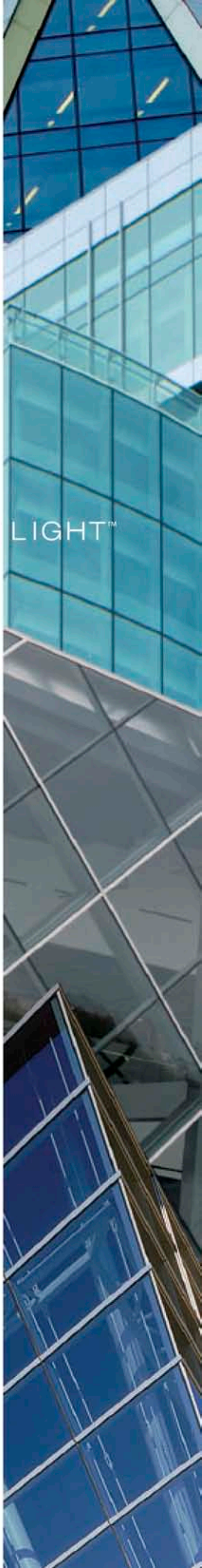
SunGuard®
GUARDIAN ADVANCED ARCHITECTURAL GLASS
GUARDIAN INDUSTRIES CORP.

SYRACUSE GLASS COMPANY

Technical Information

What you need to know to BUILD WITH LIGHT™



Contents

Introduction

Architects, designers and builders have more choices of glass today than ever before. Those choices can make a tremendous difference in your project's cost, energy efficiency and environmental impact. So you need accurate, detailed information to ensure that you choose the right glass.

This brochure provides technical information – including performance capabilities and glazing guidelines – for all types of SunGuard Advanced Architectural Glass from Guardian. It also contains instructions for the proper handling, maintenance and cleaning of the glass before, during and after building construction. We believe that you'll find most of the answers you need in this brochure, but you're always welcome to call us at 1-866-GuardSG (482-7374) to consult with a SunGuard Advanced Architectural Glass specialist or to order a glass sample.

Types of Glass

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

ANNEALED GLASS

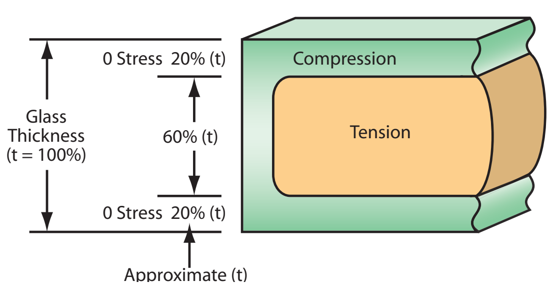
Float glass (also called "flat" glass) that has not been heat-strengthened or tempered is annealed glass. Annealing float glass is the process of controlled cooling to prevent residual stress in the glass and is an inherent operation of the float glass manufacturing process. Annealed glass can be cut,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

HEAT-STRENGTHENED GLASS

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

TEMPERED GLASS

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



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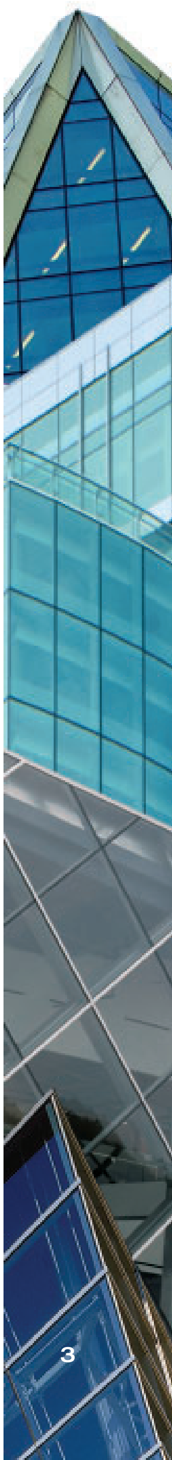
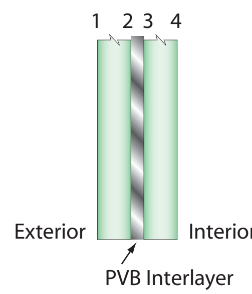


requirements of the various code organizations that set standards for safety glass. This type of glass is intended for general glazing, and safety glazing such as sliding doors, storm doors, building entrances, bath and shower enclosures, interior partitions and other uses requiring superior strength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

LAMINATED GLASS

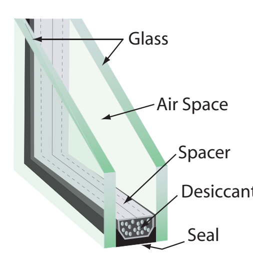
Laminated glass is two or more lites (pieces) of glass permanently bonded together with one or more plastic interlayers (PVB) using heat and pressure. The glass and interlayers can be a variety of colors and thicknesses designed to meet building code standards and requirements as necessary. Laminated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



INSULATING GLASS

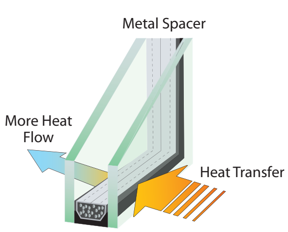
Insulating glass refers to two or more lites of glass sealed around the edges with an air space between, to form a single unit. Commonly referred to as an “IG unit,” insulating glass is the most effective way to reduce air-to-air heat transfer through the glazing. When used in conjunction with low-E and/or reflective glass coatings, IG units become effective means to conserve energy and comply with energy codes. The most common architectural insulating glass unit configuration is 1/4" glass/ 1/2" air space/ 1/4" glass.

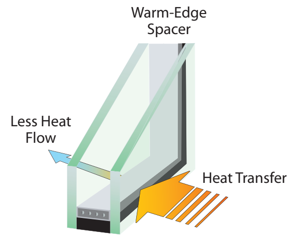
As low-E coatings have become better at reducing air-to-air heat transfer, spacer technology has become the focus of incremental thermal improvements. Typical commercial spacers are composed of formed aluminum filled with desiccant to absorb any residual moisture inside the IG unit, thus reducing potential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



WARM-EDGE SPACER

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

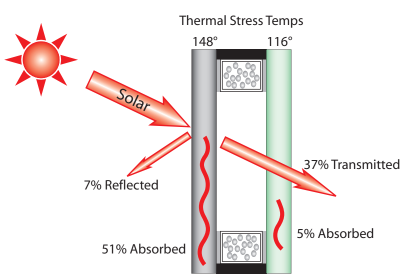




TINTED GLASS (HEAT-ABSORBING) VS. LOW-E COATED GLASS

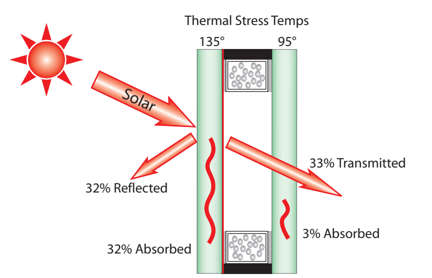
Low-E coatings reduce the amount of direct solar energy entering the building. Before the development of low-E coatings, architects relied on tinted (heat-absorbing glass) or reflective coatings to reduce solar energy transmission. Tinted glass almost always requires heat-treatment to reduce potential thermal stress and breakage and tends to reradiate the absorbed heat. Reflective coatings are effective at reducing heat gain but also reduce visible light transmission. Low-E coatings reflect solar energy away from the glazing, often without requiring heat-treatment, and generally have lower visible light reflection.

GRAY INSULATED GLASS UNIT

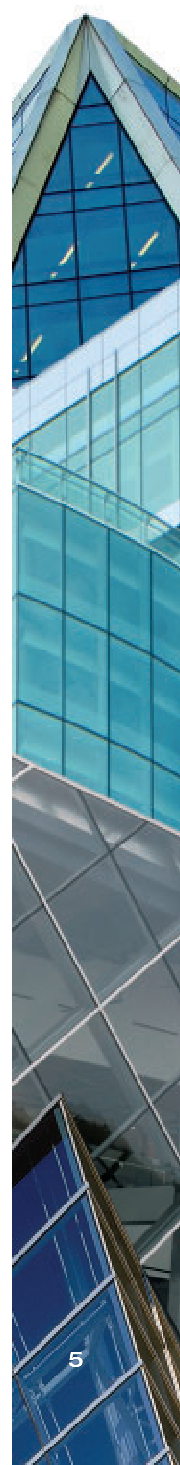


Tinted Glass (heat-absorbing glass)
¼" gray float glass outboard / ¼" clear inboard
Tvis = 42% SHGC =0.48

HIGH-PERFORMANCE COATED IG UNIT

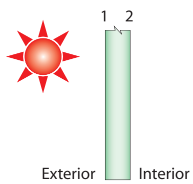


Low-E Glass (heat-reflecting glass)
¼" clear w/SunGuard SuperNeutral 68 outboard / ¼" clear inboard
Tvis = 68% SHGC =0.38

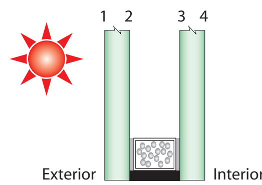


COMMON GLASS CONFIGURATIONS

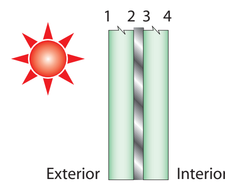
The following images depict the most common glass configurations and identify the glass surfaces with numbers showing the glass surfaces counting from exterior to interior.



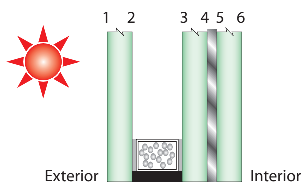
Monolithic Glass



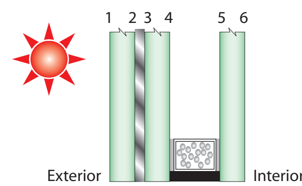
Insulating Glass Unit (IG)



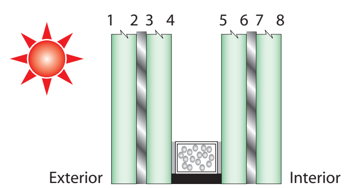
Laminated Glass



IG Unit with Laminated Inboard



IG Unit with Laminated Outboard



IG Unit with Laminated Outboard & Inboard

SPANDREL GLASS

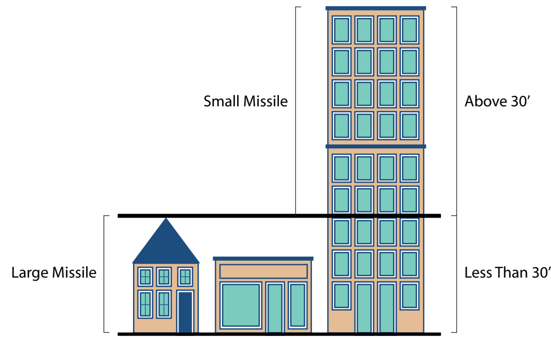
Spandrel glass is the area of glass panels that conceal structural building components such as columns, floors, HVAC systems, electrical wiring, plumbing, etc. Spandrel glass is typically located between vision glass on each floor of a building.

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

When high light-transmitting or low-reflecting vision glass is specified, achieving an exact spandrel match can be difficult. Daylight conditions can have a dramatic effect on the perception of vision to spandrel appearance. For instance, a clear, bright sunny day produces highly reflective viewing conditions and may provide a good vision to spandrel glass match. A gray, cloudy day may allow more visual transmission from the exterior and produce more contrast between the vision and spandrel glass. Guardian recommends full-size, outdoor mock-ups be prepared and approved in order to confirm the most desirable spandrel option for a specific project.

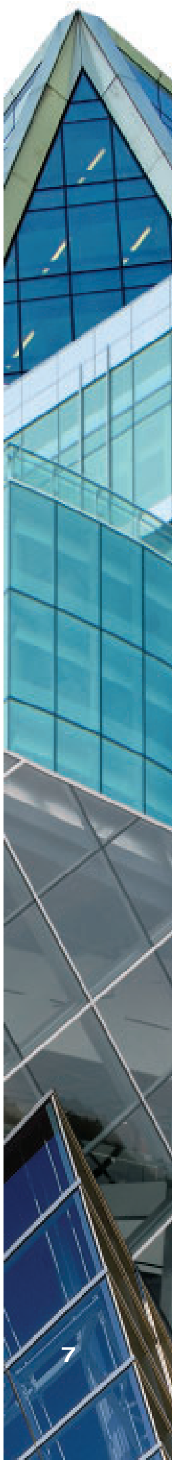
HURRICANE GLASS

The coastal areas of North America have begun adopting "hurricane codes" to help prevent catastrophic building failure during hurricane conditions. Initially, Dade County, Florida, enacted requirements that have been used as a model for other areas such as Texas and the Gulf Coast, as well as up the Atlantic Seaboard. The codes may vary regionally, so design professionals are encouraged to research the local municipality codes when beginning new projects. The diagram indicates basic Dade County, Florida, code requirements for small and large missile glazing testing.



TURTLE GLASS

It has been discovered that light shining brightly from buildings within the line of sight of the seashore attracts marine turtle hatchlings away from their natural environment at sea. Due to this behavior, the design of projects along the Florida coastline requires adherence to the Florida Model Lighting Ordinance for Marine Turtle Protection. The ordinance requires architectural glass installed in coastal buildings to transmit no more than 45 percent of interior light.



Performance Characteristics of Glass

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

ENERGY CONSERVATION AND COATED GLASS

The use of coated glass and insulating glass units can have a significant impact on the energy consumption of commercial buildings. A reduction in HVAC system cooling capacity reduces the initial investment, and annual savings from reduced energy consumption for heating and cooling requirements provides a return on glazing investment year after year. Studies have shown that over a 10-year period, the energy savings from high-performance coated glass can be several hundred thousand dollars for a typical six-story building, and the payback can be as little as two years.

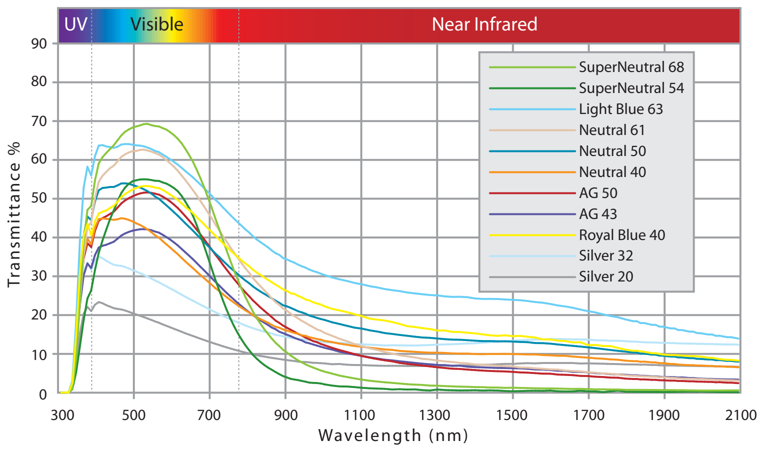
Guardian Industries has invested substantial resources over the years in search of improved solar heat gain and U-values of commercial coated glass products. The SunGuard product line is one of the results of that investment – a wide range of performance characteristics to meet varying local and regional energy codes as well as some of the highest performing, most energy-efficient coatings available today.

GLASS PERFORMANCE: SPECTRAL GRAPH

Today's advanced architectural glazing products attempt to balance the demands of aesthetic appearance, energy conservation and building occupant comfort. Theoretically speaking, an "ideal" glazing would transmit 100 percent of the sun's visible energy (light) and reflect, or block, all of the ultraviolet and infrared energy – while providing an aesthetically pleasing appearance from both the exterior and interior of the building. Guardian has scientists dedicated to finding new technologies to achieve the best energy performance possible, coupled with desirable aesthetics to help designers find that balance.

The following graphs show the spectral curves of Guardian SunGuard products on clear and green glass substrates.

Spectral Curves
SunGuard Coatings on Clear Glass



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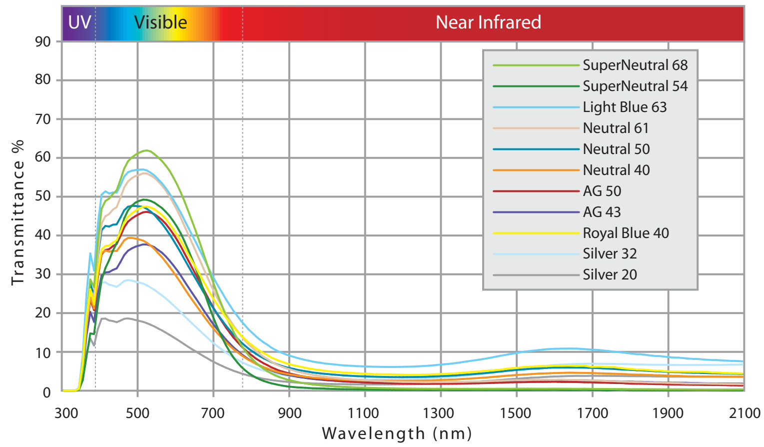
Spectral Curves
SunGuard Coatings on Green Glass

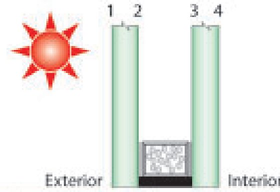


SUNGUARD ADVANCED ARCHITECTURAL GLASS

The SunGuard glass product line is designed to deliver energy efficiency that will meet or exceed energy code requirements and includes products offering a variety of aesthetically pleasing color options. The SuperNeutral™ Series presents the highest-performing energy characteristics available in high light-transmitting low-E coatings from Guardian. Our High Performance Series provides a range of light transmission, reflection and energy conservation qualities to choose from. And our Solar Series lets the design professional work with traditional "reflective" coatings that are excellent at lowering heat gain.

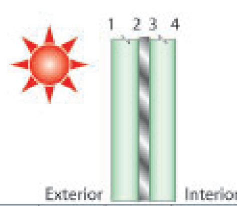
All SunGuard Advanced Architectural Glass products are distributed through Guardian's independent SunGuard Select Fabricator network. Guardian has established this network to promote consistent quality and availability. Select Fabricators can provide glass samples for mock-ups and can typically offer faster delivery than many competitors.

The following tables provide glass performance figures for a wide variety of SunGuard products and glass makeups. Please contact Guardian at 1-866-GuardSG (482-7374) if you need additional information.



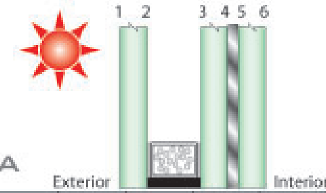
SunGuard® Insulating Glass Data

Appearance	Product	Outboard Substrate	Inboard Substrate	Transmission: Visible Light %	Transmission: Ultra-violet %	Transmission: Total Solar Energy %	Reflectance: Visible Light Out %	Reflectance: Visible Light In %	Reflectance: Total Solar Energy %	U-Value: Winter Nighttime	U-Value: Summer Daytime	Relative Heat Gain	Shading Coefficient	Solar Heat Gain Coefficient	Light to Solar Gain (LSG)
SunGuard SuperNeutral				Coating #2 Surface								6 mm / 12 mm a.s. / 6 mm			
Ultra Clear	SN 68	UltraWhite	UltraWhite	**69**	32	36	11	12	39	0.29	0.28	93	0.44	**0.39**	1.79
Ultra Clear	SN 54	UltraWhite	UltraWhite	**55**	17	25	13	18	41	0.29	0.27	69	0.33	**0.28**	1.93
Clear	SN 68	Clear	Clear	**68**	29	33	11	12	32	0.29	0.28	90	0.43	**0.38**	1.80
Clear	SN 54	Clear	Clear	**54**	15	23	13	18	33	0.29	0.27	68	0.32	**0.28**	1.91
Green	SN 68	Green	Clear	**58**	14	24	9	11	9	0.29	0.28	73	0.34	**0.30**	1.90
Green	SN 54	Green	Clear	**46**	7	17	10	18	10	0.29	0.27	59	0.27	**0.24**	1.88
				Coating #3 Surface											
Green	SN 68 (#3)	Green	Clear	**58**	14	24	10	10	10	0.29	0.28	84	0.40	**0.35**	1.64
Gray	SN 68 (#3)	Gray	Clear	**35**	13	18	6	9	15	0.29	0.28	71	0.34	**0.30**	1.20
Bronze	SN 68 (#3)	Bronze	Clear	**41**	12	20	7	9	16	0.29	0.28	75	0.36	**0.31**	1.30
Blue	SN 68 (#3)	Blue	Clear	**44**	17	21	8	9	13	0.29	0.28	78	0.37	**0.33**	1.33
Dark Green	SN 68 (#3)	SMG III	Clear	**51**	8	19	9	10	8	0.29	0.28	73	0.35	**0.30**	1.67
SunGuard High Performance				Coating #2 Surface								6 mm / 12 mm a.s. / 6 mm			
Light Blue	Light Blue 63	Clear	Clear	**62**	39	43	15	12	15	0.34	0.35	122	0.59	**0.51**	1.20
Neutral Pewter	Neutral 61	Clear	Clear	**61**	27	34	20	15	31	0.30	0.29	95	0.45	**0.40**	1.53
Neutral Blue	Neutral 50	Clear	Clear	**50**	30	31	16	11	19	0.33	0.32	94	0.45	**0.39**	1.28
Neutral Gray	Neutral 40	Clear	Clear	**40**	26	25	20	12	22	0.33	0.33	78	0.37	**0.32**	1.25
Crisp Silver	AG 50	Clear	Clear	**50**	26	28	28	18	36	0.30	0.28	80	0.38	**0.33**	1.51
Crisp Silver	AG 43	Clear	Clear	**41**	23	24	30	15	33	0.31	0.30	71	0.33	**0.29**	1.39
Royal Blue	Royal Blue 40	Clear	Clear	**38**	21	24	24	18	24	0.31	0.31	76	0.36	**0.31**	1.21
Blue-Green	Light Blue 63	Green	Clear	**52**	18	26	12	12	8	0.34	0.35	84	0.39	**0.35**	1.51
Green	Neutral 61	Green	Clear	**51**	13	23	15	14	11	0.30	0.29	71	0.34	**0.30**	1.74
Green	Neutral 50	Green	Clear	**42**	14	20	13	10	9	0.33	0.32	69	0.32	**0.28**	1.49
Green	Neutral 40	Green	Clear	**34**	12	16	16	12	10	0.33	0.33	59	0.27	**0.24**	1.39
Green	AG 50	Green	Clear	**43**	12	19	21	18	14	0.30	0.28	62	0.29	**0.25**	1.67
Green	AG 43	Green	Clear	**35**	11	15	23	14	14	0.31	0.30	55	0.26	**0.23**	1.52
Aquamarine	Royal Blue 40	Green	Clear	**32**	9	15	19	17	12	0.31	0.31	56	0.26	**0.23**	1.40
SunGuard Solar				Coating #2 Surface								6 mm / 12 mm a.s. / 6 mm			
Silver Blue-Gray	Silver 32	Clear	Clear	**29**	23	20	22	21	18	0.42	0.44	76	0.35	**0.31**	0.94
Silver	Silver 20	Clear	Clear	**18**	15	12	31	27	27	0.39	0.41	54	0.24	**0.21**	0.84
Blue-Green	Silver 32	Green	Clear	**24**	11	12	17	21	10	0.42	0.44	61	0.27	**0.24**	1.00
Green	Silver 20	Green	Clear	**15**	7	8	24	27	13	0.39	0.41	48	0.21	**0.19**	0.82
				Solar Coating #2 Surface / SuperNeutral Coating #3 Surface											
Silver Blue-Gray	Silver 32/SN 68	Clear	Clear	**24**	14	12	21	15	20	0.29	0.28	52	0.24	**0.21**	1.13
Silver	Silver 20/SN 68	Clear	Clear	**15**	9	7	31	19	28	0.29	0.27	39	0.17	**0.15**	0.99
Blue-Green	Silver 32/SN 68	Green	Clear	**21**	7	9	17	15	10	0.29	0.28	44	0.20	**0.18**	1.15
Green	Silver 20/SN 68	Green	Clear	**13**	4	5	24	19	13	0.29	0.27	35	0.16	**0.14**	0.93



SunGuard® Laminated Glass Data

Appearance	Product	Outboard Substrate	Inboard Substrate	Transmission: Visible Light %	Transmission: Ultra-violet %	Transmission: Total Solar Energy %	Reflectance: Visible Light Out %	Reflectance: Visible Light In %	Reflectance: Total Solar Energy %	U-Value: Winter Nighttime	U-Value: Summer Daytime	Relative Heat Gain	Shading Coefficient	Solar Heat Gain Coefficient	Light to Solar Gain (LSG)
SunGuard SuperNeutral				Coating #2 Surface								6 mm / .060 PVB / 6 mm			
Ultra Clear	SN 68	UltraWhite	UltraWhite	**68**	0	31	10	11	40	0.95	0.87	103	0.46	**0.39**	1.73
Clear	SN 68	Clear	Clear	**67**	0	29	11	11	33	0.95	0.87	105	0.46	**0.40**	1.67
Green	SN 68	Green	Clear	**57**	0	21	9	10	10	0.95	0.87	107	0.47	**0.41**	1.38
SunGuard High Performance				Coating #2 Surface								6 mm / .060 PVB / 6 mm			
Light Blue	Light Blue 63	Clear	Clear	**65**	0	43	10	6	14	0.95	0.87	140	0.64	**0.56**	1.17
Blue-Green	Light Blue 63	Green	Clear	**55**	0	26	8	6	7	0.95	0.87	116	0.52	**0.45**	1.22
SunGuard Solar				Coating #2 Surface								6 mm / .060 PVB / 6 mm			
Silver Blue-Gray	Silver 32	Clear	Clear	**31**	0	21	22	13	20	0.95	0.87	101	0.45	**0.39**	0.81
Silver	Silver 20	Clear	Clear	**19**	0	13	32	21	28	0.95	0.87	81	0.35	**0.30**	0.64
Blue-Green	Silver 32	Green	Clear	**27**	0	13	17	13	10	0.95	0.87	93	0.40	**0.35**	0.76
Green	Silver 20	Green	Clear	**16**	0	8	24	21	13	0.95	0.87	83	0.35	**0.31**	0.53



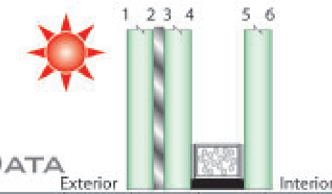
SunGuard®

Insulating Glass w/ Lami Inboard Data

Appearance	Product	Outboard Substrate	Inboard Substrate	Transmission			Reflectance			U-Value		Relative Heat Gain	Shading Coefficient	**Solar Heat Gain Coefficient**	Light to Solar Gain (LSG)
				Visible Light %	Ultra-violet %	Total Solar Energy %	Visible Light Out %	Visible Light In %	Total Solar Energy %	Winter Nighttime	Summer Daytime				
SunGuard SuperNeutral						Coating #2 Surface				6 mm / 12 mm a.s. / 6 mm / .060 PVB / 6 mm					
Ultra Clear	SN 68	UltraWhite	UW/UW	**68**	0	33	10	12	39	0.28	0.27	91	0.44	**0.38**	1.77
Ultra Clear	SN 54	UltraWhite	UW/UW	**54**	0	23	13	17	41	0.28	0.27	68	0.32	**0.28**	1.91
Clear	SN 68	Clear	Clear/Clear	**65**	0	29	11	12	32	0.28	0.27	89	0.42	**0.37**	1.77
Clear	SN 54	Clear	Clear/Clear	**52**	0	21	13	17	33	0.28	0.27	67	0.32	**0.28**	1.87
Green	SN 68	Green	Clear/Clear	**56**	0	21	9	11	9	0.28	0.27	71	0.34	**0.30**	1.87
Green	SN 54	Green	Clear/Clear	**44**	0	16	10	17	10	0.28	0.27	58	0.27	**0.24**	1.84
						Coating #3 Surface									
Gray	SN 68 (#3)	Gray	Clear/Clear	**34**	0	16	6	8	15	0.28	0.27	70	0.33	**0.29**	1.19
Bronze	SN 68 (#3)	Bronze	Clear/Clear	**39**	0	18	7	9	16	0.28	0.27	74	0.35	**0.31**	1.28
Blue	SN 68 (#3)	Blue	Clear/Clear	**42**	0	19	8	9	13	0.28	0.27	77	0.37	**0.32**	1.32
SunGuard High Performance						Coating #2 Surface				6 mm / 12 mm a.s. / 6 mm / .060 PVB / 6 mm					
Light Blue	Light Blue 63	Clear	Clear/Clear	**59**	0	37	15	12	15	0.33	0.34	119	0.57	**0.50**	1.20
Neutral Pewter	Neutral 61	Clear	Clear/Clear	**58**	0	30	20	14	31	0.29	0.28	93	0.45	**0.39**	1.51
Neutral Blue	Neutral 50	Clear	Clear/Clear	**48**	0	27	16	10	19	0.32	0.32	91	0.43	**0.38**	1.27
Neutral Gray	Neutral 40	Clear	Clear/Clear	**38**	0	21	20	11	22	0.32	0.32	75	0.35	**0.31**	1.24
Crisp Silver	AG 50	Clear	Clear/Clear	**48**	0	24	28	17	36	0.29	0.28	78	0.37	**0.32**	1.49
Crisp Silver	AG 43	Clear	Clear/Clear	**39**	0	20	30	14	33	0.30	0.29	69	0.33	**0.28**	1.38
Royal Blue	Royal Blue 40	Clear	Clear/Clear	**37**	0	21	24	17	24	0.31	0.30	74	0.35	**0.30**	1.20
Blue-Green	Light Blue 63	Green	Clear/Clear	**51**	0	23	12	11	8	0.33	0.34	82	0.38	**0.34**	1.50
Green	Neutral 61	Green	Clear/Clear	**50**	0	20	15	14	11	0.29	0.28	70	0.33	**0.29**	1.71
Green	Neutral 50	Green	Clear/Clear	**41**	0	18	13	10	9	0.32	0.32	67	0.31	**0.28**	1.48
Green	Neutral 40	Green	Clear/Clear	**33**	0	14	16	11	10	0.32	0.32	58	0.27	**0.24**	1.38
Green	AG 50	Green	Clear/Clear	**41**	0	17	21	17	14	0.29	0.28	61	0.28	**0.25**	1.65
Green	AG 43	Green	Clear/Clear	**33**	0	14	23	14	14	0.30	0.29	54	0.25	**0.22**	1.50
Aquamarine	Royal Blue 40	Green	Clear/Clear	**31**	0	13	19	16	12	0.31	0.30	55	0.25	**0.22**	1.38
SunGuard Solar						Coating #2 Surface				6 mm / 12 mm a.s. / 6 mm / .060 PVB / 6 mm					
Silver Blue-Gray	Silver 32	Clear	Clear/Clear	**28**	0	17	21	20	18	0.40	0.42	72	0.33	**0.29**	0.94
Silver	Silver 20	Clear	Clear/Clear	**17**	0	10	31	25	27	0.38	0.40	52	0.23	**0.21**	0.85
Blue-Green	Silver 32	Green	Clear/Clear	**23**	0	11	17	20	10	0.40	0.42	58	0.26	**0.23**	1.01
Green	Silver 20	Green	Clear/Clear	**15**	0	7	24	25	13	0.38	0.40	46	0.20	**0.18**	0.82

SunGuard®

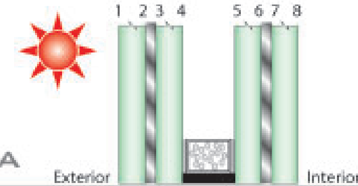
Insulating Glass w/ Lami Outboard Data



Appearance	Product	Outboard Substrate	Inboard Substrate	Transmission: **Visible Light %**	Transmission: Ultra-violet %	Transmission: Total Solar Energy %	Reflectance: Visible Light Out %	Reflectance: Visible Light In %	Reflectance: Total Solar Energy %	U-Value: Winter Nighttime	U-Value: Summer Daytime	Relative Heat Gain	Shading Coefficient	**Solar Heat Gain Coefficient**	Light to Solar Gain (LSG)
SunGuard SuperNeutral				Coating #4 Surface						6 mm / .060 PVB / 6 mm / 12 mm a.s. / 6 mm					
Clear	SN 68	Clear/Clear	Clear	**65**	0	29	10	12	19	0.28	0.27	86	0.41	**0.36**	1.83
Clear	SN 54	Clear/Clear	Clear	**52**	0	21	12	18	21	0.28	0.27	67	0.32	**0.28**	1.86
Green	SN 68	Green/Clear	Clear	**56**	0	21	9	11	7	0.28	0.27	69	0.32	**0.29**	1.94
Green	SN 54	Green/Clear	Clear	**44**	0	16	10	18	8	0.28	0.27	57	0.27	**0.24**	1.88
Gray	SN 68	Gray/Clear	Clear	**34**	0	16	6	10	9	0.28	0.27	58	0.27	**0.24**	1.44
Gray	SN 54	Gray/Clear	Clear	**27**	0	12	6	17	9	0.28	0.27	47	0.22	**0.19**	1.40
Bronze	SN 68	Bronze/Clear	Clear	**39**	0	18	6	11	10	0.28	0.27	61	0.29	**0.25**	1.55
Bronze	SN 54	Bronze/Clear	Clear	**31**	0	13	7	17	10	0.28	0.27	50	0.23	**0.20**	1.52
Blue	SN 68	Blue/Clear	Clear	**42**	0	19	7	11	9	0.28	0.27	63	0.30	**0.26**	1.61
Blue	SN 54	Blue/Clear	Clear	**33**	0	14	8	17	9	0.28	0.27	52	0.24	**0.21**	1.57
SunGuard High Performance				Coating #4 Surface						6 mm / .060 PVB / 6 mm / 12 mm a.s. / 6 mm					
Light Blue	Light Blue 63	Clear/Clear	Clear	**59**	0	37	14	12	11	0.33	0.34	109	0.33	**0.34**	1.30
Neutral Pewter	Neutral 61	Clear/Clear	Clear	**58**	0	30	19	15	20	0.29	0.28	88	0.42	**0.37**	1.58
Neutral Blue	Neutral 50	Clear/Clear	Clear	**48**	0	27	15	10	13	0.32	0.32	86	0.41	**0.36**	1.33
Neutral Gray	Neutral 40	Clear/Clear	Clear	**38**	0	21	19	12	16	0.32	0.32	73	0.34	**0.30**	1.28
Crisp Silver	AG 50	Clear/Clear	Clear	**48**	0	24	26	18	24	0.29	0.28	75	0.36	**0.31**	1.55
Crisp Silver	AG 43	Clear/Clear	Clear	**39**	0	20	28	15	23	0.30	0.29	67	0.32	**0.28**	1.41
Royal Blue	Royal Blue 40	Clear/Clear	Clear	**37**	0	21	23	18	17	0.31	0.30	71	0.33	**0.29**	1.25
Blue-Green	Light Blue 63	Green/Clear	Clear	**51**	0	23	11	12	7	0.33	0.34	77	0.36	**0.32**	1.58
Green	Neutral 61	Green/Clear	Clear	**50**	0	20	15	14	9	0.29	0.28	67	0.32	**0.28**	1.78
Green	Neutral 50	Green/Clear	Clear	**41**	0	18	12	10	8	0.32	0.32	64	0.30	**0.27**	1.53
Green	Neutral 40	Green/Clear	Clear	**33**	0	14	15	12	9	0.32	0.32	57	0.26	**0.23**	1.41
Green	AG 50	Green/Clear	Clear	**41**	0	17	20	18	11	0.29	0.28	58	0.27	**0.24**	1.71
Green	AG 43	Green/Clear	Clear	**33**	0	14	21	14	11	0.30	0.29	53	0.24	**0.22**	1.54
Aquamarine	Royal Blue 40	Green/Clear	Clear	**31**	0	13	18	17	10	0.31	0.30	53	0.25	**0.22**	1.42
SunGuard Solar				Coating #4 Surface						6 mm / .060 PVB / 6 mm / 12 mm a.s. / 6 mm					
Silver Blue-Gray	Silver 32	Clear/Clear	Clear	**27**	0	17	20	21	14	0.41	0.42	73	0.33	**0.29**	0.94
Silver	Silver 20	Clear/Clear	Clear	**17**	0	10	29	27	20	0.38	0.40	55	0.25	**0.22**	0.80
Blue-Green	Silver 32	Green/Clear	Clear	**23**	0	11	16	21	9	0.41	0.42	58	0.26	**0.23**	1.00
Green	Silver 20	Green/Clear	Clear	**15**	0	7	22	27	11	0.38	0.40	47	0.21	**0.19**	0.80

SunGuard®

Laminated Outboard & Inboard Data



Appearance	Product	Outboard Substrate	Inboard Substrate	Transmission			Reflectance			U-Value		Relative Heat Gain	Shading Coefficient	**Solar Heat Gain Coefficient**	Light to Solar Gain (LSG)
				Visible Light %	Ultra-violet %	Total Solar Energy %	Visible Light Out %	Visible Light In %	Total Solar Energy %	Winter Nighttime	Summer Daytime				
SunGuard SuperNeutral					Coating #4 Surface		6 mm / .060 PVB / 6 mm / 12 mm a.s. / 6 mm / .060 PVB / 6 mm								
Ultra Clear	SN 68	UW/UW	UW/UW	**66**	0	31	10	12	28	0.28	0.26	89	0.42	**0.37**	1.77
Ultra Clear	SN 54	UW/UW	UW/UW	**52**	0	22	12	17	30	0.28	0.26	68	0.32	**0.28**	1.85
Clear	SN 68	Clear/Clear	Clear/Clear	**63**	0	27	10	11	19	0.28	0.26	84	0.40	**0.35**	1.79
Clear	SN 54	Clear/Clear	Clear/Clear	**50**	0	20	12	17	21	0.28	0.26	66	0.31	**0.28**	1.82
Green	SN 68	Green/Clear	Clear/Clear	**54**	0	20	9	11	7	0.28	0.26	68	0.32	**0.28**	1.90
Green	SN 54	Green/Clear	Clear/Clear	**43**	0	15	10	17	8	0.28	0.26	56	0.26	**0.23**	1.83
SunGuard High Performance					Coating #4 Surface		6 mm / .060 PVB / 6 mm / 12 mm a.s. / 6 mm / .060 PVB / 6 mm								
Light Blue	Light Blue 63	Clear/Clear	Clear/Clear	**57**	0	32	14	12	10	0.33	0.33	107	0.51	**0.45**	1.28
Neutral Pewter	Neutral 61	Clear/Clear	Clear/Clear	**56**	0	27	19	14	20	0.29	0.28	87	0.41	**0.36**	1.55
Neutral Blue	Neutral 50	Clear/Clear	Clear/Clear	**46**	0	24	15	10	13	0.31	0.31	84	0.40	**0.35**	1.32
Neutral Gray	Neutral 40	Clear/Clear	Clear/Clear	**37**	0	19	19	11	16	0.31	0.31	71	0.34	**0.29**	1.26
Crisp Silver	AG 50	Clear/Clear	Clear/Clear	**47**	0	22	26	17	24	0.28	0.27	74	0.35	**0.31**	1.52
Crisp Silver	AG 43	Clear/Clear	Clear/Clear	**38**	0	18	28	14	23	0.29	0.28	66	0.31	**0.27**	1.39
Royal Blue	Royal Blue 40	Clear/Clear	Clear/Clear	**35**	0	19	23	17	17	0.30	0.29	69	0.33	**0.29**	1.23
Blue-Green	Light Blue 63	Green/Clear	Clear/Clear	**49**	0	21	11	11	7	0.33	0.33	76	0.36	**0.31**	1.56
Green	Neutral 61	Green/Clear	Clear/Clear	**48**	0	19	15	14	9	0.29	0.28	66	0.31	**0.27**	1.75
Green	Neutral 50	Green/Clear	Clear/Clear	**39**	0	16	12	10	8	0.31	0.31	63	0.29	**0.26**	1.51
Green	Neutral 40	Green/Clear	Clear/Clear	**32**	0	13	15	11	9	0.31	0.31	55	0.26	**0.23**	1.39
Green	AG 50	Green/Clear	Clear/Clear	**40**	0	15	20	17	11	0.28	0.27	57	0.27	**0.24**	1.67
Green	AG 43	Green/Clear	Clear/Clear	**32**	0	13	21	14	11	0.29	0.28	52	0.24	**0.21**	1.51
Aquamarine	Royal Blue 40	Green/Clear	Clear/Clear	**30**	0	12	18	16	10	0.30	0.29	52	0.24	**0.21**	1.39
SunGuard Solar					Coating #4 Surface		6 mm / .060 PVB / 6 mm / 12 mm a.s. / 6 mm / .060 PVB / 6 mm								
Silver Blue-Gray	Silver 32	Clear/Clear	Clear/Clear	**27**	0	15	20	20	14	0.39	0.41	70	0.32	**0.28**	0.93
Silver	Silver 20	Clear/Clear	Clear/Clear	**17**	0	9	29	25	20	0.37	0.39	53	0.24	**0.21**	0.79
Blue-Green	Silver 32	Green/Clear	Clear/Clear	**23**	0	10	16	20	9	0.39	0.41	57	0.25	**0.23**	1.00
Green	Silver 20	Green/Clear	Clear/Clear	**14**	0	6	22	25	11	0.37	0.39	46	0.20	**0.18**	0.79

NOTES:

- The performance values shown are nominal and subject to variations due to manufacturing tolerances.
- Guardian performance data are calculated in accordance with the LBNL Window 5.2 computer analysis using an air mass of 1.5.
- Outboard lite may require heat strengthening or tempering to resist potential thermal stresses. Please contact Guardian for assistance.
- A slight shift in visible light reflectance or transmission may be noticed after heat-treatment.
- Guardian recommends edge deletion for all low-E coatings.
- Guardian reserves the right to change product performance characteristics without notice or obligation.

ACOUSTICAL INFORMATION

The acoustic performance of glazing assemblies is expressed in two terms: Sound Transmission Class (STC) is used to measure the sound transmission loss of interior walls, ceilings and floors; and Outdoor-Indoor Transmission Class (OITC), which measures the sound transmission loss of exterior glazing applications. High sound transmission loss – good sound insulation – is desired in many commercial curtain wall applications. Limiting sound transmission through glazing requires review and testing of the entire glazing system. Laminated glass and insulating glass tend to produce higher OITC ratings because the laminate dampens vibration and the air space limits sound transmission. For more information, refer to the Glass Association of North America Glazing Manual. The following chart indicates typical sound transmission losses for various glass configurations.

Typical Sound Transmission Loss (dB)

Glass Configuration	Frequency in Hertz (Hz)																		
	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	STC	OITC
1/4″	23	25	25	24	28	26	29	31	33	34	34	35	34	30	27	32	37	41	31	29
1/2″	26	30	26	30	33	33	34	36	37	35	32	32	36	40	43	46	50	51	36	33
1/8″ - 0.030″ PVB - 1/8″	25	26	28	27	29	29	30	32	34	35	35	36	36	35	35	38	43	46	35	31
1/4″- 0.030″ PVB - 1/4″	28	31	29	31	32	33	32	33	35	36	36	35	36	40	43	46	48	51	37	33
1/4″- 0.060″ PVB - 1/4″	27	28	27	30	31	31	33	35	36	37	37	37	36	37	41	44	48	51	37	33
1/8″ - 3/8″as - 1/8″	26	23	23	20	23	19	23	27	29	32	35	39	44	47	48	41	36	43	31	26
1/4″ - 1/2″as - 1/4″	29	22	26	18	25	25	31	32	34	36	39	40	39	35	36	46	52	58	35	28
1/8″ - 1/2″as - 1/8″- .030PVB - 1/8″	27	29	25	24	25	27	29	31	35	38	40	41	42	43	46	50	49	53	37	31
1/4″ - 1/2″as - 1/8″- .030PVB - 1/8″	27	27	24	28	26	33	34	35	38	40	42	43	42	40	42	47	51	54	39	32
1/4″ - 1/2″as - 1/4″- .030PVB - 1/4″	30	26	30	30	29	36	37	37	39	39	41	42	43	44	46	51	53	55	41	35

HOW TO VIEW/EVALUATE GLASS HAND SAMPLES

Coated glass is normally selected based on reflected color, as this is typically seen in outdoor/natural lighting conditions. To see the reflected color of glass, it is best to view samples with a black background. Position the sample so that someone can look at an image that is reflected from the glass surface. This is the true reflected color of the sample.

Example: Place a piece of black paper, or other low-gloss black material, on a desktop or other flat surface. Position the glass sample on the paper with the exterior side up, so that you can see the image of the overhead lights being reflected from the glass surface. To view the transmitted color, it is best to view samples using a white background. Evaluating glass samples with a white background will not give a true indication of the exterior appearance of the sample. This instead projects the transmitted color and is not what you will see once the glass is installed in the building.

Guardian recommends that samples be viewed in outdoor/natural lighting conditions, preferably in a slightly overcast condition, for the most accurate rendering of transmitted and reflected color. Also, architects are encouraged to consider angle of observation, interior lighting conditions and potential effects of glare when choosing glazing products.

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

We recommend viewing glass samples outdoors whenever possible. After removing the glass from the sample box, place it in a vertical or slightly angled position. Viewing the glass with a black background in the distance is preferred to replicate lighting once installed in the structure. Then look through the glass to provide the best indication of the appearance of installed glass.

Fabrication and Glazing

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

OPTICAL DISTORTION

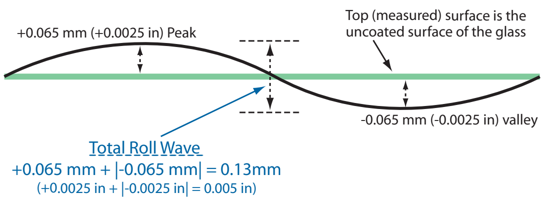
Many conditions may contribute to optical distortion, including glazing errors and fabrication procedures. Minimizing optical distortion resulting from the heat-treatment process will greatly enhance the appearance of the final product. Roll wave and bow and warp are sources of optical distortion that should be carefully specified when design considerations are being evaluated.

Roll wave occurs as glass passes over the rollers in a continuous-operation, heat-treating furnace. As the glass heats up, it may sag between rollers and become “frozen” in place during the cooling (quench) process. This may produce roller wave distortion in the finished product. Guardian recommends that:

- Glass should be processed so roll wave will be horizontal to the base dimension of the finished unit, whenever possible.
- A roll distortion gauge should be used to measure roll distortion.
- A target of 0.07mm (0.003") with a maximum of 0.13mm (0.005") roll wave for any commercial application.

Bow and warp occurs as a result of the heat-treating process and can be reduced through the proper use of heat-up maximum temperature/cycle time and cool-down cycle time/temperature.

- ASTM C 1048 addresses bow and warp and states that localized bow and warp may be determined with the use of a straight edge spanning the concave surface. The glass must be measured with a feeler gauge or dial indicator.
- Guardian requires SunGuard Select Fabricators to use half of the ASTM guideline as a target in production.

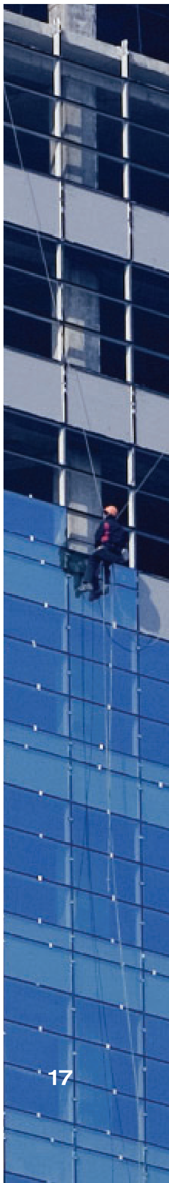


THERMAL BREAKAGE

Thermal breakage can be influenced by a number of factors. A critical factor to consider in the early stages of glass selection is whether the glass will be shaded. When glass is partially shaded by building overhangs or extensions, it becomes cooler at the edges and stress in the glass may occur, which can result in thermal breakage.

In areas where thermal breakage may be of concern, a thermal breakage analysis must be completed to determine if heat-treating (heat-strengthening or tempering) may be needed.

continued



Heat-treating may also be necessary due to high wind loads or safety glass code requirements. The degree to which the central area of the glass becomes hot is largely dependent on the solar absorption of the glass, which varies between different types of glass.

Some additional factors that may influence thermal breakage are listed below:

- Glass framing that is in direct contact with concrete or other materials that may contribute to the cooling of the glass edge
- Excessive coverage of the glass edge by the frame
- Heat-absorbing films attached to the glass after installation
- The use of internal shading devices such as curtains, drapes or venetian blinds – if shading devices are used, they must be placed away from the glass to allow for a free flow of air at the glass surface
- The airflow from room cooling or heating vents must be directed away from the glass
- Buildings not heated during the construction phase may experience an increase in thermal breakage
- Generally speaking, the greater the glass edge area, the greater the risk of thermal breakage

The potential risk of thermal breakage can be estimated by a computer-aided thermal stress analysis. Contact Guardian's Science & Technology Center for assistance with thermal stress analysis.

HEAT-SOAKING

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

Heat-soaking is a process that may expose NiS inclusions in tempered glass. The process involves placing the tempered glass inside a chamber and raising the temperature to approximately 290°C to accelerate nickel sulfide expansion. This causes glass containing nickel sulfide inclusions to break in the heat soak chamber, thus reducing the risk of potential field breakage. The heat-soaking process is not 100 percent effective, adds cost and carries the risk of reducing the compressive stress in tempered glass.

Heat-strengthened glass has a much lower potential incidence of spontaneous breakage than tempered glass. For applications where additional glass strength is required due to thermal stress, and safety glass is not mandated, Guardian recommends heat-strengthened or laminated glass to reduce the potential for spontaneous breakage.

WIND LOAD

Guardian follows the current ASTM E 1300 Standard Practice for Determining the Minimum Thickness and Type of Glass Required to Resist a Specified Load. This information represents in-service glass and supersedes the traditional straight-line graph as well as other wind load charts. The ASTM wind load standard is applicable to projects built in the United States. Wind load standards for other countries may differ, and this difference must be addressed in the early stages of design. Contact Guardian's Science & Technology Center for assistance with wind load analysis.

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

Insulating Glass: The effects of wind on insulating glass units are, in many cases, complex and require a computer-assisted wind load analysis to adequately consider some of the variables. Design professionals must take into account the following variables:

- Load sharing other than 50-50
- Air space contraction and expansion due to changes in temperature, barometric pressure and altitude variation in weathering of the glass surfaces, e.g., surface #1 vs. surface #2
- Edge condition – free or fixed
- Asymmetrical loading, i.e., lites of varying thickness
- Variation in sightline or airspace width
- Thermal stress

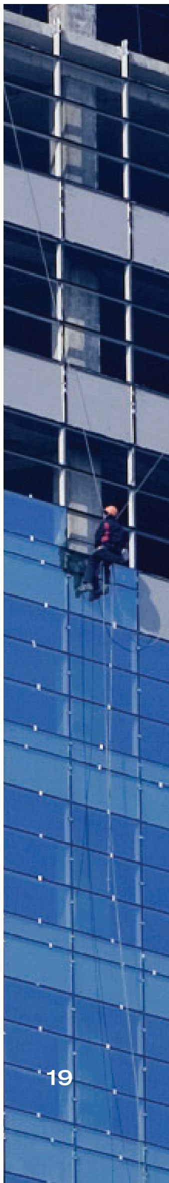
When all or some of these variables are taken into account, the maximum wind load may differ considerably from the data taken from a wind load chart.

BENDING GUARDIAN SPUTTER-COATED GLASS

SunGuard heat-treatable coatings are thermally stable and have been utilized in bent glass applications. SunGuard products used in bent glass applications maintain their aesthetic, optical and performance properties. Bending constraints are based on coating thickness, radius and concave vs. convex applications. The bending of SunGuard products must only be performed by SunGuard Select Fabricators. Guardian recommends a full-scale mock-up be fabricated and viewed prior to final specification approval. Please contact Guardian Science & Technology Center for complete information regarding bent glass applications.

STRAIN PATTERN

Strain pattern refers to a specific geometric pattern of iridescence or darkish shadows that may appear under certain lighting conditions, particularly in the presence of polarized light (also called "quench marks"). The phenomena are caused by the localized stresses imparted by the rapid air cooling of the heat-treating operation. Strain pattern is characteristic of heat-treated glass and is not considered a defect.

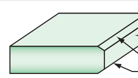
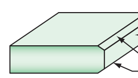
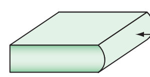
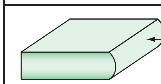
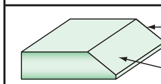
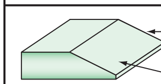
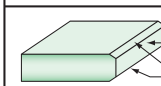


MOIRÉ PATTERNS

Moiré is an optical phenomenon that may appear as a wavy, rippled or circular pattern under certain lighting conditions. Moiré patterns may be created when one semitransparent object with a repetitive pattern is placed over another and the two are not aligned. The moiré patterns are not defects in the glass or silk-screen pattern – they are a pattern in the image formed by the human eye. This may occur when silk-screen patterns of lines or dots are closely spaced, and a secondary pattern is created by the shadow of the ceramic frit on another surface of an insulating glass unit, for instance, when a spandrel panel is installed behind silk-screened glass. Another potential moiré pattern may be the result of light transmitted through the glass portion not covered with ceramic frit.

GLASS EDGE TYPES

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

Edge Diagram	Description	Typical Application
	Flat Ground	Silicone structural glazing with exposed edges
	Flat Polish	Silicone structural glazing where edge condition is critical for aesthetic purposes
	Ground Pencil Edge	Mirrors, Decorative furniture glass
	Polished Pencil Edge	Mirrors, Decorative furniture glass
	Ground Miter	Silicone structural glazing
	Bevel	Mirrors, Decorative furniture glass
	Seamed Edges	Normal edge treatment for heat-treated glass

GLASS HANDLING, STORAGE, MAINTENANCE AND CLEANING

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

One of the most harmful materials to glass is glass itself. When glass is stored prior to fabrication, it should be separated by an airspace, separator or paper. When removing glass from storage, avoid sliding one pane over another, as they can be scratched or abraded. Glass edges should not contact the frame or other hard surfaces during installation. Use rolling blocks, as necessary, when moving glass.

Glass should be washed frequently to remove surface dirt and also to protect the glass from staining. Glass staining occurs when the sodium within the glass reacts with moisture in the air. Sodium, when combined with small amounts of water, can create sodium hydroxide, which is corrosive to glass. If this sodium hydroxide is left on the glass surface for a prolonged period of time, the glass will be permanently damaged and may have to be replaced. The sodium hydroxide is easily removed with water and normal glass-cleaning solutions, e.g., alcohol and water, or ammonia and water. Installed glass is less prone to sodium hydroxide damage due to the natural cleansing of the glass surface by rain.

Recommended Cleaning Or Washing Solutions

A. General Glass Cleaning

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

B. Precautions

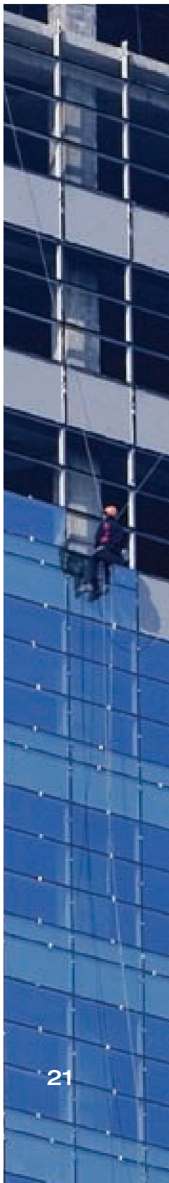
- Avoid abrasive or highly alkaline cleaners. Do not use petroleum products, i.e., gasoline, kerosene or lighter fluid.
- Hydrofluoric and phosphoric acid are corrosive to the glass surface and should not be used.
- Protect the glass surface from over-spray or runoff from acids and cleaning agents used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

COATED GLASS: MINIMUM & MAXIMUM SIZES:

The sizes of glass listed below pertain to float glass manufacturing capabilities. To determine the minimum and maximum sizes available for finished glass products, the glass fabricator must be consulted. Physical/mechanical capabilities and constraints of the fabricator will affect the final finished glass size availability.

Float Glass	Clear	Green
Thickness	3 mm - 15 mm	3 mm - 10 mm
Maximum Stock Sheet	130" x 204"	130" x 204"
Minimum Cut-Size	24" x 36"	24" x 36"

continued



Coated Glass		Carleton, MI	Geneva, NY	Kingsburg, CA
SunGuard Products		Light Blue 63, Neutral 61, Neutral 61 HT, Neutral 50, Neutral 40, AG 43, AG 50, Royal Blue 40, Silver 32, Silver 20	SN 68, SN 68 HT	SN 68, SN 68 HT, SN 54, SN 54 HT
Thickness:	Clear glass	3 mm - 10 mm	$\leq$ 8 mm	$\leq$ 6 mm
	Green glass	$\leq$ 6 mm	$\leq$ 6 mm	n/a
Maximum Stock Sheet		98" x 144"	100" x 144"	102" x 144"
Standard Stock Sheet		96" x 130"	96" x 130"	102" x 130"

OVERSIZE GLASS: INSULATING AND HEAT-TREATMENT CONSIDERATIONS

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

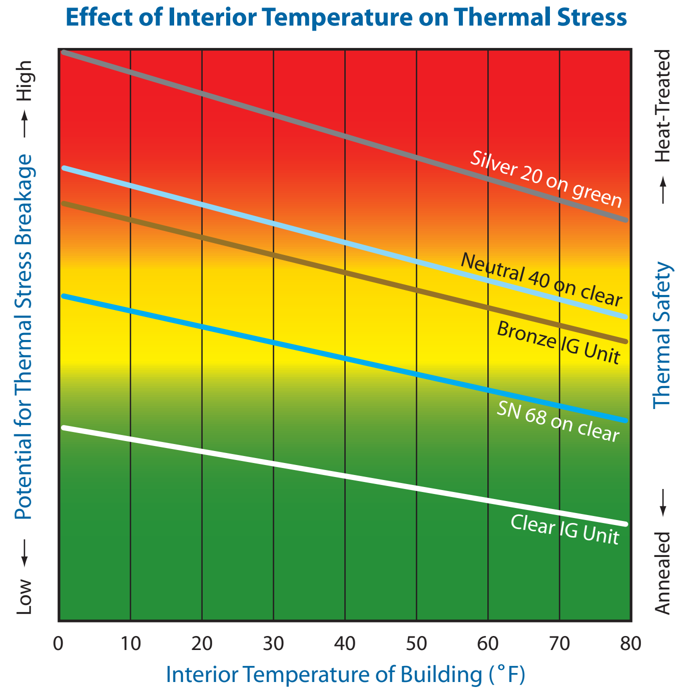
Maximum glass sizes are dictated by the size of glass available from the primary manufacturer, the fabrication equipment limitations, the capabilities of the contract glazier to install the unit, availability of specialized shipping and handling equipment to deliver the unit, and the specific glass makeup, such as coated glass, silk-screened glass, heat-treated glass, laminated glass, insulated glass or some combination of these items. Generally speaking, glass that is 60" or less in width can be heat-treated on a high-speed furnace, which will make the glass more economical and more readily available. Glass from 60" to 84" in width is available from a number of fabricators, and some have capability up to 96", but the cost may be higher. Once the total size of the insulated unit exceeds 50 square feet, the number of potential glass fabricators will diminish, and the cost will go up significantly. Many fabricators have a standard practice of heat-treating both lites of an insulating glass unit when the unit size exceeds 35 square feet, and unit sizes over 50 square feet will almost always require this practice. Fabricators providing heat-treated glass may also recommend oversize glass to be tempered rather than heat-strengthened to better control overall flatness. Guardian recommends the specific glass makeup be reviewed with a glass fabricator so that the availability of glass to meet project lead times and budget can be confirmed.

CONSTRUCTION-PHASE RISKS OF THERMAL BREAKAGE

There is a higher risk of thermal stress breakage during the construction phase of a project, and such breakage may diminish once the building is closed in and heated.

Thermal stress breakage is caused primarily by a temperature gradient developing between the edge and center portions of the glass pane. The most critical exposure in which thermal breakage can occur is under conditions when the glass edges are cold and the central region is heated. This condition is common in buildings with overhangs and vertical extensions.

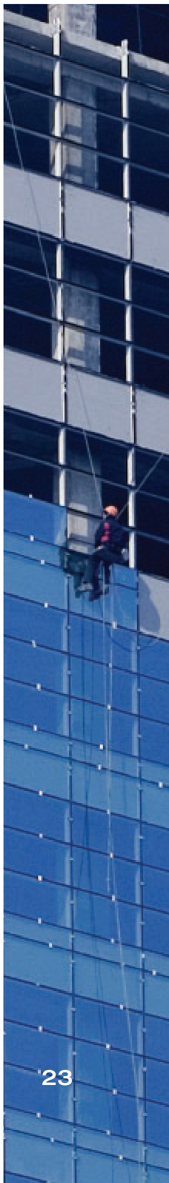
Thermal stresses present during construction occur particularly when the building interior is not heated, and the panes of glass are exposed to direct sunlight. In such cases, breakage can occur as the sun heats the central portion of the glass, while the edges are cooled by the frame. This type of breakage is possible even with the absence of overhangs or vertical extensions. The risk is greatest for heat-absorbing glass, such as tints and reflective glass. In insulating glass, the risk of thermal breakage is further increased when heat-absorbing tinted glass is used.



The best control of thermal breakage is heating the interior of the building and specifying heat-treated glass, either heat-strengthened or tempered. The above graph shows the dramatic extent to which heating the building decreases risk of breakage from thermal stress. Guardian Industries will provide an analysis of the risk of thermal breakage during construction if the anticipated building temperatures and appropriate window details are provided. However, a thermal stress analysis is not a guarantee against breakage. The analysis is a service to our customers for the purpose of product selection. The selection of product type and prevention of thermal breakage are the responsibility of the design professional.

STATISTICAL PROBABILITY OF GLASS BREAKAGE

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



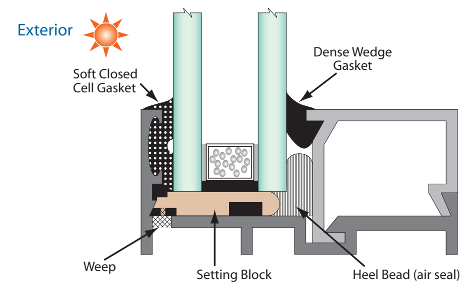
GLAZING GUIDELINES

All glass products are to be glazed in a manner that ensures the glass is free-floating, non-load-bearing and glazed with a material that remains resilient. An adequate weep system, or materials which totally repel the passage of water, is necessary to avoid premature failure of fabricated glass, opacified spandrel and laminated glass. Adequate clearance for bow and warp of heat-strengthened and tempered glass must be provided as specified in ASTM Standard C 1048. For complete industry-accepted information about glazing guidelines, please review the Glass Association of North America's Glazing Manual.

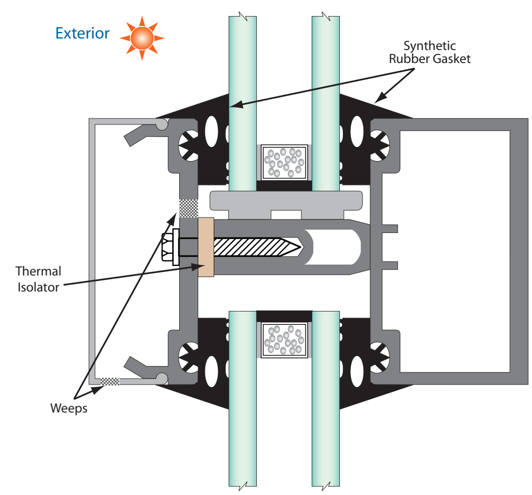
Conventional Glazing:

- Framing must be structurally sound, with sufficient strength to support the glass weight without any sagging, twisting or deformation that may impose a load on the glass.
- No framing member should deflect more than 1/175 of its span, with a maximum deflection of ¾" when under load.
- Appropriate setting blocks, face gaskets, wedges and edge spacers must meet current requirements of ASTM Standards D 395 and C 864 for hardness, deformation, compression set and polymer content.
- Framing members must be free of any glazing obstructions that would result in glass damage.
- Minimum framing extension is necessary to reduce the likelihood of thermal breakage. In situations where thermal breakage may be a concern, request a thermal stress analysis.
- Anti-walk blocks should be used in situations where glass movement is anticipated, i.e., lateral movement due to wind loading, seismic loads or other building movement.

DRY GLAZING



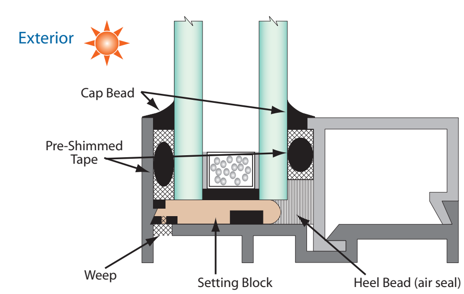
PRESSURE GLAZING



Silicone Structural Glazing:

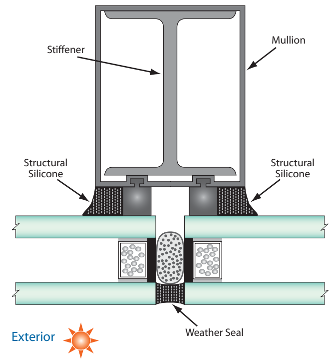
- Glass is not typically used as a structural member. Support framing must be of sufficient strength and dexterity to absorb all loads resulting from wind, thermal expansion or building movement.
- Backup mullions are recommended for glass thickness ¼" or less and in all instances where insulating glass is specified.

WET GLAZING



- Higher light-transmitting coating may show edge read-through. Insulating glass used in structural glazing must be silicone units.
- Opacified spandrel must have trim in the back of the opacifier to ensure glass-to-silicone adhesion.
- The compatibility and adhesive characteristics of the structural silicone are to be confirmed in the early stages of design.

SILICONE STRUCTURAL GLAZING



QUALITY/INSPECTION GUIDELINES

The following quality standards are offered as suggested guidelines for the evaluation of coated glass products, based on ASTM 1376.

General:

- Normal viewing distance is 10 feet for vision glass and 15 feet for spandrel glass. The viewing angle should be 90° against a bright, uniform background. Spandrel glass is viewed against a dark, uniform background.
- The area of most importance is the central viewing area, which is defined by 80% of the length and 80% of the width dimensions centered on a lite of glass. The remaining area is considered the outer area.

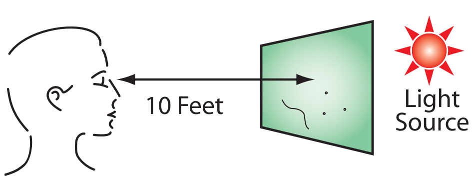
Pinholes and Clusters (viewed in transmission):

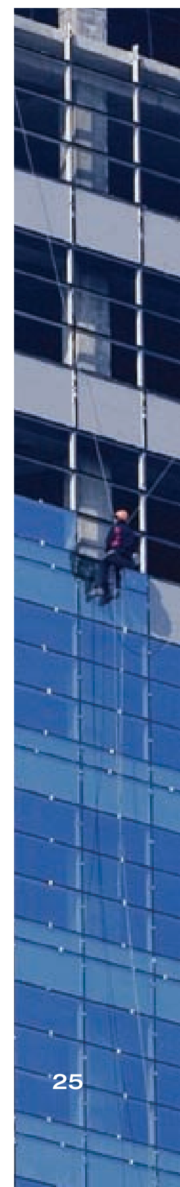
- Pinholes up to 1.5mm (1/16") are acceptable.
- A cluster is defined as two or more pinholes up to 1.5mm (1/16") each that are readily apparent and located in an area of 75mm (3") diameter.
- Clusters of pinholes within the central viewing area are not acceptable.
- Clusters greater than 0.82mm (1/32") and visible from 3 meters (10 feet) are acceptable only outside the central viewing area.

Scratches (viewed in transmission):

- Scratches longer than 50mm (2") within the central viewing area are not acceptable.

Pinholes, Clusters & Scratches

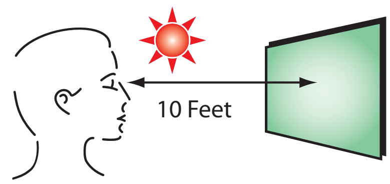




Color uniformity (viewed in reflection):

- Coated glass may exhibit slightly different hue or color that may not be apparent in hand samples.
- Color and reflectance may vary slightly overall and be considered acceptable.
- Due to the reflectivity of some glass coatings, distortion of reflected objects may be more apparent. This characteristic is more pronounced with heat-treated, laminated and insulated glass.

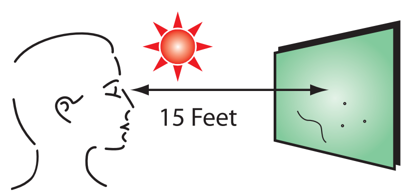
Reflectance & Color



Spandrel Glass (viewed in reflection):

- Coated glass may exhibit slightly different hue or color that may not be apparent in hand samples.
- Color and reflectance may vary slightly overall and be considered acceptable.
- Pinholes up to 3.0 mm (1/8”) are acceptable.
- Scratches up to 75 mm (3”) are acceptable.

Spandrel Glass



Other Resources

ARCHITECTURAL TOOLS

Guardian offers a full line of architectural glass products. We also offer several tools designed to help architects find solutions and specify Guardian products. Our PRODUCT MASTERSPEC™ is based on Section 088100 from the AIA MASTERSPEC® library, and it helps simplify the preparation of specification documents. We also offer a USGBC LEED® brochure for architects looking for LEED certification through the use of high-performance glass.

NATIONAL, REGIONAL AND LOCAL BUILDING CODES/STANDARDS

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

- ANSI Z 97.1 Glazing Materials Used in Buildings, Safety Performance Specifications and Methods of Test
- ASTM C 1036 Standard Specification for Flat Glass
- ASTM C 1048 Standard Specification for Heat-Treated Flat Glass--Kind HS, Kind FT Coated and Uncoated Glass
- ASTM C 1172 Standard Specification for Laminated Architectural Flat Glass
- ASTM C 1376 Standard Specification for Pyrolytic and Vacuum Deposition Coatings on Glass
- ASTM E 773 Standard Test Method for Accelerated Weathering of Sealed Insulating Glass Units
- ASTM E 774 Standard Specification for the Classification of the Durability of Sealed Insulating Glass Units
- ASTM E 1886 Test Method for Performance of Exterior Windows, Curtain Walls, Doors and Storm Shutters Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials
- ASTM E 1996 Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors and Storm Shutters Impacted by Windborne Debris in Hurricanes
- ASTM E 2188 Standard Test Method for Insulating Glass Unit Performance
- ASTM E 2190 Standard Specification for Insulating Glass Unit Performance and Evaluation
- ASTM F 1642 Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings
- CPSC 16CFR-1201 Safety Standard for Architectural Glazing Materials

WARRANTY

Guardian provides a coated glass products warranty to our direct customer, typically the glass fabricator, for a period of 10 years. This covers the coated glass only – the insulating glass units will typically be covered by a warranty provided by the fabricator. Similarly, Guardian laminated glass products are covered by a 5-year warranty. Contact your Guardian Sales Representative for a copy of specific product warranty documents.

A wide range of documents, including 3-part specifications in CSI format, a photo gallery of projects, a product selection tool, Select Fabricator locator, AIA/CES presentation information and technical documents have been published online. Please visit www.SunGuardGlass.com or call us at 1-866-GuardSG (482-7374).

Glossary

COLOR RENDERING INDEX (CRI)

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

HEAT GAIN

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

HEAT TRANSFER METHODS

Heat transfer occurs through convection, conduction or radiation (also referred to as “emission”). Convection results from the movement of air due to temperature differences. For instance, warm air moves in an upward direction and, conversely, cool air moves in a downward direction. Conduction results when energy moves from one object to another. Radiation, or emission, occurs when heat (energy) can move through space to an object and then is transmitted, reflected or absorbed.

HYBRID: LOW-E/REFLECTIVE COATINGS

A combination of medium outdoor reflectivity and low-E performance qualities. These coatings allow the designer to combine low U-values, reduced solar heat gain and visual aesthetics. Guardian offers AG 43 and AG 50.

INFRARED (LONG-WAVE) ENERGY

Energy generated by radiated heat sources such as electric coil heaters or natural gas-powered, forced-air furnaces. Also, any object that can absorb heat and radiate it is producing long-wave, infrared energy. *NOTE:* When short-wave energy from the sun is absorbed and radiated by glazing, it is converted to long-wave energy.

LIGHT-TO-SOLAR GAIN

Ratio of the visible light transmittance to the Solar Heat Gain Coefficient. LSG=Tvis/SHGC. A higher LSG ratio means sunlight entering the room is more efficient for daylighting, especially for summer conditions where more light is desired with less solar gain. This ratio is the measurement used to determine whether the glazing is “spectrally selective.”

LOW-E COATINGS

Relatively neutral in appearance, low-E coatings reduce heat gain or loss by reflecting long-wave infrared energy (heat) and, therefore decrease the U-Value and improve energy efficiency.

Current sputter-coated low-E coatings are multilayered, complex designs engineered to provide high visible light transmission, low visible light reflection and reduce heat transfer. SunGuard SN 68, SN 54, Light Blue 63, Neutral 61, Neutral 50, Neutral 40 and Royal Blue 40 are low-E coatings.

RELATIVE HEAT GAIN (RHG)

The total heat gain through glass for a specific set of conditions. This value considers indoor/outdoor air temperature differences and the effect of solar radiation. The units are Btu/hr.ft². RHG = [(89°F - 75°F)(Summer U-Value) + (200 Btu/hr.ft²)(Shading Coefficient)]

R-VALUE

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

SHADING COEFFICIENT (SC)

An alternative measure of the heat gain through glass from solar radiation. Specifically, the shading coefficient is the ratio between the solar heat gain for a particular type of glass and that of double-strength clear glass. A lower shading coefficient indicates lower solar heat gain. For reference, 1/8" (3.1 mm) clear glass has a value of 1.00. (SC is an older term being replaced by the SHGC).

SOLAR CONVERSIONS

- ***Direct Solar Transmittance:*** Solar Energy Transmittance
- ***Shading Coefficient:*** Solar Heat Gain Coefficient/0.86
- ***Indirect Solar Transmittance:*** Total Solar Transmittance - Direct Solar Transmittance
- ***Absorptance:*** 1 - Direct Solar Transmittance - Solar Reflectance

Units of Measure

<u>U-Value</u>

$$\frac{BTU}{hr{\cdot}ft^2{\cdot}F} \times 5.6783 = \frac{W}{m^2K}$$

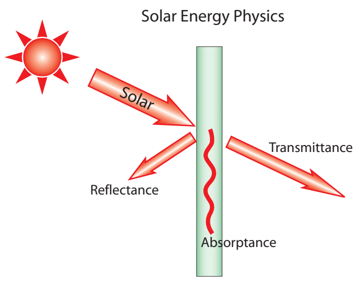
$$\frac{BTU}{hr{\cdot}ft^2{\cdot}F} \times 4.887 = \frac{Kcal}{hr{\cdot}m^2{\cdot}C}$$

<u>Relative Heat Gain</u>

$$\frac{BTU}{hr{\cdot}ft^2} \times 3.1525 = \frac{W}{m^2}$$

$$\frac{BTU}{hr{\cdot}ft^2} \times 2.715 = \frac{Kcal}{hr{\cdot}m^2}$$

SOLAR ENERGY



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

- ***% Reflectance Out*** – percentage of incident solar energy directly reflected from the glass back outdoors.
- ***% Absorptance*** – percentage of incident solar energy absorbed into the glass.
- ***% Transmittance*** – percentage of incident solar energy directly transmitted through the glass.

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

SOLAR HEAT GAIN COEFFICIENT (SHGC)

The percent of solar energy incident on the glass that is transferred indoors, both directly and indirectly through the glass. The direct gain portion equals the solar energy transmittance, while the indirect is the fraction of solar incident on the glass that is absorbed and re-radiated or convected indoors. For example, 1/8" (3.1 mm) uncoated clear glass has a SHGC of approximately 0.86, of which 0.84 is direct gain (solar transmittance) and 0.02 is indirect gain (convection/re-radiation).

SOLAR/REFLECTIVE COATINGS

Typically, highly reflective coatings that reduce solar heat gain through reflection and absorption. Though very effective at reducing heat gain, visible light transmittance is generally low and U-Values are not as energy efficient as low-E coatings. Guardian offers SunGuard Silver 20 and Silver 32 in this product category.

SPECTRALLY SELECTIVE GLAZING

High-performance glazing that admits as much daylight as possible, while preventing transmission of as much solar heat as possible. By controlling solar heat gain in summer, preventing loss of interior heat in winter, and allowing occupants to reduce electric lighting use by making maximum use of daylight, spectrally selective glazing significantly reduces building energy consumption. The United States Department of Energy has established a Light-to-Solar Gain Ratio of 1.25 as the minimum measurement to be classified as a "Spectrally Selective Glazing." The calculation of spectrally selective glazing follows the formula described in the Light-to-Solar Gain definition on page 29.

TRANSMITTANCE PERCENT

Percentage of incident ultraviolet energy that is directly transmitted through the glass. Long-term exposure to UV light may result in fabric and pigment fading, plastic deterioration and changes to the appearance of many types of wood.

UV

Ultraviolet radiant energy from the sun having a wavelength range of 300 to 380 nm with air mass of 1.5.

U-VALUE (U-FACTOR)

A measure of the heat gain or loss through glass due to the difference between indoor and outdoor air temperatures. It is also referred to as the overall coefficient of heat transfer. A lower U-Value indicates better insulating properties. The units are Btu/(hr)(ft2)(°F).

VISIBLE LIGHT

Radiant energy in the wavelength range of 380 nm to 780 nm with Ill. D65 and CIE 2° observer.

- ***% Transmittance*** – percentage of incident visible light directly transmitted through the glass.
- ***% Reflectance Indoors*** – percentage of incident visible light directly reflected from the glass back indoors.
- ***% Reflectance Outdoors*** – percentage of incident visible light directly reflected from the glass back outdoors.

SunGuard®

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