up to 176°F
Moisture resistance	All Krystal Kolours colors can be used in humid environments (bathrooms and kitchens), but should never be immersed in water The two metallic colors (Metal Grey and Rich Aluminum) require a safety backing to be applied in such locations; consult AGC Krystal Kolours should be protected from any water leaking in behind the glass; silicone should be used for seals
UV resistance	Yes, the colors are fixed during the manufacturing process and there is no discoloration with sun exposure

> Bonding

Krystal Kolours™ can be bonded using tile adhesives, silicones, or high-strength adhesive tape. For mechanical mounting, customers may use framing systems, metal clips, or screws fixed directly into the glass.

Please consult AGC Technical Services with any questions about safely mounting or attaching Krystal Kolours painted glass to other materials.

Uses

Single glazing	Yes
Insulating glazing	No, see Applications below

Applications

Interior	Wall coverings and furniture—including partitions, tables, shelves, fixed and sliding doors for cupboards and wardrobes, display cases, and glass bases
Exterior	No, Krystal Kolours cannot be used in facade double glazing, even if the painted side faces inward, due to the risk of thermal shock

3.4 KRYSTAL IMAGES™ HIGH-DEFINITION IMAGES

Crystal clear images that blur the line between fantasy and reality.



African Tulip, Gerhard Hillman | naturesface.com.au

A boardroom set against a waterfall so lifelike you can almost hear the roar of the water. A view of Lady Liberty so breathtaking you'd swear you are in a lower Manhattan loft. These are just a few of the feelings you can evoke when you incorporate high-definition imagery into your design with KRYSTAL IMAGES™ glass from AGC. No longer must you limit yourself to paint or patterns when it comes to distinguishing a wall. Any design image can be created in KRYSTAL IMAGES glass, from stunning natural scenes, to remarkable landmarks, to unique corporate logos. If you can picture it, you can capture it.

> Key Attributes

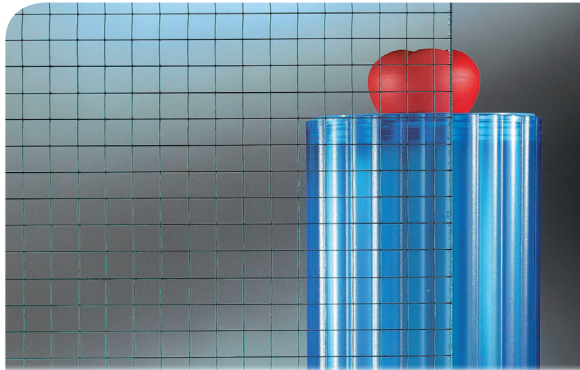
- > High-resolution print technology
- > Up to 1,440 DPI [Min. 300 DPI]
- > Available in Translucent, Transparent, Opaque
- > KRYSTAL KLEAR™ low-iron substrate
- > Meets CPSC Safety Glazing

> Product Specifications

- > Minimum Size: 12" x 12"
- > Maximum Size: 60" x 144"
- > Thicknesses: Monolithic: ¼" up to ¾"
and insulated ¾" and greater

3.5 POLISHED WIRED GLASS

AGC Glass Company North America produces its high-quality Polished Wired glass products by “sandwiching” steel wire mesh between two layers of molten glass in a continuous rolled glass process.



Close up, polished wired glass

Polished Wired glass from AGC is available in two attractive patterns. Our obscure wired glass can meet a variety aesthetic needs:

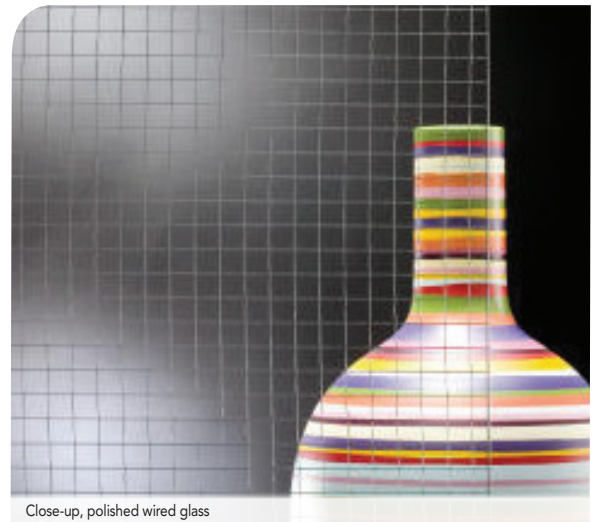
- > **Diamond** features an attractive diamond mesh pattern
- > **Cross (Square)** has an integral mesh pattern in the form of squares
- > **Obscure** combines the qualities of mesh with a degree of privacy

Because they can prevent the spread of fire, as well as provide protection from glass shards in the event of glass breakage, AGC's Polished Wired products are ideal for applications in schools, hospitals, and other settings where personal safety is a concern.

In certain installations and applications, Polished Wired solutions from AGC can meet the safety codes established by ASTM, ANSI, CAN/CGSB, and UL. Please consult the Technical Services team at AGC for additional information on meeting these standards.

Standard Thicknesses—inches (mm)

Diamond—1/4 in. (6 mm)
Cross (Square)—1/4 in. (6 mm)
Obscure Diamond—1/4 in. (6 mm)
Obscure Cross (Square)—1/4 in. (6 mm)



Close-up, polished wired glass



IV. BRANDS AND PRODUCTS

4. RESIDENTIAL GLASS

4.0	Introduction	184
4.1	Comfort Select™	184
	Comfort Select 73	185
	Comfort Select 63	186
	Comfort Select R42	187
	Comfort Select 40	188
	Comfort Select 36	189
	Comfort Select 28	190
4.2	U4	191
4.3	Product Range & Performance	192

4.0 INTRODUCTION

A NEW WAY TO SELECT THE RIGHT GLASS FOR THE RIGHT REGION.

You now have more options than ever for meeting ENERGY STAR® requirements—no matter where you are. New Comfort Select residential glass from AGC is designed specifically for your region (or regions). So now you can offer performance advantages that go well beyond ENERGY STAR.

4.1 COMFORT SELECT™

The NEW Comfort Select™ family of residential low-emissivity coated glass products is part of the AGC global technology platform, backed by a history of real world applications. Selecting the right glass can be overwhelming at times, so AGC has made it simple and straightforward for our customers to choose the best performing product for each climate region. Whether you need passive solar and lower U-values in northern climates, or low solar heat gain in southern climates; AGC has the right product for you. Keeping homes throughout North America comfortable and energy efficient: That's AGC. Moving Beyond Glass so that AGC customers will be able to beautifully combine form with function.

▼ COMFORT SELECT™ 73

Comfort Select 73 is a durable hard-coated low-emissivity glass that provides passive solar gain resulting in year-round cost savings. Designed for use on the #3 surface, Comfort Select 73 offers a U-value of 0.29 and solar heat gain coefficient (SHGC) of 0.73. Thus, maximizing energy efficiency in the colder Northern region climates, where heating is dominant and the greatest energy concern.

Performance

Double Glazing: 1/8" - 1/2" air - 1/8" (3-12-3)						
Configuration	Color	VLT	U-Air	U-Argon	SHGC	LSG
Clear/Comfort Select™ 73 #3	Neutral	74%	0.33	0.29	0.72	1.03
Comfort Select™ 73 #2 / U4	Neutral	67%	0.26	0.23	0.60	1.12

Processing Options

Tempering and heat strengthening	Yes
Laminating	Yes, under certain conditions—consult AGC Technical Services
Bending	No
Silkscreening and enamelling	No

Uses

Monolithic glazing	Yes
Insulating glazing	Yes, the Comfort Select 73 coating can be placed in position #2, 3 & 4

Applications

Interior	Yes
Exterior	No

Standard Thicknesses

SGL (2.5 mm)	5/32 in. (4 mm)
DSG 1/8 in. (3 mm)	3/16 in. (5 mm)

▼ COMFORT SELECT™ 63

Comfort Select 63 is a neutral soft-coated low-e glass that provides thermal insulation and captures passive solar energy in cooler climates. With a U-value of 0.26, SHGC of 0.61 and 79% VLT, Comfort Select 63 allows free solar heat gain during winter months, while also retaining radiant energy within the interior of the home for added comfort in Northern and North-Central regions.

Performance

Double Glazing: 1/8" - 1/2" air - 1/8" (3-12-3)						
Configuration	Color	VLT	U-Air	U-Argon	SHGC	LSG
Clear/Comfort Select™ 63 #3	Neutral	79%	0.31	0.26	0.61	1.30
Comfort Select™ 63 #2 / U4	Neutral	72%	0.24	0.21	0.54	1.34

Processing Options

Tempering and heat strengthening	Yes, using the post-temperable coating
Laminating	Yes, under certain conditions—consult AGC Technical Services
Bending	No
Silkscreening and enamelling	No

Uses

Monolithic glazing	No
Insulating glazing	Yes, the Comfort Select 63 coating can be placed in position #2 or #3

Applications

Interior	Yes
Exterior	No

Standard Thicknesses

SGL (2.5 mm)	5/32 in. (4 mm)
DSG 1/8 in. (3 mm)	3/16 in. (5 mm)

▼ COMFORT SELECT™ R42

Comfort Select R42 is a neutral reflective soft-coated low-e glass designed to block solar energy. Providing a 0.25 U-value, 0.43 SHGC and 65% VLT Comfort Select R42 delivers excellent performance and a beautiful reflective appearance. The lower solar heat gain coefficient makes Comfort Select R42 ideal for air-conditioned environments, particularly the South-Central and Southern regions.

Performance

Double Glazing: 1/8" - 1/2" air - 1/8" (3-12-3)						
Configuration	Color	VLT	U-Air	U-Argon	SHGC	LSG
Comfort Select™ R42 #2/Clear	Neutral	65%	0.30	0.25	0.43	1.50
Comfort Select™ R42 #2 / U4	Neutral	59%	0.24	0.20	0.41	1.45

Processing Options

Tempering and heat strengthening	Yes, using the post-temperable coating
Laminating	Yes, under certain conditions—consult AGC Technical Services
Bending	No
Silkscreening and enamelling	No

Uses

Monolithic glazing	Yes
Insulating glazing	Yes, the Comfort Select R42 coating can be placed in position #2 only

Applications

Interior	Yes
Exterior	No

Standard Thicknesses

SGL (2.5 mm)	5/32 in. (4 mm)
DSG 1/8 in. (3 mm)	3/16 in. (5 mm)

▼ COMFORT SELECT™ 40

Comfort Select 40 is a soft-coated low-e glass providing solar heat control in moderate to hot climates of the North-Central and South-Central regions. Comfort Select 40 delivers a 0.24 U-value, 0.39 SHGC and 73% VLT. The neutral appearance and high level of natural light makes Comfort Select 40 the ideal solution for homes where heating and cooling requirements vary throughout the year.

Performance

Double Glazing: 1/8" - 1/2" air - 1/8" (3-12-3)						
Configuration	Color	VLT	U-Air	U-Argon	SHGC	LSG
Comfort Select™ 40 #2 / Clear	Neutral	72%	0.29	0.25	0.39	1.85
Comfort Select™ 40 #2 / U4	Neutral	66%	0.23	0.20	0.37	1.78

Processing Options

Tempering and heat strengthening	Yes, using the post-temperable coating
Laminating	Yes, under certain conditions—consult AGC Technical Services
Bending	No
Silkscreening and enamelling	No

Uses

Monolithic glazing	No
Insulating glazing	Yes, the Comfort Select 40 coating can be placed in position #2 or #3

Applications

Interior	Yes
Exterior	No

Standard Thicknesses

SGL (2.5 mm)	5/32 in. (4 mm)
DSG 1/8 in. (3 mm)	3/16 in. (5 mm)

▼ COMFORT SELECT™ 36

Comfort Select 36 is a soft-coated low-e glass providing a higher level of solar heat control in hotter climate regions. With a 0.25 U-value, 0.36 SHGC and 66% VLT, Comfort Select 36 improves energy efficiency and keeps interior temperatures comfortable in the North-Central and South-Central regions.

Performance

Double Glazing: 1/8" - 1/2" air - 1/8" (3-12-3)						
Configuration	Color	VLT	U-Air	U-Argon	SHGC	LSG
Comfort Select™ 36 #2 / Clear	Neutral	66%	0.29	0.25	0.36	1.82
Comfort Select™ 36 #2 / U4	Neutral	60%	0.23	0.20	0.34	1.75

Processing Options

Tempering and heat strengthening	Yes, using the post-temperable coating
Laminating	Yes, under certain conditions—consult AGC Technical Services
Bending	No
Silkscreening and enamelling	No

Uses

Monolithic glazing	Yes
Insulating glazing	Yes, the Comfort Select 36 coating can be placed in position #2 or #3

Applications

Interior	Yes
Exterior	No

Standard Thicknesses

SGL (2.5 mm)	5/32 in. (4 mm)
DSG 1/8 in. (3 mm)	3/16 in. (5 mm)

▼ COMFORT SELECT™ 28

Comfort Select 28 is a triple silver, soft-coated, low-e glass. It is designed for maximum solar control performance in the hottest climates of the Southern region and is ideal for meeting the energy code requirements in climates that are cooling dominate. With 0.28 SHGC, 0.24 U-value, and 62% VLT Comfort Select 28 provides impressive solar blocking, high levels of light transmission that paired with the neutral color make it a perfect choice for residential application.

Performance

Double Glazing: 1/8" - 1/2" air - 1/8" (3-12-3)						
Configuration	Color	VLT	U-Air	U-Argon	SHGC	LSG
Comfort Select™ 28 # 2/ Clear	Neutral	62%	0.29	0.24	0.28	2.22
Comfort Select™ 28 #2 / U4	Neutral	56%	0.23	0.20	0.26	2.14

Processing Options

Tempering and heat strengthening	Yes, using the post-temperable coating
Laminating	Yes, under certain conditions—consult AGC Technical Services
Bending	No
Silkscreening and enamelling	No

Uses

Monolithic glazing	Yes
Insulating glazing	Yes, the Comfort Select 28 coating can be placed in position #2 only

Applications

Interior	Yes
Exterior	No

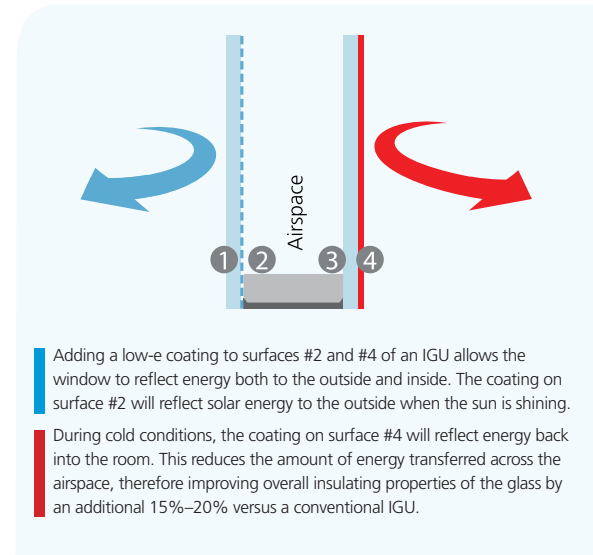
Standard Thicknesses

SGL (2.5 mm)	5/32 in. (4 mm)
DSG 1/8 in. (3 mm)	3/16 in. (5 mm)

4.2 U4

U4- 4TH SURFACE TECHNOLOGY DELIVERS TRIPLE-GLAZED ENERGY PERFORMANCE IN A DOUBLE-GLAZED UNIT.

Pioneered in 2010, U4 – 4th Surface Technology allows you to improve window performance by 15%—without changing your manufacturing processes. Adding an additional low-e coating on the inside surface #4, allows you to reach the same level of efficiency as costlier triple-glazed units. The superior thermal performance of U4 allows it to be ideal for any region and climate.



Low-e IGU with U4 Technology

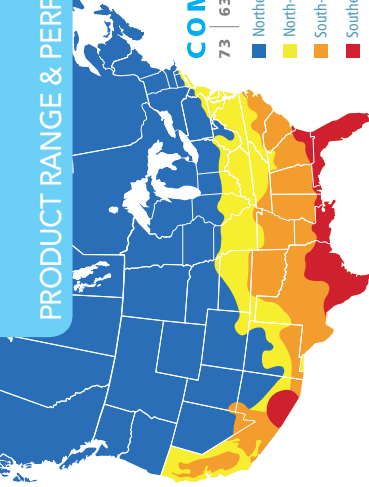
Adding a low-e coating to surfaces #2 and #4 of an IGU allows the window to reflect energy both to the outside and inside. The coating on surface #2 will reflect solar energy to the outside when the sun is shining.

During cold conditions, the coating on surface #4 will reflect energy back into the room. This reduces the amount of energy transferred across the airspace, therefore improving overall insulating properties of the glass by an additional 15%–20% versus a conventional IGU.

PRODUCT RANGE & PERFORMANCE

RESIDENTIAL LOW-E INSULATING GLASS PERFORMANCE COMPARISON

COMFORT SELECT™ 3/4" (19mm) Dual Insulating Units - 1/8" (3mm) | 1/2" (13mm) | 1/8" (3mm)



COMFORT Select
73 | 63 | R42 | 40 | 36 | 28

■ Northern (mostly heating)

■ North-Central (heating and cooling)

■ South-Central (heating and cooling)

■ Southern (mostly cooling)

Product	Winter U-Value		SHGC	Transmittance			LSG	DW Index
	Air	Argon		Visible	Solar	UV		
Clear Comfort Select 73 #3	0.33	0.29	0.72	74%	58%	43%	1.03	0.63
Clear Comfort Select 63 #3	0.31	0.26	0.61	79%	52%	38%	1.30	0.67
Comfort Select 40 #2 Clear	0.29	0.25	0.39	72%	36%	19%	1.85	0.56
Comfort Select 36 #2 Clear	0.29	0.25	0.36	66%	33%	15%	1.82	0.50
Comfort Select 28 #2 Clear	0.29	0.24	0.28	62%	25%	14%	2.22	0.45
Comfort Select R42 #2 Clear	0.30	0.25	0.43	65%	39%	24%	1.50	0.50

PRODUCT RANGE & PERFORMANCE

RESIDENTIAL LOW-E INSULATING GLASS PERFORMANCE COMPARISON

COMFORT SELECT™ 3/4" (19mm) with U4 Technology #4 Surface Low-E Dual Insulating Units - 1/8" (3mm) | 1/2" (13mm) | 1/8" (3mm)

COMFORT Select
73 | 63 | R42 | 40 | 36 | 28

■ Northern (mostly heating)

■ North-Central (heating and cooling)

■ South-Central (heating and cooling)

■ Southern (mostly cooling)

Product	Winter U-Value		SHGC	Transmittance			LSG	DW Index
	Air	Argon		Visible	Solar	UV		
Comfort Select 73 #2 U4	0.26	0.23	0.60	67%	52%	33%	1.12	0.55
Comfort Select 63 #2 U4	0.24	0.21	0.54	72%	47%	29%	1.34	0.58
Comfort Select 40 #2 U4	0.23	0.20	0.37	66%	32%	14%	1.78	0.48
Comfort Select 36 #2 U4	0.23	0.20	0.34	60%	30%	12%	1.75	0.44
Comfort Select 28 #2 U4	0.23	0.20	0.26	56%	23%	10%	2.14	0.39
Comfort Select R42 #2 U4	0.24	0.20	0.41	59%	36%	19%	1.45	0.43

U4 indicates Comfort Select 73 #4 surface on the inboard lite, in addition to the #2 surface coating designated on the outboard lite.



IV. BRANDS AND PRODUCTS

5. FIRE-RATED GLASS

5.0	Introduction	196
5.1	Fire Resistance	196
	Guidelines for Glazing	202
	Glossary	203
	IBC Labeling Requirements	205
5.2	AGC Fire-Rated Glazing Products	206
	5.2.1 Fire Resistive Glazing	206
	Pyrobel® 45	206
	Pyrobel® 60	207
	Pyrobel® 90	207
	Pyrobel® 120	208
	5.2.2 Fire Protective Glazing	208
	Pyroedge™ 20	208
	Schott Pyran® Platinum	209
5.3	Fire-Rated Framing Brands	209
	StileLite 45/90™	209
	StileLite 100™	210
	StileLite 200™	210
	StileLite 300™	210
	StileLite Doors™	211
	Vision 60 System™	212
	Vision 120 System™	212
	Quick-Frame System™	212

5.0 INTRODUCTION

PYROSAFE™ FIRE-RATED GLASS AND FRAMING SYSTEMS

AGC's Pyrosafe™ family of fire-rated glass and framing systems offers the protection and code compliance your project demands—as well as the ability to bring inspired designs to life. Ratings of up to 180 minutes can be achieved with glass that is wireless, colorless, and distortion free. So you can be sure your design vision will always come through.

5.1 FIRE-RESISTANCE

▼ Fire-Protective Glazing

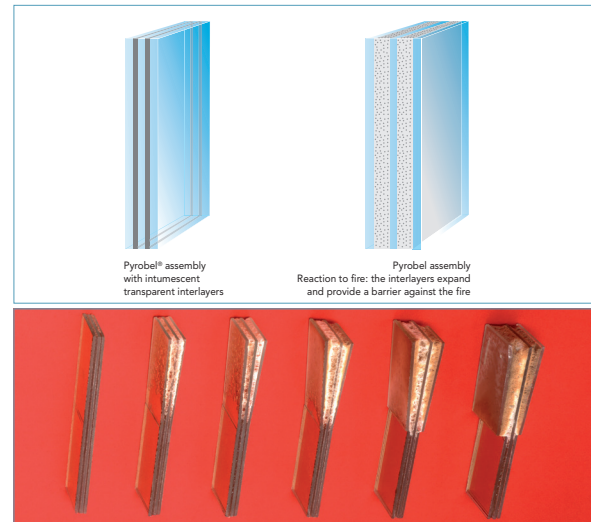
This category includes polished wired glass, ceramics, specialty tempered glass, and filmed glass (both nonwired and wired). These products are generally between 1/4" and 5/8" thick. Fire ratings range from 20 minutes to 3 hours, depending on the product and application. Generally, fire-protective glazing is limited to 45 minutes in interior borrowed lites. Always consult your local building code official for appropriate use of fire-protective glazing.

> *Wired Glass* was the original fire-rated glass relying on embedded wires to hold the annealed glass together during a fire endurance and hose stream test. Historically it was required to meet the American National Standards Institute (ANSI) Z97.1 *American National Standard for Safety Glazing Materials Used in Buildings - Safety Performance Specifications Method of Test* impact standard (100 ft.-lbs.). In nonhazardous fire-rated locations, traditional wired glass can be used up to the size tested and approved. Wired glass under most codes in the U.S. today must meet the higher standard of CPSC 16CFR 1201. Filmed wired glass has been developed for safety areas by some manufacturers that meet Consumer Product Safety Commission (CPSC) 16 CFR 1201 *Safety Standard for Architectural Glazing*

Materials Category I or Category II safety standards

> *Ceramics* withstand a fire endurance and hose stream test, and when laminated or filmed can meet CPSC 16 CFR 1201 Cat II (400 ft.-lbs.) safety requirements for use in hazardous locations. Fire ratings range from 20 to 180 minutes depending on application. Consult your local building code official for appropriate use of protective glazing

> *Specialty Monolithic Tempered Glass*, clear tempered glass with ratings of 20 minutes, listed for CPSC 16 CFR 1201 Category II (400 ft.-lbs.) safety for use in door locations



> *Laminated intumescent* and gel-filled glazing may fall within the *fire protective* designation when used with either a traditional non-thermally broken frame or in areas where only a 45-minute rating is required. However, when a higher margin of safety is desired due to their thermal-limiting characteristics (such as schools, hospitals, homes for the aged, and other areas where egress may be hampered or confused) these products may be selected

Fire-Protective Product Notes - Some of the previous products provide improved acoustical, energy performance, or radiant heat transfer characteristics depending on the product selected. Contact the fire-rated glazing supplier for details on these enhanced performance characteristics.

▼ Key Questions to Ask in Selecting Fire-Protective Glazing Products

1. What is the minimum fire rating required for this application?
2. Is an impact safety rating required?
3. Are there size limitations placed on the usage of a product based on code requirements?

▼ Fire-Resistant Glazing

This category includes intumescent multi-laminate and gel-filled units. These clear, transparent products contain flames, contain the spread of smoke, and prevent the transfer of radiant heat for 45 minutes to 2 hours. These products are listed by third-party testing agencies as “non load bearing transparent walls” and are therefore not limited to the 25% glazed area restriction when used in a temperature rise framing system of equal rating to the glazing.

Intumescent multi-laminate – These products utilize multiple sheets of annealed glass laminated together using special intumescent interlayers. The number of interlayers and overall thickness determine the fire rating. Under fire conditions the interlayers become opaque and expand to prevent the transmission of heat, smoke, and flames.

Gel-filled – These units resemble insulating glass units; however, the cavity is filled with clear gel. The thickness of the gel cavity determines the fire rating. Under fire conditions the gel crystallizes into an opaque heat-absorbing char that prevents the transmission of heat, smoke, and flames.

Fire-Resistive Product Notes - Intumescent multi-laminate and gel-filled products provide improved acoustical performance and are available for exterior use with energy-saving make-ups. They can also be provided in special make-ups for bullet, blast, hurricane, attack resistance, and other custom protections. Contact AGC for details on these enhanced performance characteristics.

▼ Key Questions to Ask in Selecting Fire-Resistive Glazing Products

1. What is the minimum fire rating required for this application?
2. Is the framing capable of meeting the fire-resistive rating of the glazing?
3. What are the size limitations of the selected fire-resistive glazing?
4. Is the application exterior or interior?

▼ DEFINITIONS

Fire-Protection Rating – The period of time that an opening protective assembly will maintain the ability to confine a fire as determined by tests – NFPA 252/ NFPA 257/UL 9/UL 10C/ASTM E 2010/ASTM E 2074. Canadian – CAN S 104, 105 and 106

Fire-Resistance – That property of materials or their assemblies that prevents or retards the passage of excessive heat, hot gases, or flames under conditions of use.

Fire-Resistance Rating – The period of time a building element, component, or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by tests – NFPA 251/ASTM E 119/UL 263 (wall assemblies). Canadian – CAN S 101, 104, 105 and 106

Fire-Rated Products Comparison

	Fire Rating	Safety Rating	Meets Hose Stream Test	ASTM E 119 Heat Barrier (C)	Exterior/Interior Use
Traditional Wired Glass	20 – 90 minutes (A)	ANSI Z97.1 100 ft.-lbs.	Yes	No	Yes
Filmed Wired Glass	20 – 90 minutes (A)	CPSC 16 CFR 1201 Category II 400 ft.-lbs.	Yes	No	Yes
Specialty Tempered	20 minutes	CPSC 16 CFR 1201 Category II 400 ft.-lbs.	No	No	Yes
Ceramic	20 minutes – 3 hours (B)	None	Yes	No	Yes
Filmed Ceramic	20 minutes – 3 hours (B)	CPSC 16 CFR 1201 Category II 400 ft.-lbs.	Yes	No	Yes
Laminated Ceramic	20 minutes – 3 hours (B)	CPSC 16 CFR 1201 Category II 400 ft.-lbs.	Yes	No	Yes
Multi-Laminated Intumescent	45 minutes – 2 hours	CPSC 16 CFR 1201 Category II 400 ft.-lbs.	Yes	Yes	Yes (D)
Gel-Filled	45 minutes – 2 hours	CPSC 16 CFR 1201 Category II 400 ft.-lbs.	Yes	Yes	Yes (D)

IMPORTANT INFORMATION

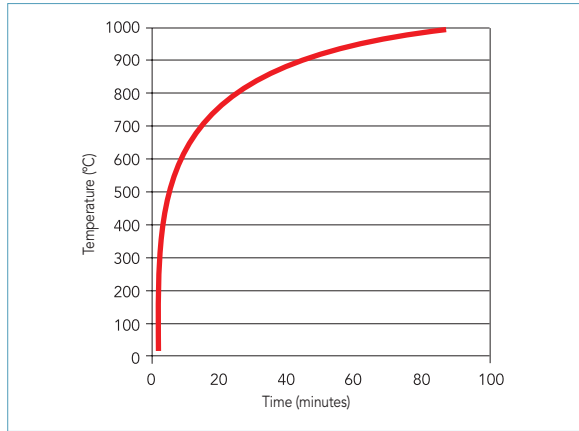
- (A) Up to 90 minutes in door applications not to exceed 100 sq. in.; 45 minutes for other applications.
- (B) Up to 3 hours in door applications not to exceed 100 sq. in.
- (C) While some of the above products do not meet the requirements of the ASTM standard for barrier walls, products may offer significant heat reduction. Contact the manufacturers for detailed information
- (D) For exterior applications, special fabrication may be needed. Advise the manufacturer of intended exterior uses of the product

▼ TESTING AND CERTIFICATIONS BY INDEPENDENT LABORATORIES

Test standards prescribed by the building codes for fire-rated glazing and fire-rated glazing systems fall into three categories: doors, windows/borrowed lites, and “transparent wall systems.” These standards prescribe standardized fire and hose stream test procedures that apply to the assemblies intended to be used to retard the spread of fire, smoke, and, in the case of wall systems, radiated and convective heat. The degree of fire protection measured in units of time is not an absolute value because all possible actual fire scenarios are not represented by the standard fire exposures. All of the standard test procedures are intended to evaluate the ability of an assembly to remain in an opening during a prescribed fire test exposure. It is then followed by the application of a prescribed hose stream.



The time-temperature fire curve, generally referred to as the ASTM E-119 curve, reflects the temperature in degrees for each segment of time the assembly is exposed.



Upon successful testing of the assembly, independent laboratories will certify and list the products and allow manufacturers to label accordingly. To assure compliance with that tested, the laboratories will inspect the manufacturing location quarterly. This inspection includes an audit of the manufacturing process and procedures in comparison to the product tested as well as the proper labeling of the glazing and glazing systems.

▼ GUIDELINES FOR GLAZING IN FIRE-RATED METAL FRAMES

When setting glass in metal frames, it should be noted that many of these frames are used in fire-rated barriers. The model codes of the United States and the National Fire Protection Association Standard No. 80, Standard for Fire Doors and Fire Windows, mandate the use of labeled glass and labeled frames in fire-rated applications. This means the glass and frame must

bear the mark (label) of an independent third-party agency (such as Underwriters Laboratories, Factory Mutual, Warnock Hersey, etc.). The label attests to the fact that the glass and frame have been tested under the auspices of the third-party agency and shown to achieve a specified fire-protection rating. Furthermore, the glass manufacturer or frame manufacturer is required, as a condition of the label, to furnish installation instructions. The glazing must be installed in accordance with the manufacturer's instructions, reflecting the manner in which the product was tested to achieve the fire rating.

NFPA 80 should also be consulted for installation details, glass area limits, and other requirements. NFPA 80 and some labeling agencies specify that the clearance between the edges of the glazing and the inside edge of the frame may not exceed 1/8". The 1/8" clearance should not be exceeded unless otherwise noted in the individual listing or the manufacturer's installation instructions.

▼ GLOSSARY

NFPA-80: Standard for Fire Doors and Other Opening Protectives

This standard regulates the installation and maintenance of assemblies and devices used to protect openings in walls, floors, and ceilings against the spread of fire and smoke within, into, or out of buildings. **1.1.1** With the exception of fabric fire-safety curtain assemblies, this standard addresses assemblies that have been subjected to standardized fire tests. **1.1.2** Incinerator doors, record room doors, and vault doors are not covered in this standard. **1.1.3** Requirements for horizontally sliding, vertically sliding, and swinging doors as used in this standard do not apply to hoistway doors for elevators and dumbwaiters. **1.1.4** This standard does not cover fire-resistant glazing materials and horizontally sliding accordion or folding assemblies fabricated for use as walls and tested as wall assemblies in accordance with NFPA 251, Standard Methods of Tests of Fire Resistance of Building Construction and Materials.

IBC (2003 and 2006) Sec. 700, 1000, 2400

The International Building Code (IBC) was introduced in 2000. The 2000 IBC was a culmination of three U.S. model building codes (SBCCI, BOCA and IBC) rolled into one U.S. code. The 2000 IBC was revised in 2003 and 2006 and has been adopted by virtually every state in the U.S. It is now the standard code for all construction in the U.S. and sets forth requirements for fire-rated glazing within the building envelope.

CPSC 16 CFR 1201 (Consumer Product Safety Commission): Impact Safety Rating

The CPSC standard is not only a test method and a procedure for determining the safety performance of architectural glazing, but also a federal standard that mandates where and when safety glazing materials must be used in architectural applications and preempts any nonidentical state or local standard.

ANSI Z.97 Cat. I and II (American National Standard Institute): Impact Safety Rating

ANSI Z97.1 is only a voluntary safety performance specification and test method. It does not attempt to declare when and where safety glazing materials must be used, leaving those determinations up to the building codes and to glass and fenestration specifiers. Cat. I is equivalent to a 100 ft. lb. impact. Cat. II is equivalent to a 400 ft. lb. or higher impact.

UBC

Uniform Building Code

SBCCI

Southern Building Code Congress International

BOCA

Building Officials and Code Administrators International

▼ IBC LABELING REQUIREMENTS FOR FIRE-RATED GLAZING**Location Indicator**

- D** denotes **D**OORS
 - O** denotes **O**PENING (window, sidelite, transom, etc.)
 - W** denotes **W**ALLS (glass must meet ASTM E-119 and provide a barrier to radiant heat transfer)
- Hose Stream Test**
- H** denotes glazing meets **H**OSE stream test requirement (required for 45 minutes and above)
 - NH** denotes the glazing does **N**OT meet the **H**OSE stream requirement (applies to 20-minute glazing only)

Temperature Rise

- T** denotes glazing meets **T**EMPERATURE rise criteria
- NT** denotes glazing does **N**OT meet **T**EMPERATURE rise criteria

Fire-Rating (Minutes)

- XX** denotes fire protection rating period in minutes

5.2 AGC FIRE-RATED GLAZING BRANDS



PYROSAFE™ FIRE-RATED GLASS AND FRAMING SYSTEMS

AGC's Pyrosafe™ family of fire-rated glass and framing systems offers the protection and code compliance your project demands—as well as the ability to bring inspired designs to life. Ratings of up to 180 minutes can be achieved with glass that is wireless, colorless, and distortion free. So you can be sure your design vision will always come through.

5.2.1 FIRE-RESISTIVE GLAZING

Pyrobel, manufactured in Belgium and the Czech Republic in large sheets, is shipped to the AGC fabrication center in the U.S. There it is cut to size, labeled, boxed, and shipped to the customer's desired location. It is an intumescent laminated product that varies in thickness depending upon the fire exposure required. Due to its structure it can be classified as either a fire-protective or fire-resistant glazing. The Pyrobel glazing generally limits the temperature rise on the non-fire side to a maximum of 250° F above ambient. During a fire, the glazing will turn opaque and form a rigid barrier to fire, smoke, and heat radiation. Fire ratings range from 45 minutes to 120 minutes. Interestingly, Pyrobel may also be butt glazed to form a rigid non-framed "transparent wall."

▼ PYROBEL® 45

Pyrobel® 45 is fire rated for 45 minutes with a hose stream. The intumescent interlayers expand, offering maximum protection for egress and property. Temperature rise is limited to 250° above ambient at 30 minutes. This wireless, colorless, and distortion-free glazing has been tested to the latest

positive-pressure standards as mandated by IBC and NFPA 5000. The glazing is safety rated for all hazardous areas and is tested to ANSI Z97.1 and CPSC 16CFR 1201 (Cat. I and II 400 ft. lb. impact). Pyrobel 45 is available for standard steel door and frame assemblies and is for interior and exterior use.

▼ PYROBEL® 60

Pyrobel® 60 is wireless, colorless, and distortion-free, fire-rated glazing for 60 minutes with hose stream. With optional sandblasted (opaque) lites, Pyrobel® 60 is available for interior and exterior use and for standard steel doorframe assemblies. Pyrobel® 60 has been tested to the latest positive-pressure standards as mandated by IBC and NFPA 5000. The glazing is safety rated for all hazardous areas and is tested to ANSI Z97.1 and CPSC 16CFR 1201 (Cat. I and II 400 ft. lb. impact). The intumescent interlayers expand, offering maximum protection for egress and property protection. Temperature rise is limited to 250° above ambient.

▼ PYROBEL® 90

Pyrobel® 90 fire-rated glazing is for 90-minute application with hose stream. It has been safety tested and rated to meet all local, regional, state, and federal code requirements. This wireless, colorless, and distortion-free glazing has been tested to the latest positive-pressure standards as mandated by IBC and NFPA 5000. The glazing is safety rated for all hazardous areas and is tested to ANSI Z97.1 and CPSC 16CFR 1201 (Cat. I and II 400 ft. lb. impact). The intumescent interlayers expand, offering maximum protection for egress and property protection. Temperature rise is limited to 250° above ambient. It has been tested as a complete transparent wall assembly utilizing simple on-site construction of steel stud/gypsum framing or other approved framing.

▼ PYROBEL® 120

Pyrobel® 120 is a clear fire-rated glazing for 2-hour applications with hose stream. It has been safety tested and rated to meet all local, regional, state, and federal code requirements. This wireless, colorless, and distortion-free glazing has been tested as a complete transparent wall assembly utilizing simple Quick-Frame™ construction or StileLite™ 300 framing. The glazing is safety rated for all hazardous areas and is tested to ANSI Z97.1 and CPSC 16CFR 1201 (Cat. I and II 400 ft. lb. impact). The intumescent interlayers expand, offering maximum protection for egress and property protection. Temperature rise is limited to 250° above ambient. Pyrobel® 120 is generally used for interior applications only; check with factory for exterior options available.

5.2.2 FIRE PROTECTIVE GLAZING

AGC has a complete range of tempered glass, ceramics, intumescent, and framing products offering a variety of levels of fire protection and fire resistance.

PyroEdge

PyroEdge is a very popular low-cost, clear, non-wired 1/4" and 3/8" tempered product offering protection from flame and smoke generally for 20 minute door assemblies.

▼ PYROEDGE™ 20

Pyroedge™ 20 is a clear 1/4" or 3/8" tempered glazing rated for 20- and 30- minute applications without hose stream. The large sizes include 4' x 9' steel and wood doors with exceptional replacement for wired glass. The glazing is safety rated for all hazardous areas and is tested to ANSI Z97.1 and CPSC 16CFR 1201 (Cat. I and II 400 ft. lb. impact). It has been tested to the latest positive-pressure standards as mandated by IBC and NFPA 5000. With Pyroedge™ 20, there are optional beveled edges and acid-etched (opaque) lites. It is fire-rated for interior and exterior use, and is manufactured in multiple U.S. locations for fast delivery.

▼ Schott Pyran® Platinum

In conjunction with Schott glass, AGC offers multiple distribution points for Pyran Platinum ceramic glazing. It is offered in three types: non-safety, filmed safety, and laminated safety glazing. Due to its unique manufacturing capability, it is also classified as a green product. Fire ratings run from 20 minutes to 180 minutes depending upon the application.

5.3 FIRE-RATED FRAMING BRANDS

AGC offers a range of fire-rated framing systems for all its brands of fire-rated glazing:

Hollow Metal

Standard hollow metal framing is available with listings from 45 minutes to 90 minutes. Special custom configurations are available although limited by testing standards. All framing is shipped either primed or finish painted with the appropriate laboratory fire-rating certification.

▼ STILELITE 45/90™

StileLite 45/90™ hollow framing system is used in applications with fire-rating requirements from 20 to 90 minutes and can incorporate fully glazed single or pair doors for a continuous glazing option. It is approved for use with Pyrobel® 45-, 60-, 90-minute fire-and safety-rated glazing as well as PYRAN® Platinum, PYRAN® Platinum-F, PYRAN® Platinum-L, and PyroEdge 20™. StileLite 45/90™ has been tested to positive-pressure standards and large sizes for sidelites, borrowed lites, windows, and transom lites. Closed-cell foam glazing tape and setting blocks are provided with each glass order.

▼ STILELITE 100™

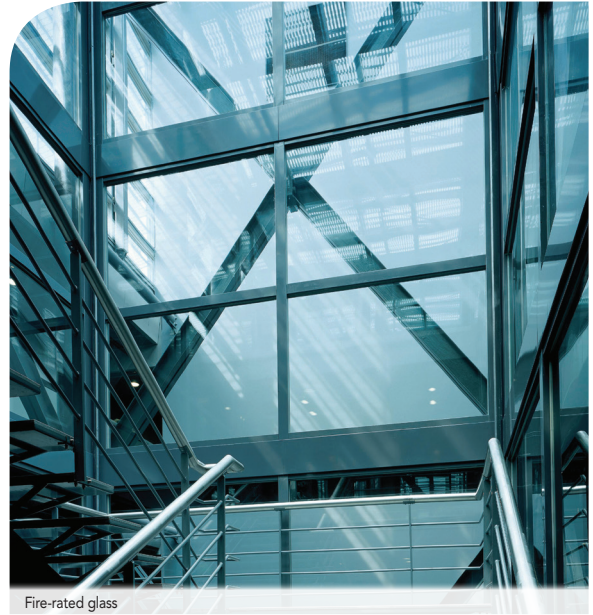
StileLite 100™ is a 250° temperature rise, fire-rated framing system for 60-minute transparent walls. The slim 1-7/8" profile can incorporate fully glazed 60-minute single and pair doors for a floor to ceiling continuous glazed wall. With a unlimited number of modules, each module up to 93"x 93" and the visible glass area of each opening can be up to 3,916 sq. in. while not exceeding 46-3/4" wide and 83- 3/4" high. All frames are 14-gauge steel with jamb sizes from 4-3/4" to 14". There are numerous Endura Shield Tnemec paint finishes and stainless steel options available. It can also be manufactured from cold-roll galvanized or No. 4 stainless steel.

▼ STILELITE 200™

StileLite 200™ is a fully welded, 250° temperature-rise, fire-rated storefront framing system for 60-minute transparent walls. It offers a clean sightline with a 1-7/8" profile and can incorporate fully glazed 60-minute single and pair doors for a floor to ceiling continuous glazed wall. With a unlimited number of modules, each module up to 93"x 93" and the visible glass area of each opening can be up to 3,916 sq. in. while not exceeding 46-3/4" wide and 83- 3/4" high. All frames are 14-gauge steel with jamb sizes from 4-3/4" to 1". Multiple Tnemec paint finishes and stainless steel options are available. This framing system is an excellent perimeter frame for Vision 60™.

▼ STILELITE 300™

StileLite 300™ Curtainwall is a fully welded, modular-constructed, fire-rated curtainwall framing system for 45 to 120-minute transparent walls. It offers a sleek 2-3/8" profile and is the only U.S. manufactured and fabricated system of its kind. The finish options include: primed, finish paint, and stainless steel. It is used with Pyrobel® fire-rated glazings.



Fire-rated glass

▼ STILELITE DOORS™

StileLite Doors™ are used with the StileLite™ framing system. The doors are up to 48" wide (96" pairs) x 108" high. The standard is 1-3/4" thick with 6" stiles and rails, and 10" sills. The maximum temperature rise is 450° F. The glass opening sizes for 60-minute doors is up to 44" x 87-5/8" (not to exceed 3,855 sq. in.) The glass opening sizes for 90-minute doors is up to 35-1/4" x 35-1/4" or 45" x 45" (not to exceed 1,243 sq. in.). The finishing options include pre-finished wood veneer, numerous stainless steel options, and finish paint.

▼ VISION 60 SYSTEM™

Vision 60 System™ is a unique and exclusive 60-minute butt-glazed transparent wall system. It utilizes Pyrobel® 60 glazing and the Quick-Frame™ or StileLite™ 100 or 200 frames at the perimeter, eliminating all intermediate framing mullions for truly free and open vision. There can be an unlimited number of glass panels glazed into the wall; however, it is subject to structural engineering approval. The glass panels are separated by no more than 4mm of space and are glazed with 100% pure silicone. The decorative profiles of aluminum, wood, or steel may be applied to the face of the glazing without affecting the performance of the system. Full lite doors (single or pair) can be incorporated into the Vision 60 System™ for a continuous glazed wall.

▼ VISION 120 SYSTEM™

Vision 120 System™ is a unique and exclusive 120-minute butt-glazed transparent wall system. It utilizes Pyrobel® 120 glazing and the Quick-Frame™ at the perimeter, eliminating all intermediate framing mullions for truly free and open vision. There can be an unlimited number of glass panels glazed into the wall; however, it is subject to structural engineering approval. The glass panels are separated by no more than 4mm of space and are glazed according to spec.

▼ QUICK-FRAME SYSTEM™

The Quick-Frame System™ is tested as a 1- and 2- hour wall system. It is approved for use with Pyrobel® 45-, 60-, 90-, and 120-minute fire- and safety-rated glazing. This framing system provides more light and viewing and the system eliminates restrictions on glazing percentage of wall area. It has been tested to positive-pressure standards and the convenient on-site construction speeds installation using standard building materials. Decorative coverings such as wood, steel, or aluminum may be used to match the surrounding area and the frame is for use in interior applications only.



ROC Almelo, Almelo, Netherlands - Photographer: Hans Willemsen - Pyrobel

V. PRODUCTION LOCATIONS

Below is a listing of AGC facilities throughout North America

▼ AGC Glass Company - Manufacturing

Greenland Plant

AGC Road, HWY. 11W
Church Hill, TN 37642
Phone: (423) 357-2400
Fax: (423) 357-2476

Spring Hill Plant

20400 N. Webster
Spring Hill, KS 66083
Phone: (913) 592-6100
Fax: (913) 592-6110

Richmond Plant

201 Duncannon Lane
Richmond, KY 40475
Phone: (859) 625-9002
Fax: (859) 625-9050

▼ AGC Coating Plants

Abingdon Plant

18370 Oak Park Drive
Abingdon, VA 24210
Phone: (276) 619-6000
Fax: (276) 619-6039

Spring Hill Plant

20400 N. Webster
Spring Hill, KS 66083
Phone: (913) 592-6100
Fax: (913) 592-6110

AGC Residential Fabrication

Boardman Plant

365 McClurg Rd., Suite E
Boardman, OH 44512
Phone: (330) 965-1000
Fax: (330) 965-1011

Quakertown Plant

480 California Rd.
Quakertown, PA 18951
Phone: (215) 538-9424
Fax: (215) 538-9438

▼ AGC Commercial Fabrication - U.S. Locations

AGC-Alvarado

1201 Highway 67
East Alvarado, TX 76009
Phone: (817) 477-1144
(800) 777-5171
Fax: (817) 783-7123

AGC-Atlanta

660 Campbell Court
Lithia Springs, GA 30122
Phone: (678) 322-1540
(800) 727-2343
Fax: (678) 322-1590

AGC-Baton Rouge

1414 Julia St.
Baton Rouge, LA 70802
Phone: (225) 344-9401
(800) 695-2341
Fax: (225) 343-2318

AGC-Carbondale

Clidco Drive
P.O. Box 313
Carbondale, PA 18407
Phone: (800) 233-4170
Fax: (570) 282-1382

AGC-Fall River

575 Currant Rd.
Fall River, MA 02720
Phone: (508) 675-9220
(800) 666-2343
Fax: (508) 677-3212

AGC-Hebron

160 North High Street
Hebron, OH 43025
Phone: (888) 480-2343
Fax: (740) 929-2440

AGC-Houston

5909 Milwee St.
Houston, TX 77292
Phone: (713) 686-2509
(800) 897-7992
Fax: (713) 686-7650

AGC-Jacksonville

6600 Suemac Place
Jacksonville, FL 32254
Phone: (904) 786-6611
(800) 627-2341
Fax: (904) 781-9779

AGC-Knoxville

2522 Westcott Boulevard
Knoxville, TN 37931
Phone: (865) 691-2040
(800) 395-2343
Fax: (865) 691-2585

AGC-Opelousas

710 West Landry St.
Opelousas, LA 70570
Phone: (800) 489-3386
Fax: (337) 942-5005

AGC-Richmond

6200 Gorman Rd.
Richmond, VA 23231
Phone: (804) 222-0120
Fax: (804) 226-1859

AGC-Salt Lake City

3515 South 300 West
Salt Lake City, UT 84115
Phone: (801) 268-2521
(800) 453-6226
Fax: (801) 284-6421

AGC-San Antonio

5807 Business Park
San Antonio, TX 78218
Phone: (210) 653-7790
(800) 727-7790
Fax: (210) 655-3945

▼ AGC Commercial Fabrication - Canadian Locations

AGC-Winnipeg

450 Deschambault St.
Winnipeg, Manitoba
R2H 0K1
Phone: (204) 233-0229
Fax: (204) 233-0762

AGC-Regina

500 10th Ave.
E. Regina, Saskatchewan
S4N 6G7
Phone: (306) 525-2341
Fax: (306) 757-4862

▼ AGC Glass Centres - Canadian Locations

AGC-Toronto

295 Connie Crescent, Unit 1
Vaughan, Ontario
L6W 4N7
Phone: (416) 259-2309
Fax: (416) 259-4761

AGC-Thunder Bay

129 South Vickers St.
Thunder Bay, Ontario
P7C 4V9
Phone: (807) 622-7701
Fax: (807) 623-0031

AGC-Winnipeg

308 Colony Street
Winnipeg, Manitoba
R3C 1W6
Phone: (204) 783-0413
Fax: (204) 788-4657

AGC-Hamilton

510 Cannon St.
E. Hamilton, Ontario
L8L 2E7
Phone: (905) 549-4614
Fax: (905) 549-3696

AGC-Regina

500 10th Ave.
E. Regina, Saskatchewan
S4N 6G7
Phone: (306) 525-2341
Fax: (306) 757-4862

AGC-Kingston

120 Railway St.
Kingston, Ontario
K7K 2L9
Phone: (613) 546-7220
Fax: (613) 546-1280



VI. GLOSSARY

GLOSSARY

Acoustics

The science of sound and sound control.

Adhesion

The property of a coating or sealant to bond to the surface to which it is applied.

Adhesive Failure

Loss of bond of a coating or sealant from the surface to which it was applied.

Air Infiltration

The amount of air leaking in and out of a building through cracks in walls, windows, and doors.

Annealing

In the manufacturing of float glass, the process of controlled cooling done in a Lehr to prevent residual stresses in the glass. Re-annealing is the process of removing objectionable stresses in glass by reheating to a suitable temperature followed by controlled cooling.

Annealing Lehr

An in-line controlled heating/cooling apparatus located after the tin bath and before the cooling conveyor of a float glass production line. Its purpose is to relieve induced stress from the flat glass product to allow normal cold end processing.

Anti-Walk Blocks

Elastomeric blocks that limit lateral glass movement in the glazing channel, which may result from thermal, seismic, wind load effects, building movement, and other forces that may apply.

Aspect Ratio

The quotient of the long side of a glazing lite over the short side of that lite.

Autoclave

A vessel that employs high pressure and heat. In the glass industry, used to produce a bond between glass and PVB or urethane sheet, creating a laminated glass product.

Backer Rod

A polyethylene or polyurethane foam material installed under compression and used to control sealant joint depth, provide a surface for sealant tooling, serve as a bond breaker to prevent three-sided adhesion, and provide an hour-glass contour of the finished bead.

Back Putty

(See Bed or Bedding)

Back-up

A material placed into a joint to control the depth of the sealant and to prevent adhesion at the base of the sealant bead.

Bead

An applied sealant in a joint irrespective of the method of application, such as caulking bead, glazing bead, etc. Also a molding or stop used to hold glass or panels in position.

In glazing, the bead of compound or sealant applied between a lite of glass or panel and the stationary stop or sight bar of the sash or frame. It is usually the first bead of compound or sealant to be applied when setting glass or panels.

Bedding of Stop

In glazing, the application of compound or sealant at the base of the channel, just before the stop is placed in position, or buttered (see Buttering) on the inside face of the stop.

Bent Glass

Flat glass that has been shaped into curved shapes while hot.

Bevel of Compound Bead

In glazing, a bead of compound applied to provide a slanted top surface so that water will drain away from the glass or panel.

Beveling

The process of edge finishing flat glass to a bevel angle.

Bite

The dimension by which the framing system overlaps the edge of the glazing infill.

Bleeding

A migration of a liquid to the surface of a component or into/onto an adjacent material.

Blisters

A profusion of bubbles in a coating film that forms during the heat-treating process and remains after the film solidifies.

Block

Rectangular cured sections of EPDM, neoprene, silicone, or other suitable material, used to position the glass product in the glazing channel.

Bow (and Warp)

A curve, bend, or other deviation from flatness in glass.

Breather Tube Units (See also Capillary Tube Units)

An insulating glass unit with a tube and/or hole factory-placed into the unit's spacer to accommodate pressure differences encountered in shipping due to change in elevation. The tube and/or hole are to be properly sealed on the jobsite prior to unit installation. Consult IG unit fabricator.

Bubbles

In laminated glass, a gas pocket in the interlayer material or between the glass and the interlayer. In float glass, a gaseous inclusion greater than 1/32" (.8 mm) in diameter.

Bubbling

Open or closed pockets in a sealant caused by release, production, or expansion of gasses.

Bulb Edge

In float glass manufacture, the extreme lateral edge of the ribbon as drawn.

Bullet-Resistant Glass

A multiple lamination of glass or glass and plastic that is designed to resist penetration from medium- to super-power small arms and high-power rifles.

Buttering

Application of sealant or compound to the flat surface of some member before placing the member in position, such as the buttering of a removable stop before fastening the stop in place.

Butt Glazing

The installation of glass products where the vertical glass edges are without structural supporting mullions.

Capillary Tube Units (See also Breather Tube Units)

An insulating glass unit with a very small inside diameter metal tube of specific length factory-placed into the unit's spacer to accommodate pressure differences encountered in shipping because of substantial changes in elevation and the pressure differences encountered daily after installation. Capillary tubes may or may not require sealing prior to installation. Consult IG unit fabricator.

Caulk

(v) The application of a sealant to a joint, crack, or crevice. (n) A compound used for sealing that has minimum joint movement capability; sometimes called low-performance sealant.

Channel

(See Pocket)

Channel Glazing

The installation of glass products into U-shaped glazing channels. The channels may have fixed stops; however, at least one glazing stop on one edge must be removable.

Channel Width

The distance between opposing glazing stops.

Checks

Very small cracks in flat glass, usually at the edge.

Chemically Strengthened Glass

Glass that has been strengthened by ion-exchange to produce a compressive stress layer at the treated surface.

Chipped Edge

An imperfection due to breakage of a small fragment from the cut edge of the glass. Generally this is not serious except in heat-absorbing glass.

Clips

Wire spring devices used to hold glass in rabbeted sash, without stops, and face glazed.

Cohesive Failure

Internal splitting of a compound resulting from overstressing of the compound.

Compatibility

The ability of two or more materials to exist in close and permanent association for an indefinite period with no adverse effect of one on the other.

Compound

A chemical formulation of ingredients used to produce a caulking, elastomeric joint sealant, etc.

Compression Gasket

A gasket designed to function under compression.

Compression Set

The permanent deformation of a material after removal of the compressive stress.

Condensation

The appearance of moisture (water vapor) on the surface of an object caused by warm moist air coming into contact with a colder object.

Consistency

Degree of softness or firmness of a compound as supplied in the container and varying according to method of application, such as gun, knife, tool, etc.

Coolness Index

(See Luminous Efficacy)

Crush

A lightly pitted area on glass resulting in a dull gray appearance.

Cullet

Broken glass, excess glass from a previous melt, or edges trimmed off when cutting glass to size. Cullet is an essential ingredient in the raw batch in glass-making because it facilitates melting.

Curing Agent

One part of a multipart sealant that when added to the base, will cause the base to change its physical state by chemical reaction between the two parts.

Cut Sizes

Glass cut to specified width and length.

Cutter

Tool used in cutting glass.

Cutting

Scoring glass with a diamond, steel wheel, or other hard alloy wheel and breaking it along the score. Other methods of cutting glass include water jet and laser.

Deflection (framing member)

The amount of bending movement of any part of a structural member perpendicular to the axis of the member under an applied load.

Deflection (center of glass)

The amount of bending movement of the center of a glass lite perpendicular to the plane of the glass surface under an applied load.

Design Pressure

Specified pressure a product is designed to withstand.

Diffusing

Scattering, dispersing; as the tendency to eliminate a direct beam of light.

Digs

Deep, short scratches.

Distortion

Alteration of viewed images caused by variations in glass flatness or inhomogeneous portions within the glass. An inherent characteristic of heat-treated glass.

Double Glazing

In general, any use of two lites of glass, separated by an air space, within an opening, to improve insulation against heat transfer and/or sound transmission. In insulating glass units, the air between the glass sheets is thoroughly dried and the space is sealed, eliminating possible condensation and providing superior insulating properties.

Double Strength

In float glass, approximately 1/8" (3 mm) thick.

Dry Glazing

Also called compression glazing, a term used to describe various means of sealing monolithic and insulating glass in the supporting framing system with synthetic rubber and other elastomeric gasket materials.

Dry Seal

Accomplishment of weather seal between glass and sash by use of strips or gaskets of neoprene, EPDM, silicone, or other flexible material. A dry seal may not be completely watertight.

Durometer

The measurement of hardness of a material (see also Shore "A" Hardness). A gauge to measure the hardness of an elastomeric material.

EPDM

Ethylene Propylene Diene Monomer, a synthetic rubber.

Edge Block

(See Anti-walk Blocks)

Edge Clearance

Nominal spacing between the edge of the glass product and the bottom of the glazing pocket (channel).

Edging

Grinding the edge of flat glass to a desired shape or finish.

Elastomer

An elastic rubberlike substance, such as natural or synthetic rubber.

Elastomeric

(adj) Having the property of returning to its original shape and position after removal of load. (n) An elastic rubberlike substance.

Emissivity

The measure of a surface's ability to emit long-wave infrared radiation.

Etch

To alter the surface of glass with hydrofluoric acid or other caustic agents. Permanent etching of glass may occur from alkali and other runoff from surrounding building materials.

Exterior Glazed

Glazing infills set from the exterior of the building.

Exterior Stop

The molding or bead that holds the lite or panel in place when it is on the exterior side of the lite or panel.

Facade (face)

The whole exterior side of a building that can be seen at one view; strictly speaking, the principal front. Commonly used as reference to the exterior skin of a building.

Face Glazing

A system having a triangular bead of compound applied with a putty knife after bedding, setting, and clipping the glazing infill in place on a rabbetted sash.

Fenestration

Any glazed panel, window, door, curtain wall, or skylight unit on the exterior of a building.

Figured Glass

(See Patterned Glass)

Fillet Bead

Caulking or sealant placed in such a manner that it forms an angle between the materials being caulked.

Fire-Polish

To make glass smooth or glossy by the action of fire or intense heat.

Fire-Protection Rating

The period of time that an opening protective assembly will maintain the ability to confine a fire as determined by tests – NFPA 252/ NFPA 257/UL 9/UL 10c/ASTM E 2010/ASTM E 2074.

Fire-Resistance

That property of materials or their assemblies that prevents or retards the passage of excessive heat, hot gases, or flames under conditions of use.

Fire-Resistance Rating

The period of time a building element, component, or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by tests – NFPA 251/ASTM E 119/UL 263 (wall assemblies).

Flare

A protrusion on the edge of a lite of glass.

Flat Glass

A general term that describes float glass, sheet glass, plate glass, and rolled glass.

Float Glass

Glass formed on a bath of molten tin. The surface in contact with the tin is known as the tin surface or tin side. The top surface is known as the atmosphere surface or air side.

Flush Glazing (Pocket Glazing)

The setting of a lite of glass or panel into a four-sided sash or frame opening containing a recessed U-shaped channel without removable stop on three sides of the sash or frame and one channel with a removable stop along the fourth side.

Frosted Finish

A surface treatment for glass, consisting of an acid etching of one or both surfaces that diffuses transmitted light and reduces glare.

Fully Tempered Glass

Flat or bent glass that has been heat-treated to have either a minimum surface compression of 10,000 psi (69 MPa) or an edge compression not less than 9,700 psi (67 MPa) in accordance with the requirements of ASTM C 1048, kind FT or to meet the requirements of ANSI Z97.1 or CPSC 16 CFR 1201. Outside of North America, sometimes called “toughened glass.”

Gas-Filled Units

Insulating glass units with a gas other than air in the air space to decrease the unit’s thermal conductivity (U-value) or to increase the unit’s sound insulating value.

Gaskets

Preformed shapes of rubber or rubberlike composition, such as strips, grommets, etc., used to fill and seal a joint or opening either alone or in conjunction with a supplemental application of a sealant.

Girth

In bent glass, the distance around the concave or convex surface measured perpendicular to the height, including any flats.

Glass

A hard brittle substance, usually transparent, made by fusing silicates under high temperatures with soda, lime, etc.

Glass Clad Polycarbonate

One or more lites of flat glass bonded with an aliphatic urethane interlayer to one or more sheets of extruded polycarbonate in a pressure/temperature/vacuum laminating process.

Glass Fines

Minute glass particles typically resulting from glass fabrication processes (e.g., cutting, grinding, polishing, drilling, edging, etc.).

Glass Quality (Flat)

Defined by ASTM C 1036 on the basis of end use and allowable blemishes.

Glazing

(n) A generic term used to describe an infill material such as glass, panels, etc. (v) The process of installing an infill material into a prepared opening in windows, door panels, partitions, etc.

Glazing Bead

A strip surrounding the edge of the glass in a window or door that holds the glass in place.

Glazing Channel

A three-sided, U-shaped sash detail into which a glass product is installed and retained.

Gun Consistency

Sealant formulated in a degree of viscosity suitable for application through the nozzle of a caulking gun.

Heat-Absorbing Glass

Glass that absorbs an appreciable amount of solar energy.

Heat-Resisting Glass

Glass able to withstand high thermal shock, generally because of a low coefficient of expansion.

Heat-Strengthened Glass

Flat or bent glass that has been heat-treated to have a surface compression between 3,500 and 7,500 psi (24 to 52 MPa) and meet the requirements of ASTM C 1048, kind HS. Heat-strengthened glass is not a safety glazing material and will not meet the requirements of ANSI Z97.1 or CPSC 16 CFR 1201.

Heat-Treated

Term used both for fully tempered glass and heat-strengthened glass.

Heel Bead

Sealant applied at the base of a channel after setting the lite or panel and before the removable stop is installed; one of its purposes being to prevent leakage past the stop.

High-Transmission Glass

Glass that transmits an exceptionally high percentage of visible light.

Insulating Glass Unit

Two or more lites of glass spaced apart and hermetically sealed to form a single-glazed unit with an air space between each lite (commonly called IG units).

Interior Glazed

Glazing infills set from the interior of the building.

Interior Stop

The removable molding or bead that holds the lite in place when it is on the interior side of the lite.

Interlayer

Any material used to bond two lites of glass and/or plastic together to form a laminate.

Jamb

The vertical frame members at the perimeter of the opening.

Joint

The space or opening between two or more adjoining surfaces.

Kink

An abrupt deviation from a flat plane or the normal contours of bow and warp; most commonly found near the edge of a piece of heat-treated glass.

Knife Consistency

Compound formulated in a degree of firmness suitable for application with a putty knife such as used for face glazing and other sealant applications.

Knocked Down (KD)

Fabricated framing components shipped loose for assembly at another location.

Laminated Glass

Two or more lites of glass permanently bonded together with one or more interlayers.

Laminated Plastics (Plastic Laminates)

Two or more lites (or sheets) of polycarbonate (or acrylic) with an aliphatic urethane interlayer between polycarbonate or acrylic bonded together under heat and pressure.

Lehr

A long tunnel-shaped oven for annealing glass, usually by a continuous process.

Lite

Another term for a pane of glass. Sometimes spelled "light" in industry literature, but spelled "lite" in this text to avoid confusion with light as in "visible light."

Live Load

Load produced by the use and occupancy of the building or other structure. Does not include construction or environmental loads such as wind load, snow load, ice load, rain load, seismic load, or dead load.

Low-emissivity (low-e)

A low rate of emitting (radiating) absorbed radiant energy. The radiant energy (heat, i.e., long-wave infrared) is in effect reradiated back toward its source.

Luminous Efficacy (Light-to-Solar Gain Ratio)

The visible transmittance of a glazing system divided by the solar heat gain coefficient (or shading coefficient). This ratio is helpful in selecting glazing products for different climates in terms of those that transmit more heat than light and those that transmit more light than heat.

Mastic

Descriptive of heavy-consistency compounds that may remain adhesive and pliable with age.

Microscopic Surface Particles

Any glass fines, debris, dust, grit, refractory particles, etc. that are invisible to the naked eye and that adhere to one or both glass surfaces during the heat-treating process.

Migration

Spreading or creeping of a constituent of a compound onto/into adjacent surfaces. See Bleeding.

Modulus

Stress at a given strain. Also tensile strength at a given elongation.

Mullion

A horizontal or vertical member that supports and holds such items as panels, glass, sash, or sections of a curtain wall.

Multiple-Glazed Units

Insulating glass units with three or more lites of glass.

Muntins

Horizontal or vertical bars that divide the sash frame into smaller lites of glass. Muntins are smaller in dimensions and weight than mullions.

Neoprene

A synthetic rubber having physical properties closely resembling those of natural rubber. It is made by polymerizing chloroprenes, and the latter is produced from acetylene and hydrogen chloride.

Non-Drying (Non-Curing)

A sealant that does not set up or cure.

Non-Sag

A sealant formulation having a consistency that will permit application in vertical joints without appreciable sagging or slumping. A performance characteristic that allows the sealant to be installed in a sloped or vertical joint application without appreciable sagging or slumping.

Non-Skinning

Descriptive of a product that does not form a surface skin.

Non-Staining

Characteristic of a compound that will not stain a surface.

Nozzle

The tubular tip of a caulking gun through which the compound is extruded.

OITC (Outside-Inside Transmission Class)

A rating used to classify the performance of glazing in exterior applications (for more information see ASTM E 1332 and ASTM E 1425).

Obscure Glass

(See Patterned Glass)

Organic

Any compound that consists of carbon and hydrogen with a restricted number of other elements, such as oxygen, nitrogen, sulphur, phosphorous, chlorine, etc.

Patterned Glass

One type of rolled glass having a pattern impressed on one or both sides. Used extensively for light control, bath enclosures, and decorative glazing. Sometimes called "rolled," "figured," or "obscure" glass.

Permanent Set

The amount by which a material fails to return to its original dimensions after being deformed by an applied force or load.

Pocket (Channel)

A three-sided, U-shaped opening in a sash or frame to receive glazing infill. Contrasted to a rabbet, which is a two-sided, L-shaped section, as with face-glazed window sash.

Pocket (Channel) Depth

The inside dimension from the bottom of the pocket to the top. Pocket depth equals the bite plus the edge clearance.

Pocket Glazing

(See Flush Glazing)

Pocket (Channel) Width

The measurement between stationary stops (or stationary stop and removable stop) in a U-shaped channel.

Points

Thin, flat triangular or diamond-shaped pieces of zinc used to hold glass in wood sash by driving them into the wood.

Polariscope

A device for examining the degree of strain in a sample of glass.

Polished Wired Glass

Wired glass that has been ground and polished on both surfaces.

Polyisobutylene

Typically the primary seal in a dual-seal IG unit and the key component in restricting moisture vapor transmission.

Polymer

A chemical structure consisting of long chains of molecular units.

Polysulfide Sealant

Polysulfide liquid polymer sealants that are mercaptan terminated, long-chain aliphatic polymers containing disulfide linkages, can be converted to rubbers at room temperature without shrinkage upon addition of a curing agent.

Polyurethane Sealant

An organic compound formed by the reaction of a glycol with an isocyanate.

Polyvinyl Chloride (PVC)

Polymer formed by polymerization of vinyl chloride monomer. Sometimes called vinyl.

Pot Life

The time interval following the addition of an accelerator before a chemically curing material will become too viscous to apply satisfactorily.

Pre-Shimmed Tape Sealant

A sealant having a preformed shape containing solids or discrete particles that limit its deformation under compression.

Primer

A coating specifically designed to enhance the adhesion of sealant systems to certain surfaces to form a barrier to prevent migration of components or to seal a porous substrate.

Priming

Sealing of a porous surface so that compound will not stain, lose elasticity, shrink excessively, etc. because of loss of oil or vehicle into the surround. A sealant primer or surface conditioner may be used to promote adhesion of a curing type sealant to certain surfaces.

Pyrolytic Deposition

A process for applying a thin metallic coating to the surface of flat glass during the float glass manufacturing process.

Rabbit

An L-shaped section that can be face glazed or receive a removable glazing bead to hold the lite of glass in place.

Racking

A movement or distortion of sash or frames causing a change in angularity of corners.

Reflective Glass

Glass with a metallic coating to reduce solar heat gain (see also Solar Control Glass).

Relative Heat Gain

The amount of heat gain through a glass product taking into consideration the effects of solar heat gain (shading coefficient) and conductive heat gain (U-value). The value is expressed in Btu/hr/ft² (W/m²).

The relative heat gain is calculated as $RHG = (\text{Summer U-value} \times 140F) + (\text{Shading Coefficient} \times 200)$. The lower the relative heat gain, the more the glass product restricts heat gain.

Removable Double Glazing (RDG)

A removable glazed panel or sash on the inside or outside of an existing sash or window, such as a storm panel, used for additional insulation and protection against the elements.

Roll (or Roller) Distortion

Waviness imparted to horizontal heat-treated glass while the glass is transported through the furnace on a roller conveyor. The waves produce a distortion when the glass is viewed in reflection.

Roll Impressions

Indentations in the surface of rolled glass that are caused by contact of the glass with the rolls and/or displaced roll disks while the glass surface is in a plastic state.

Roll Marks (also Roll Scratches)

A series of fine parallel scratches or tears on the surface of rolled glass in the direction of draw. They are 1/8" (3 mm) long or smaller, but usually so fine and so close together that they appear to be a series of incipient checks rather than scratches. They are caused by a difference in velocity between rolls and the sheet of glass.

Rolled Glass

Glass formed by rolling, including patterned and wired glass.

Rough Opening

The opening in a wall into which a door or window is to be installed.

Rub

A series of small scratches in glass generally caused during transport by a chip lodged between two lites.

R-Value

The thermal resistance of a glazing system expressed ft²/hr/oF/Btu (m²/W/oC). The R-value is the reciprocal of the U-value. The higher the R-value, the less heat is transmitted throughout the glazing material.

STC (Sound Transmission Class)

A single number rating derived from individual transmission losses at specified test frequencies (for more information see ASTM E 90 and ASTM E 413). It is used for interior walls, ceilings, and floors and in the past was also used for preliminary comparison of the performance of various glazing materials.

STL (Sound Transmission Loss)

The reduction of the amount of sound energy passing through a wall, floor, roof, etc. It is related to the specific frequency (Hz) at which it is measured and is expressed in decibels (dB). Also called "Transmission Loss" (TL).

Sandblasted Finish

A surface treatment for flat glass obtained by spraying the glass with hard particles to roughen one or both surfaces of the glass. The effect is to increase obscurity and diffusion, but it makes the glass weaker and harder to clean.

Sash

The window frame, including muntin bars if used, to receive the glazing infill.

Score

To penetrate the surface of a lite of glass by means of a cutting device, e.g., a glass cutter, along a predetermined line in order to produce a lite of glass of a specific size and/or shape.

Scratches

Any marking or tearing of the surface appearing as though it had been done by either a sharp or rough instrument.

Screw-On Bead (or Applied Stop)

Stop, molding, or bead fastened by screws as compared with those that snap into position without additional fastening.

Sealant

An elastomeric material with adhesive qualities, applied between components of a similar or dissimilar nature to provide an effective barrier against the passage of the elements.

Sealed Insulating Glass Units

(See Insulating Glass Unit)

Seam

(v) To grind, usually with an abrasive belt, wet or dry, the sharp edges of a piece of glass.

Seeds

Minute bubbles in float glass less than 1/32" (.8 mm) in diameter.

Setting

Placement of lites or panels in sash or frames. Also action of a compound as it becomes more firm after application.

Setting Blocks

Generally, rectangular cured extrusions of neoprene, EPDM, silicone, rubber, or other suitable material on which the glass product bottom edge is placed to effectively support the weight of the glass.

Shading Coefficient

The ratio of the solar heat gain through a specific glass product to the solar heat gain through a lite of 1/8" (3mm) clear glass. Glass of 1/8" (3mm) thickness is given a value of 1.0; therefore, the shading coefficient of a glass product is calculated as follows:

$$S.C. = \frac{\text{Solar Heat Gain of the Glass in Question}}{\text{Solar Heat Gain of 1/8" Clear Glass}}$$

Shadowgraph

A device for inspecting glass with respect to distortion and other defects.

Shelf Life

Used in the glazing and sealant business to refer to the length of time a product may be stored before beginning to lose its effectiveness. Manufacturers usually state the shelf life and the necessary storage conditions on the package.

Shims

(See Spacers)

Shore "A" Hardness

Measure of firmness of a compound by means of a Durometer Hardness Gauge (Shore "A" hardness range of 20-25 is about the firmness of an art gum eraser. A hardness of 90 is about the firmness of a rubber heel).

Sight Line

The line along the perimeter of glazing infills corresponding to the top edge of stationary and removable stops. The line to which sealants contacting the glazing infill are sometimes finished off.

Silicone Sealant

A sealant having as its chemical composition a backbone consisting of alternating silicon-oxygen atoms.

Sloped Glazing

Any installation of glass that is at a slope of 15 degrees or more from vertical.

Smoke

Streaked areas appearing as slight discoloration on glass.

Solar Control Glass

Tinted and/or coated glass that reduces the amount of solar heat gain transmitted through a glazed product.

Solar Energy Reflectance

In the solar spectrum, the percentage of solar energy that is reflected from the glass surface(s).

Solar Energy Transmittance

The percentage of ultraviolet, visible, and near infrared energy within the solar spectrum (300 to 2100 nanometers) that is transmitted through the glass.

Solar Heat Gain Coefficient

The ratio of the solar heat gain entering the space area through the fenestration product to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

Solarization

Change in transmission, and sometimes color, of plastics as a result of exposure to sunlight or other radiation.

Sound Transmission Class (See STC)**Sound Transmission Loss** (See STL).**Spacers (Shims)**

Small blocks of neoprene, EPDM, silicone, or other suitable material placed on each side of the glass product to provide glass centering, maintain uniform width of sealant bead, and prevent excessive sealant distortion.

Spandrel

The panel(s) of a wall located between vision areas of windows that conceal structural columns, floors, and shear walls.

Spectrally Selective Glass

Tinted and/or coated flat glass that reduces the amount of solar heat gain transmitted through a glazed product.

Sputtering (See Vacuum (Sputtering) Deposition)**Stain**

Discoloration of either a glass or finished aluminum surface caused by alkalis that leach from surrounding materials such as precast or cast-in-place concrete or from sealants, pollutants, or other contaminants.

Stones

Any crystalline inclusion imbedded in the glass.

Stop

Either the stationary lip or the removable molding of the rabbet, serving to hold the glazing infill in the sash or frame with the help of spacers.

Storm Door

A panel or sash door placed on the outside of an existing door to provide additional protection from the elements. GANA Glazing Manual-102, 2004.

Storm Window

A glazed panel or sash placed on the inside or outside of an existing sash or window as additional protection against the elements.

Strain

The percentage of elongation or compression of a material or portion of a material caused by an applied force.

Strain Pattern

A specific geometric pattern of iridescence or darkish shadows that may appear under certain lighting conditions, particularly in the presence of polarized light (also called quench marks). The phenomenon is caused by the localized stresses imparted by the rapid air cooling of the tempering operation. Strain pattern is characteristic of heat-treated glass.

Stress (Residual)

Any condition of tension or compression existing within the glass, particularly due to incomplete annealing, temperature gradient, or inhomogeneity.

Striking Off

The operation of smoothing off excess compound or sealant at sight line when applying same around lites or panels.

Structural Glazing Gaskets

Cured elastomeric channel-shaped extrusions used in place of a conventional sash to install glass products onto structurally supporting sub-frames, with the pressure of sealing exerted by the insertion of separate lockstrip wedging splines.

Structural Silicone Glazing

The use of a silicone sealant for the structural transfer of loads from the glass to its perimeter support system and retention of the glass in the opening.

Substrate

A base material to which other materials or fabrication procedures are applied.

Tape Sealant

A sealant having a preformed shape and intended to be used in a joint under compression.

Tempered Glass (See Fully Tempered Glass)**Thermal Endurance**

The relative ability of glass to withstand thermal shock.

Tinted Glass

Glass with colorants added to the basic glass batch that give the glass color as well as light- and heat-reducing capabilities. The color extends throughout the thickness of the glass. Typical colors include bronze, grey, dark grey, aquamarine, green, deep green, blue, and black.

Toe Bead

Sealant applied at the intersection of the outboard glazing stop and the bottom of the glazing channel; must be sized to also provide a seal to the edge of the glass.

Tong Marks

Small surface indentations near and parallel to one edge of vertically tempered or vertically heat-strengthened glass resulting from the tongs used to suspend the glass during the heat-treating process.

Tooling

The operation of pressing in and striking a sealant in a joint to press the sealant against the sides of a joint and secure good adhesion; the finishing off of the surface of a sealant in a joint so that it is flush with the surface.

Toughened Glass

International terminology for fully tempered glass (see Fully Tempered Glass).

Transmittance

The ability of glass to pass light and/or heat, usually expressed in percentages (visible transmittance, thermal transmittance, etc.).

Two-Part (Multi-Component) Sealant

A product comprised of a base and curing agent or accelerator, necessarily packaged in two separate containers, that are uniformly mixed just prior to use.

Ultraviolet

The name of the invisible portion of the light spectrum with wavelengths shorter than 390 nanometers.

Unit

Term normally used to refer to one single assembly of insulating glass.

United Inches

Total of one width and one height of a lite of glass in inches.

U-Value

A measure of air-to-air heat transmission (loss or gain) due to the thermal conductance and the difference in indoor and outdoor temperatures. As the U-value decreases, so does the amount of heat that is transferred through the glazing material. The lower the U-value, the more restrictive the fenestration product is to heat transfer. Reciprocal of R-value.

Vacuum (Sputtering) Deposition

Process for applying multiple layers of metallic coatings to the surface of flat glass in a vacuum chamber.

Vents (See Checks)**Vinyl Glazing**

Holding glass in place with extruded vinyl channel or roll-in type.

Visible Light Reflectance

The percentage of visible light (390 to 770 nanometers) within the solar spectrum that is reflected from the glass surface.

Visible Light Transmittance

The percentage of visible light (390 to 770 nanometers) within the solar spectrum that is transmitted through glass.

Warp

(See Bow and Warp)

Wave

An optical effect in flat glass due to irregularities in the surface of the glass that make objects viewed at various angles appear wavy or bent.

Weathering (also Stain)

Attack of a glass surface by atmospheric elements.

Weather-stripping

A material or device used to seal the opening between sash and/or sash and frame.

Weeps (or Weep Holes)

Drain holes or slots in the sash or framing member to prevent accumulation of condensation and water.

Wet Seal

Application of an elastomeric sealant between the glass and sash to form a weather-tight seal.

Window

An opening constructed in a wall or roof and functioning to admit light or air to an enclosure, usually framed and spanned with glass mounted to permit opening and closing.

Wired Glass

Rolled glass having a layer of meshed or stranded wire completely imbedded as nearly as possible to the center of thickness of the lite. This glass is available as polished glass (one or both surfaces) and patterned glass. Approved polished wired glass is used as transparent or translucent fire protection rated glazing. Patterned wired glass is sometimes used as decorative glass. It breaks more easily than unwired glass of the same thickness, but the wire restrains the fragments from falling out of the frame when broken.

Work Life

The time during which a curing sealant (usually two compounds) remains suitable for use after being mixed with a catalyst.

Zebra Board

A board with alternating black and white diagonal lines used to observe optical transmission and reflection qualities in coated and uncoated glass.



VII.

PERFORMANCE SUMMARY TABLES

Architectural Low-e Glass

Energy Select™ chart 1	248
Energy Select 25 chart 2	249

Residential Low-e Glass

Comfort Select™

Dual Glazed chart 3	250
U4 Dual Glazed chart 4	251
Triple Glazed (1 Low-e lite) chart 5	252
Triple Glazed (2 Low-e lites) chart 6	253

Tinted Float Glass

Solarshield® – Monolithic chart 7	254
Solarshield – Dual Glazed chart 8	255
Solarshield – Dual Glazed Low-e chart 9	256

Reflective Glass

Stopsol® – Monolithic chart 10	257
Stopsol – Dual Glazed chart 11	258
Stopsol – Dual Glazed Low-e chart 12	259

Acoustical Performance Data chart 13	260
--------------------------------------	-----

Energy Select™ - Architectural Low-E Glass													
Dual Glazing (6 12 6)	Product	Visible Light			Reflectance			U-Value (Air)		SC	SHGC	LSG	DW
		Trans	Solar	UV	Ref Out	Ref In	Solar	Air	Argon				
	Energy Select 28 #2 Clear	62%	23%	4%	10%	11%	36%	0.29	0.23	0.32	0.28	2.21	0.41
	Energy Select 36 #2 Clear	63%	31%	13%	12%	16%	30%	0.29	0.25	0.41	0.36	1.75	0.28
	Energy Select 40 #2 Clear	69%	34%	17%	12%	12%	31%	0.29	0.25	0.44	0.39	1.79	0.37
	Energy Select R42 #2 Clear	62%	37%	22%	26%	21%	33%	0.30	0.25	0.49	0.42	1.46	0.34
	Clear Energy Select 63 #3	76%	48%	32%	11%	11%	23%	0.30	0.26	0.68	0.59	1.29	0.63

chart 2 Energy Select 25 - Low-E Solutions on Solarshield Tints													
Dual Glazing (6 12 6)	Product	Visible Light			Reflectance			U-Value (Air)		SC	SHGC	LSG	DW
		Trans	Solar	UV	Ref Out	Ref In	Solar	Air	Argon				
	Energy Select 25 Pure Grey #2 Clear	36%	18%	7%	6%	10%	14%	0.29	0.25	0.29	0.25	1.40	0.28
	Energy Select 25 Pure Bronze #2 Clear	40%	20%	6%	7%	15%	16%	0.29	0.25	0.31	0.27	1.47	0.28
	Energy Select 25 Meadow Green #2 Clear	51%	20%	6%	10%	15%	8%	0.29	0.25	0.32	0.28	1.86	0.37
	Energy Select 25 Forest Green #2 Clear	48%	19%	4%	9%	14%	7%	0.29	0.25	0.30	0.26	1.87	0.34

chart 3 Comfort Select™ - Residential Low-E Coatings

Product	Dual Glazing 1/8" -1/2" - 1/8" (3 12 3)			Visible Light				Reflectance				U-Value (Air)		SHGC	SC	LSG	DW
	Trans	Solar		UV	Ref Out	Ref In	Solar	Ref Out	Ref In	Solar	Air	Argon					
		67%	52%										33%	33%	20%	17%	43%
Clear Comfort Select 73 #3	74%	58%	43%	43%	43%	17%	16%	0.33	0.29	0.83	0.72	1.03	0.63				
Clear Comfort Select 63 #3	79%	52%	38%	12%	12%	26%	26%	0.31	0.26	0.70	0.61	1.30	0.67				
Comfort Select R42 #2 Clear	65%	39%	24%	25%	20%	38%	38%	0.30	0.25	0.49	0.43	1.50	0.50				
Comfort Select 40 #2 Clear	72%	36%	19%	12%	13%	37%	37%	0.29	0.25	0.45	0.39	1.85	0.56				
Comfort Select 36 #2 Clear	66%	33%	15%	13%	17%	35%	35%	0.29	0.25	0.41	0.36	1.82	0.50				
Comfort Select 28 #2 Clear	62%	25%	14%	13%	15%	48%	48%	0.29	0.24	0.32	0.28	2.22	0.45				

chart 4 U4 - 4th Surface Technology - Residential Low-E configurations

Product	Dual Glazing 1/8" -1/2" - 1/8" (3 12 3)			Visible Light				Reflectance				U-Value (Air)		SHGC	SC	LSG	DW
	Trans	Solar		UV	Ref Out	Ref In	Solar	Ref Out	Ref In	Solar	Air	Argon					
		67%	52%										33%	33%	20%	17% <th>43%</th> <th>17%</th> <th>16%</th> <th>0.26</th> <th>0.23</th>	43%
Comfort Select 73 #2 U4	72%	47%	29%	14%	15%	28%	28%	0.24	0.21	0.62	0.54	1.34	0.58				
Comfort Select R42 #2 U4	59%	36%	19%	27%	22%	39%	39%	0.24	0.20	0.47	0.41	1.45	0.43				
Comfort Select 40 #2 U4	66%	32%	14%	14%	16%	38%	38%	0.23	0.20	0.43	0.37	1.78	0.48				
Comfort Select 36 #2 U4	60%	30%	12%	15%	19%	36%	36%	0.23	0.20	0.39	0.34	1.75	0.44				
Comfort Select 28 #2 U4	56%	23%	10%	14%	17%	48%	48%	0.23	0.20	0.30	0.26	2.14	0.39				

chart 5 Comfort Select™ Coatings - Triple Glazed units with One (1) Low-e lite

Product	Visible Light			Reflectance			SC	SHGC	LSG	DW	
	Trans	Solar		Ref Out	Ref In						U-Value (Air)
		UV	Solar		Solar	Argon					
Triple Glazing 1/8" 7/16" 1/8" 7/16" 1/8" 3 11 3 11 3											
Comfort Select 73 #2 Clear Clear	68%	50%	36%	35%	23%	19%	0.25	0.21	0.68	0.59	
Comfort Select 63 #2 Clear Clear	72%	45%	32%	17%	18%	29%	0.25	0.23	0.60	0.52	
Comfort Select R42 #2 Clear Clear	60%	34%	20%	29%	25%	40%	0.23	0.19	0.46	0.40	
Comfort Select 40 #2 Clear Clear	66%	32%	16%	17%	19%	40%	0.23	0.19	0.41	0.36	
Comfort Select 36 #2 Clear Clear	60%	29%	13%	17%	22%	37%	0.23	0.19	0.39	0.34	
Comfort Select 28 #2 Clear Clear	56%	23%	12%	16%	20%	49%	0.23	0.19	0.30	0.26	

chart 6 Comfort Select Coatings - Triple Glazed units with Two (2) Low-e lites

Product	Visible Light			Reflectance			SC	SHGC	LSG	DW	
	Trans	Solar		Ref Out	Ref In						U-Value (Air)
		UV	Solar		Solar	Argon					
Triple Glazing 1/8" 7/16" 1/8" 7/16" 1/8" 3 11 3 11 3											
Comfort Select 73 #2 Clear CS 73 #5	62%	44%	27%	23%	23%	20%	0.20	0.16	0.64	0.56	
Comfort Select 63 #2 Clear CS 63 #5	70%	40%	23%	15%	15%	30%	0.20	0.18	0.56	0.49	
Comfort Select R42 #2 Clear CS 63 #5	58%	31%	15%	27%	22%	40%	0.18	0.14	0.44	0.38	
Comfort Select 40 #2 Clear CS 63 #5	64%	30%	12%	15%	16%	38%	0.18	0.14	0.40	0.35	
Comfort Select 36 #2 Clear CS 63 #5	58%	27%	9%	15%	19%	37%	0.18	0.14	0.38	0.33	
Comfort Select 28 #2 Clear CS 63 #5	55%	22%	9%	14%	17%	49%	0.17	0.14	0.30	0.26	

Solarshield® Tinted Float Glass												
Product	Visible Light			Reflectance			U-Value (Air)		SC	SHGC	LSG	DW
	Trans	Solar	UV	RefOut	RefIn	Solar	Air	Argon				
Pure Grey	45%	44%	25%	5%	5%	5%	1.02	0.93	0.69	0.59	0.76	0.41
Pure Bronze	54%	48%	24%	5%	5%	48%	1.02	0.93	0.62	0.62	0.87	0.43
Pure Green	77%	47%	30%	7%	7%	5%	1.02	0.93	0.71	0.61	1.26	0.63
Meadow Green	70%	37%	20%	6%	6%	5%	1.02	0.93	0.63	0.55	1.27	0.55
Forest Green	65%	33%	15%	6%	6%	5%	1.02	0.93	0.60	0.52	1.26	0.49
Sky Blue	73%	47%	37%	7%	7%	5%	1.02	0.94	0.71	0.61	1.20	0.65
Pure Blue	57%	42%	31%	6%	6%	5%	1.02	0.92	0.62	0.58	0.98	0.57
Midnight Blue	34%	18%	17%	5%	5%	4%	1.02	0.92	0.49	0.42	0.83	0.37

Glazing Solutions with Solarshield Tints												
Product	Visible Light			Reflectance			U-Value (Air)		SC	SHGC	LSG	DW
	Trans	Solar	UV	RefOut	RefIn	Solar	Air	Argon				
Pure Grey Clear	40%	35%	20%	7%	12%	6%	0.48	0.45	0.54	0.47	0.85	0.36
Pure Bronze Clear	48%	39%	19%	8%	12%	7%	0.48	0.45	0.58	0.51	0.94	0.38
Pure Green Clear	68%	39%	25%	11%	13%	7%	0.47	0.45	0.58	0.50	1.37	0.56
Meadow Green Clear	63%	31%	17%	11%	13%	7%	0.47	0.45	0.49	0.43	1.45	0.48
Forest Green Clear	58%	28%	12%	10%	13%	6%	0.47	0.45	0.46	0.40	1.45	0.44
Sky Blue Clear	65%	39%	31%	11%	13%	7%	0.47	0.45	0.57	0.50	1.31	0.58
Pure Blue Clear	50%	35%	26%	8%	12%	7%	0.47	0.45	0.53	0.46	1.09	0.50
Midnight Blue Clear	31%	15%	14%	6%	11%	5%	0.47	0.45	0.34	0.29	1.05	0.32

chart 9 Solar Control Solutions with Solarshield® Tints												
Product	Visible Light		Reflectance			U-Value (Air)		SC	SHGC	LSG	DW	
	Trans	Solar	UV	Ref Out	Ref In	Solar	Air					Argon
Pure Grey Energy Select 63 (3)	39%	26%	14%	6%	9%	10%	0.30	0.26	0.41	0.36	1.08	0.33
Pure Bronze Energy Select 63 (3)	46%	29%	13%	7%	10%	12%	0.30	0.26	0.45	0.39	1.19	0.35
Pure Green Energy Select 63 (3)	67%	32%	17%	9%	11%	9%	0.30	0.26	0.48	0.41	1.61	0.52
Meadow Green Energy Select 63 (3)	61%	26%	12%	9%	11%	7%	0.30	0.26	0.41	0.36	1.71	0.45
Forest Green Energy Select 63 (3)	56%	24%	9%	8%	10%	6%	0.30	0.26	0.37	0.33	1.72	0.41
Sky Blue Energy Select 63 (3)	63%	31%	21%	9%	11%	9%	0.30	0.26	0.47	0.41	1.54	0.53
Pure Blue Energy Select 63 (3)	49%	27%	18%	7%	10%	9%	0.30	0.26	0.43	0.37	1.32	0.46
Midnight Blue Energy Select 63 (3)	30%	13%	10%	6%	9%	5%	0.30	0.26	0.25	0.22	1.35	0.30

chart 10 Stopsol® Reflective Coatings												
Product	Visible Light		Reflectance			U-Value (Air)		SC	SHGC	LSG	DW	
	Trans	Solar	UV	Ref Out	Ref In	Solar	Air					Argon
Classic Clear	38%	49%	20%	27%	34%	28%	1.02	0.92	0.65	0.58	0.65	0.29
Classic Grey	19%	29%	7%	10%	34%	10%	1.02	0.92	0.55	0.47	0.39	0.15
Classic Bronze	21%	32%	6%	12%	34%	11%	1.02	0.92	0.57	0.49	0.44	0.15
Classic Green	31%	22%	7%	20%	34%	27%	1.02	0.92	0.44	0.43	0.73	0.21
Classic Dark Blue	24%	20%	10%	14%	34%	9%	1.02	0.92	0.49	0.42	0.58	0.20
Supersilver Clear	62%	65%	36%	33%	35%	23%	0.99	0.89	0.79	0.68	0.91	0.51
Supersilver Grey	29%	35%	12%	11%	34%	9%	1.00	0.90	0.60	0.51	0.57	0.24
Supersilver Green	51%	31%	12%	24%	34%	12%	0.99	0.89	0.56	0.48	1.06	0.36
Supersilver Dark Blue	42%	34%	21%	15%	30%	22%	1.00	0.92	0.55	0.50	0.83	0.40
Silverlight PrivateBlue	27%	14%	10%	8%	24%	17%	1.02	0.95	0.41	0.39	0.69	0.25

chart 11 Glazing Solutions with Stopsol® Reflective Coatings

Product	Visible Light						Reflectance						U-Value (Air)		SC	SHGC	LSG	DW		
	Trans		Solar		UV		RefOut	RefIn	Solar	Argon	Air	Argon	Air	Argon						
	34%	40%	16%	10%	28%	35%													22%	0.47
Dual Glazing 1/4" - 1/2" - 1/4" (6 12 6)																				
Classic Clear (2) Clear	17%	23%	6%	10%	12%	35%	28%	35%	10%	22%	0.47	0.45	0.47	0.45	0.41	0.36	0.47	0.13	0.13	
Classic Grey (2) Clear	20%	26%	5%	12%	20%	35%	20%	35%	11%	11%	0.47	0.45	0.47	0.45	0.44	0.38	0.51	0.13	0.13	
Classic Bronze (2) Clear	28%	18%	6%	20%	14%	35%	14%	35%	10%	10%	0.47	0.45	0.47	0.45	0.37	0.32	0.67	0.18	0.18	
Classic Dark Blue (2) Clear	22%	19%	8%	14%	36%	36%	36%	36%	26%	26%	0.47	0.45	0.47	0.45	0.69	0.60	0.93	0.45	0.45	
Supersilver Clear (2) Clear	27%	29%	10%	12%	29%	35%	12%	35%	10%	10%	0.47	0.45	0.47	0.45	0.47	0.41	0.65	0.22	0.22	
Supersilver Grey (2) Clear	46%	27%	11%	26%	17%	35%	26%	35%	13%	13%	0.47	0.45	0.47	0.45	0.43	0.38	1.22	0.33	0.33	
Supersilver Green (2) Clear	38%	28%	18%	17%	32%	32%	17%	32%	11%	11%	0.47	0.45	0.47	0.45	0.46	0.40	0.95	0.36	0.36	
Supersilver Dark Blue (2) Clear	24%	12%	8%	8%	27%	27%	8%	27%	6%	6%	0.47	0.45	0.47	0.45	0.30	0.26	0.92	0.23	0.23	
Silverlight PrivateBlue (2) Clear																				

chart 12 Solar Control Solutions with Stopsol Reflective Coatings

Product	Visible Light						Reflectance						U-Value (Air)		SC	SHGC	LSG	DW			
	Trans		Solar		UV		RefOut	RefIn	Solar	Argon	Air	Argon	Air	Argon							
	33%	16%	15%	4%	10%	28%													31%	33%	0.30 <td>0.26</td> <td>0.41</td> <td>0.35</td> <td>0.93</td> <td>0.24</td>
Dual Glazing 1/4" - 1/2" - 1/4" (6 12 6)																					
Classic Clear (2) Energy Select 63 (3)	19%	16%	4%	12%	20%	31%	10%	31%	15%	15%	0.30	0.26	0.30	0.26	0.28	0.24	0.67	0.12	0.12	0.12	
Classic Grey (2) Energy Select 63 (3)	27%	14%	4%	20%	14%	31%	14%	31%	12%	12%	0.30	0.26	0.30	0.26	0.30	0.26	0.73	0.12	0.12	0.18	
Classic Bronze (2) Energy Select 63 (3)	21%	13%	6%	14%	19%	31%	14%	31%	12%	12%	0.30	0.26	0.30	0.26	0.26	0.22	1.21	0.18	0.17	0.17	
Classic Dark Blue (2) Energy Select 63 (3)	54%	38%	19%	35%	32%	32%	19%	35%	32%	37%	0.30	0.26	0.30	0.26	0.54	0.47	1.16	0.41	0.41	0.41	
Supersilver Clear (2) Energy Select 63 (3)	26%	20%	7%	11%	7%	31%	7%	31%	14%	14%	0.30	0.26	0.30	0.26	0.34	0.29	0.87	0.20	0.20	0.20	
Supersilver Grey (2) Energy Select 63 (3)	45%	21%	7%	25%	32%	32%	45%	25%	32%	14%	0.30	0.26	0.30	0.26	0.34	0.30	1.49	0.31	0.31	0.31	
Supersilver Green (2) Energy Select 63 (3)	37%	21%	12%	16%	29%	29%	37%	16%	29%	13%	0.30	0.26	0.30	0.26	0.35	0.30	0.20	0.33	0.33	0.33	
Supersilver Dark Blue (2) Energy Select 63 (3)	23%	10%	6%	8%	24%	24%	23%	8%	24%	6%	0.30	0.26	0.30	0.26	0.22	0.19	1.23	0.21	0.21	0.21	
Silverlight PrivateBlue (2) Energy Select 63 (3)																					

chart 13

Acoustical Performance Data

Riverbank Acoustical Laboratories TEST NO. 1	Nominal Thickness - (Configuration)	STC	OITC ²	Rw	U-Value Summer ³	U-Value Winter ³
	Monolithic					
TL 85-169	1/4"	31	29	32	1.01	1.08
TL 85-198	1/2"	37	31	37	0.97	1.03
	Laminated					
TL 85-218	1/4" - (Lami - 0.030" - Lami)	35	31	35	1.00	1.06
TL 85-170	1/4" - (1/8" - 0.030" - 1/8")	35	32	35	0.99	1.05
TL 85-224	1/4" - (1/8" - 0.060" - 1/8")	35	31	35	0.97	1.03
TL 85-234	1/4" - (1/8" - 0.045" - 1/8")	35	31	35	0.98	1.04
TL 85-200	3/8" - (3/16" - 0.030" - 3/16")	36	33	36	0.97	1.03
TL 85-229	3/8" - (1/4" - 0.030" - 1/8")	36	33	36	0.97	1.03
TL 85-223	3/8" - (1/4" - 0.060" - 1/8")	37	33	37	0.95	1.00
TL 85-225	1/2" - (1/4" - 0.030" - 1/4")	38	34	38	0.95	1.01
TL 85-232	1/2" - (1/4" - 0.045" - 1/4")	38	34	38	0.94	0.99
TL 85-228	1/2" - (1/4" - 0.060" - 1/4")	39	34	39	0.93	0.98

chart 13 (continued)

Acoustical Performance Data

TL 85-222	5/8" - (3/8" - 0.030" - 1/4")	40	36	40	0.93	0.99
TL 85-230	3/4" - (1/2" - 0.060" - 1/4")	41	36	41	0.90	0.95
	Insulating ^{4,5,6}					
TL 85-212	1/2" - (1/8" - 1/4" AS - 1/8") (SEALED)	28	26	30	0.62	0.57
TL 85-213	5/8" - (1/8" - 3/8" AS - 1/8") (SEALED)	31	26	32	0.57	0.52
TL 85-294	1" - (1/4" - 1/2" AS - 1/4") (SEALED)	35	27	37	0.54	0.48
TL 85-215	1-3/8" - (3/16" - 1" AS - 3/16") (SEALED)	35	28	35	0.54	0.48
TL 85-293	1-1/2" - (1/4" - 1" AS - 1/4") (UNSEALED)	37	30	37	0.52	0.48
TL 85-216	4-3/8" - (3/16" - 4" AS - 3/16") (UNSEALED)	44	35	44	0.52	0.48
	Laminated Insulating ^{4,5,6}					
TL 95-296	5/8" - (1/8" - 0.030" - 1/8" - 1/4" AS - 1/8") (SEALED)	35	31	35	0.61	0.56
TL 85-189	13/16" - (1/8" - 0.030" - 1/8" - 3/8" AS - 3/16") (SEALED)	37	31	37	0.55	0.50
TL 85-238	15/16" - (1/8" - 0.030" - 1/8" - 1/2" AS - 3/16") (SEALED)	39	31	39	0.53	0.48
TL 85-235	1" - (1/8" - 0.030" - 1/8" - 1/2" AS - 1/4") (SEALED)	39	31	39	0.53	0.48
TL 85-192	1-1/8" - (1/8" - 0.030" - 1/4" - 1/2" AS - 1/4") (SEALED)	40	31	40	0.53	0.47
TL 85-239	1-7/16" - (1/8" - 0.030" - 1/8" - 1" AS - 3/16") (UNSEALED)	42	33	42	0.51	0.48

Acoustical Performance Data						
chart 13 (continued)	Nominal Thickness - (Configuration)	STC	OITC ²	Rw	U-Value Summer ³	U-Value Winter ³
	Laminated Insulating ^{4,5,6} (continued)					
TL 85-173	2-7/16" - (1/8" - 0.030" - 1/8" - 2" AS - 3/16") (UNSEALED)	45	35	45	0.51	0.48
TL 85-194	2-11/16" - (1/4" - 0.030" - 1/4" - 2" AS - 3/16") (UNSEALED)	46	42	47	0.50	0.47
TL 85-196	2-7/8" - (1/4" - 0.030" - 1/4" - 2" AS - 3/8") (UNSEALED)	46	38	46	0.49	0.46
TL 95-298	1-11/16" - (1/4" - 0.030" - 1/4" - 1" AS - 3/16") (UNSEALED)	47	36	47	0.52	0.47
TL 85-174	4-7/16" - (1/8" - 0.030" - 1/8" - 4" AS - 3/16") (UNSEALED)	48	38	48	0.51	0.48
TL 85-195	4-11/16" - (1/4" - 0.030" - 1/4" - 4" AS - 3/16") (UNSEALED)	49	41	49	0.50	0.47
TL 85-197	4-7/8" - (1/4" - 0.030" - 1/4" - 4" AS - 3/8") (UNSEALED)	49	43	50	0.49	0.46
TL 85-240	4-7/8" - (1/2" - 0.030" - 1/4" - 4" AS - 1/8") (UNSEALED)	49	39	49	0.49	0.46
TL 85-172	1-1/16" - (1/8" - 0.030" - 1/8" - 1/2" AS - 1/8" - 0.030" - 1/8") (SEALED)	42	33	42	0.52	0.47
TL 95-299	1-9/16" - (1/8" - 0.030" - 1/8" - 1" AS - 1/8" - 0.030" - 1/8") (UNSEALED)	46	37	46	0.52	0.47
TL 85-236	1-13/16" - (1/4" - 0.030" - 1/4" - 1" AS - 1/8" - 0.060" - 1/8") (UNSEALED)	46	34	46	0.49	0.46

Acoustical Performance Data						
TL 85-221	5-1/16" - (1/4" - 0.060" - 1/4" - 4" AS - 1/4" - 0.030" - 1/4") (UNSEALED)	50	42	50	0.48	0.45
TL 85-220	5-1/16" - (1/2" - 0.060" - 1/4" - 4" AS - 1/4" - 0.030" - 1/4") (UNSEALED)	50	42	50	0.47	0.44
TL 85-237	4-13/16" - (1/4" - 0.030" - 1/4" - 4" AS - 1/8" - 0.060" - 1/8") (UNSEALED)	51	43	51	0.49	0.46
TL 95-301A	4-9/16" - (1/8" - 0.030" - 1/8" - 4" AS - 1/8" - 0.030" - 1/8") (UNSEALED)	52	37	51	0.51	0.47
TL 95-302	4-13/16" - (1/8" - 0.030" - 1/8" - 4" AS - 1/4" - 0.060" - 1/4") (UNSEALED)	53	45	53	0.49	0.46
	Triple Glazing ^{4,5,6}					
TL 95-294	1-3/4" - (1/4" - 1/2" AS - 1/4" - 1/2" AS - 1/4") (SEALED)	39	31	39	0.37	0.31
TL 95-295	1-13/16" - (1/4" LAM. - 1/2" AS - 1/4" LAM. - 1/2" AS - 1/4" LAM.) (UNSEALED)	44	33	44	0.36	0.30
TL 95-297	2-1/4" - (1/4" - 1" AS - 1/4" - 1/2" AS - 1/4") (UNSEALED)	46	37	46	0.36	0.30
TL 95-300	2-5/16" - (1/4" LAM. - 1" AS - 1/4" LAM. - 1/2" AS - 1/4" LAM.) (UNSEALED)	49	39	49	0.35	0.30

Data Courtesy of Saflex®

Saflex® is a registered trademark of Solvita, Inc. The data set forth are based on samples tested at Riverbank Acoustical Laboratories and are not guaranteed for all samples or applications. The results are valid for glass only and were not tested as part of a window system. All insulator thicknesses indicate Saflex® PVB interlayer.

1 RAL TL 85 and TL 95 sound transmission loss tests are in accordance with ASTM E90.

STC ratings have been determined from TL data using ASTM E413.

2 Estimated. Computation based on a one-third octave band TL at 80 Hz (which was not measured in the laboratory) that is equal to the 100-Hz one-third octave band TL, minus 2dB.

3 Center of glass values calculated using LBNL Window5.2 for makeups using clear glass.

The overall heat transfer coefficient in BTU/hrq ft/F

4 AS - Air Space

5 Sealed configurations are insulated glass units having a secondary seal

6 Unsealed configurations are individual glass panels separated by wood stops and caulked into the laboratory test opening using gazing putty.