Design Criteria

Glazing Instructions

Thermal Stress

Deflection

Glass Design Loads

Glass Thickness Selection

Spontaneous Breakage of Tempered Glass

Roller Wave Distortion in Heat-treated Glass

Mock-ups

Warranty Information

Design Criteria

Glazing Instructions

Glazing instructions are intended to assist the design professional in developing glass support systems that will minimize the possibility of glass breakage due to thermal and mechanical stresses, and to prevent premature failure of insulating and laminated glass products. Any violations, intentional or unintentional, of the Oldcastle Glass® glazing instructions will automatically void the warranty.

Cautions

1. The Oldcastle Glass® Insulating Glass (IG) warranty will be void under any of the following circumstances: if the unit is sitting in water or is installed in a glazing pocket that holds water; if the unit has not been stored and/or installed according to the Oldcastle Glass® glazing instructions; if the unit is installed in high-moisture environments (including, but not limited to, swimming pool enclosures and greenhouses); if solar-absorbing film, shades, blinds, or any foreign material are used on or near the surface of a unit, unless the product and the system details are reviewed by Oldcastle Glass® in writing; or if the unit is installed in high-vibration environments. Units installed in sloped glazing are not warranted unless glazing details are reviewed by Oldcastle Glass® in writing. Unit defectiveness caused by glass breakage or other damage is not warranted.

2. Oldcastle Glass® products cannot be used in any stopless glazing system (i.e., 2- or 4-sided structural silicone glazing) unless Oldcastle Glass® has given a prior written review of the glazing details. Failure to obtain a written review voids all Oldcastle Glass® warranties.

3. A determination of the compatibility between Oldcastle Glass® products and any other glazing system component (i.e., sealants, gaskets, tapes, setting blocks, metal finishes, etc.) is not the responsibility of Oldcastle Glass®. Failure of any Oldcastle Glass® product due to incompatibility with any other product voids all Oldcastle Glass® warranties. Acetoxy silicone used with neutral-cure silicone IG units voids all Oldcastle Glass® warranties unless Oldcastle Glass® Technical Services preapproves the glazing details in writing. Incompatibility can occur between certain types of neoprene (including setting blocks and gaskets) and silicone sealed IG units under certain conditions. Setting blocks used in stopless glazing systems must be compatible with the Oldcastle Glass® insulating glass sealants. Sealant/gasket compatibility is not the responsibility of Oldcastle Glass®; seal failure due to any sealant/gasket incompatibility problems voids all Oldcastle Glass® warranties.

4. Installation of units without all sides being structurally supported (i.e., butt-glazed without interior mullion support) voids all warranties unless Oldcastle Glass® has given a prior written review of the glazing details.

5. Do NOT use razor blades or broad knife blades of any kind to clean glass. Oldcastle Glass® is not responsible for scratches or damage caused by glass cleaners and other construction tradesmen.

The following glazing instructions are intended to assist the design professional and installer. Additional glazing recommendations and guidelines, provided by GANA, AAMA and IGMA, must also be followed.

Glass Handling

Care must be exercised in the handling and the glazing of glass to prevent damage to the glass edge. The glass must not contact the framing members during glazing. A rolling block should always be used when rotating glass to avoid corner damage. Glass must be protected from weld splatter, and blasting and other impact damage. Alkali or fluorinated materials released from concrete or masonry during rainstorms can stain or etch glass. Weathering steel releases oxides while aging, which can result in stained glass if proper periodic cleaning is not done. Solutions used to restore or neutralize masonry surfaces can attack first-surface pyrolytic, reflective coated glass.

(continued on back)

Design Criteria

Glazing Instructions (continued)

Glass Storage

Glass should be kept on a lean of 5-7° from vertical using broad, sturdy uprights. Never store glass in sunlight without using an opaque cover to protect it. Glass should be stored in a dry, clean and cool location where the temperature is above the dew point. Circulation of dry, cool air is required especially after periods of high humidity and cyclic temperatures. If glass must be stored outdoors, use tarps or plastic coverings to protect it from getting wet, and vent periodically to prevent moisture accumulation. Repeated wetting and drying of glass surfaces can result in staining or etching of the glass.

Glazing Frames

Frames must be square, in plane, free of any internal obstructions and structurally adequate.

- Diagonal differences–1/8" maximum
- Plumbness deviation–1/16" per 6' maximum
- Corner joint misalignment–1/32" maximum
- Sill deflection–1/8" maximum (when a unit is on setting blocks at quarter points).
- Maximum allowable wind load deflection = unit's long dimension in inches divided by 175 or 3/4", whichever is less.
- Expansion joints must be located between glazed openings.
- Two-span vertical mullions should have the dead load (fixed) anchor located at their midpoint. Three-span vertical mullions should never be used.
- Horizontal expansion joints should not be further apart than 20 feet or every 4 lites of glass, whichever is less. Expansion should be from the center toward both ends, to minimize joint movements and thereby reduce stresses on sealants and connectors.

Edge and Face Clearance, and Bite

The glazing system must have adequate edge and face clearance to cushion the glass, thermally isolate the glass and framing members and prevent glass-to-metal contact. Adequate bite is required to provide a proper seal against air and water infiltration; however, excessive bite will increase thermal breakage. Refer to the chart for proper clearance and bite values.

Setting Blocks

Glass should be set on 2 identical setting blocks with a Shore A Durometer hardness of 85 ± 5. They should be an equal distance from the centerline of the glass at the sill quarter points, but not less than 6" from the corner edge. Each block should be sized to provide 0.1" of length per square foot of glass area, but not less than 4" of length. The setting block should be 1/16" less than full-channel width. The height should provide the recommended nominal bite and minimum edge clearance for the glass. When a lock-strip gasket glazing system is used, each setting block should be sized to provide 0.4" of length per square foot of glass area, but not less than 6" of length. The lock-strip gasket manufacturer should recommend the height of the blocks.

Weep Systems

The glazing system must be designed to prevent the accumulation of moisture in the glazing channels for prolonged periods. This applies to dry, wet and lock-strip glazing. Oldcastle Glass® recommends 3 weep holes, 3/8" in diameter or equivalent, per sill–one at the center point of the span and one each, 4" inboard of the unit corners. For a door and window wraparound gasket, provide sufficient weep holes to prevent retention of water at the unit edges.

Antiwalk Blocks

These blocks of 30 to 40 Durometer neoprene or silicone must be used in dry gasket glazing, one per jamb. Blocks are to be 4" high, 1" wide and of a thickness to allow a 1/8" clearance between the block and unit edge. Glazing sealants must not fill the edge clearance voids.

Structural Gasket Glazing (Lock-Strip Glazing)

This system must have a continuous wet sealant applied as a cap bead to the exterior glazing leg.

(continued on next page)

Design Criteria

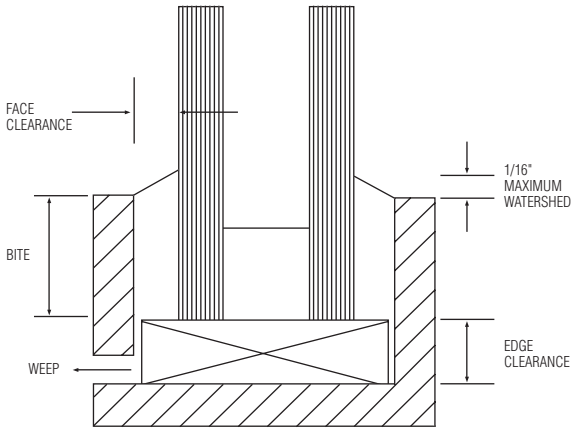
Glazing Instructions (continued)

Wedge Gasket Glazing

The wedge must be inserted starting at the mid-point of the unit's width and height. Wedging should never be started at a unit's corners.

Pressure Wall Gaskets

These gaskets must apply their sealing pressure onto the glass uniformly, 1/8" to 9/16" from the unit's edge of not more than 10 pounds per linear inch and not less than 4 pounds per linear inch. Torque-controlled wrenches are required to achieve uniform bolt tightening. Tighten bolts at the quarter points of the sill, then the quarter points of the head, then quarter points of jambs, and then the remaining bolts.



Typical Face and Edge Clearance and Bite

	Glass Thickness		Minimum Face Clearance	Minimum Edge Clearance	Bite
	inches	mm	inches	inches	inches
Single Glazing	3/32	2.5	1/16	1/8	1/4
	1/8(1)	3	1/8	1/8	1/4
	1/8(2)	3	1/8	1/4	3/8
	5/32	4	1/8	3/16	5/16
	3/16(1)	5	1/8	3/16	5/16
	3/16(2)	5	1/8	1/4	3/8
	1/4	6	1/8	1/4	3/8
	3/8	10	3/16	5/16	7/16
	1/2	12	1/4	3/8	7/16
	5/8	16	1/4	3/8	1/2
	3/4	19	1/4	1/2	5/8
	1	25	1/4	1/2	3/4
Spandrel	1/4	6	3/16	1/4	1/2
Insulating Glass	1/2	12	1/8	1/8	1/2
	5/8	16	1/8	1/8	1/2
	3/4	19	3/16	1/4	1/2
	1	25	3/16	1/4	1/2
	1-1/8	28	3/16	1/4	1/2

(1) Annealed glass
(2) Fully-tempered and heat-strengthened glass

(continued on back)

Design Criteria

Glazing Instructions (continued)

Capillary Breather Tubes

These are recommended for use with IG units that experience an elevation difference of 2,500 ft. or more in transportation or installation. Tubes must be sealed immediately upon arrival at the destination by crimping them tightly in two places. The capillary tube should be installed at the vertical dimension of the unit, with the crimped end pointed downward along the vertical edge.

Glazing and Caulking

Compounds containing plasticizing oils or solvents may not be compatible with a unit's edge seal. *(Compatibility must be verified.)*

Glazing Sealants

Structural gaskets and pressure gaskets must remain resilient for the unit's warranty period.

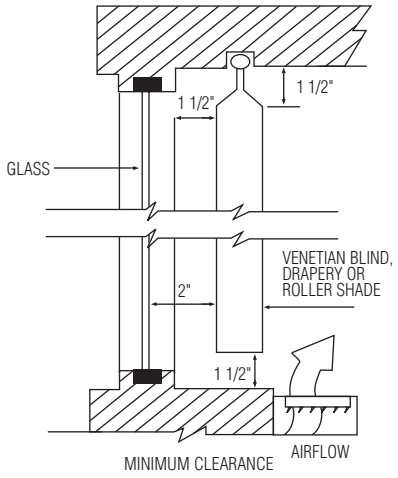
High-Risk Installations

Installations where the indoor relative humidity is frequently high may void all Oldcastle Glass® warranties. *(Refer to page 1, Cautions 1.)*

Thermal Stresses

Thermally induced edge stresses are usually the result of the warmer center portion of a glass lite being exposed to solar energy wanting to expand more than the cooler edges. The rate at which the glass absorbs energy is dependent on its type, size, thickness and shape and how it is isolated from the framing system. Other factors are building orientation, interior shading devices, exterior shading patterns, heating register location, etc. Tempering or heat-strengthening increases glass edge strength and decreases the chances for thermal breakage. The following conditions must be taken into account when considering the effects of thermal stresses:

1. Interior Heat Traps
These situations occur when there is inadequate air circulation to properly remove heat from behind the glass. Spandrel areas are a good example of glass that must be tempered or heat-strengthened to offset the rise in temperature. In vision areas, air movement must not be restricted. Suspended ceilings must be well to the room side to allow natural convection. Or the head area should include vents that provide a minimum of one square inch of ventilation for each inch of glass width. Or the glass should be heat-strengthened or tempered.



2. Interior Shading
Draperies, venetian blinds or other interior shading devices must be hung with space to permit natural air movement over the room side of the glass. The following criteria must be met to avoid formation of a heat trap:

- Minimum of 1-1/2" of clearance required, top and bottom, or one side and bottom, between the shading device and surrounding construction.
- Minimum of 2" clearance between the glass and the shading device.
- Heat/cooling outlets must be to the room side of the shading device, with airflow directed away from the glass.
- Use mechanical stops to prevent complete closure of blinds to 60% of closed position. Heat-strengthening or tempering of the glass may be necessary to offset the effects of a lack of adequate ventilation.

(continued on next page)

Design Criteria

Glazing Instructions (continued)

3. Exterior Shading
Shadows cast by overhangs, surrounding structures, trees and shrubbery can create shading patterns on the glass, creating thermal edge stress. Maximum stress occurs when 25% or less of the area of a lite is shaded and the shade includes more than 25% of the perimeter. Generally, horizontal, vertical and diagonal shading patterns are not as critical as shading that combines several patterns. Double diagonal shading is generally the most critical pattern. See the sketches (below) of typical shading patterns that are labeled "Acceptable Shading," "Marginal Shading" and "Harmful Shading." It is recommended that Oldcastle Glass® Technical Services review designs to determine whether heat-treating is required. (*See the following page for information.*)

Exterior Shading Patterns

Acceptable Shading: More than 50% of the glass area is in shade.

Marginal Shading: More than 25% of the glass area is in shade.

Harmful Shading: Less than 25% of the glass area is in shade and more than 25% of the perimeter glass is in shade.

(continued on back)

Design Criteria

Glazing Instructions (continued)

Technical Services

Oldcastle Glass® offers a wide variety of technical services, including a review of glazing details, glass thickness versus wind load recommendations, glass deflection analysis, thermal stress analysis, glass performance information and glass breakage analysis.

Thermal Stress Breakage

Thermal stress in glass is usually caused by the temperature differences between the covered edges and the center portion of the glass. Thermal stress in the glass increases as the center-of-glass and edge temperature differences increase. The probability for glass breakage increases as the thermal stress increases.

It is advisable to perform a project-specific thermal stress analysis for each project where thermal stress breakage is a concern. Many factors, besides the glass type, must be considered in a thermal stress analysis. These include, but are not limited to, the window frame material and color; glass shading from overhangs and balconies that create unusual shading patterns across the glass surfaces; blinds and window treatments; air and heating vents; blowing on the glass; glass size; as well as the direction and elevation of the sun.

Thermal stress breakage of annealed glass will occur when the thermal stress exceeds the glass edge strength. Tempering or heat-strengthening will normally prevent glass breakage due to thermal stress.

The more heat-absorbing the glass is, the higher the thermal stress will be. Tints and reflective glasses have higher solar absorption and are therefore more susceptible to thermal stress breakage.

Design Criteria

Deflection

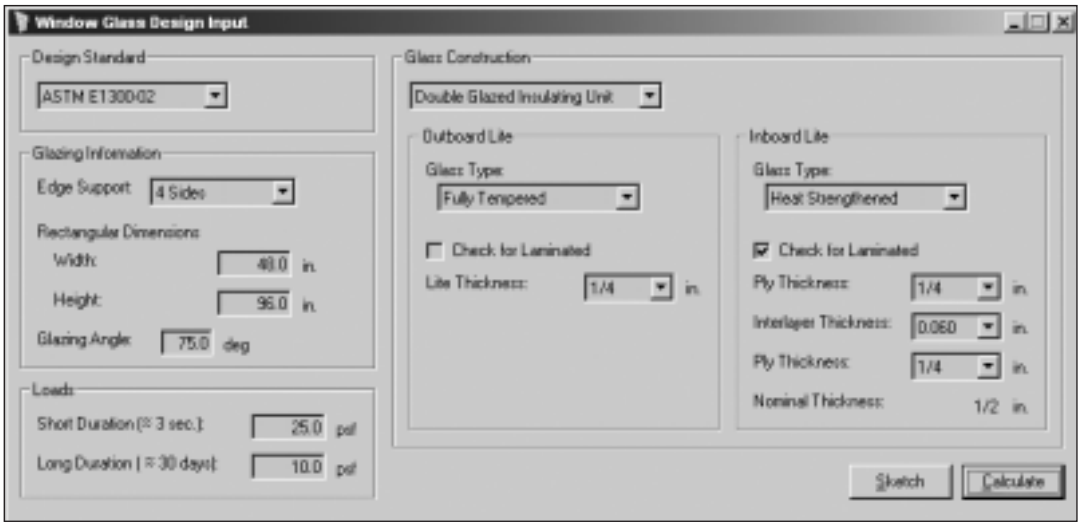
The design professional must consider deflection, as well as strength, when specifying glass products for any project. Excessive deflection at design loads could lead to glass breakage, as well as being objectionable to those working near the glass.

The dynamic and static loads (typically wind and dead loads) acting on glass will cause it to deflect. The amount and shape of the deflection depends on the glass size and thickness, and the glass edge support conditions, as well as the loads. The glass and glazing system must be designed, not only to have the strength necessary to withstand the design load, but to also limit deflection to an acceptable amount, as determined by the design professional.

ASTM E1300 is the industry standard used for determining the load resistance of glass in buildings. It also includes information for calculating the deflection of glass based on the size and thickness of glass.

Window Glass Design software developed by the Standards Design Group, Inc., is a program that is used for determining the deflection of glass at various design loads. Glass deflection and load resistance values generated by this program are based on the parameters in the ASTM E1300 standard.

Example of Window Glass Design Input Screen

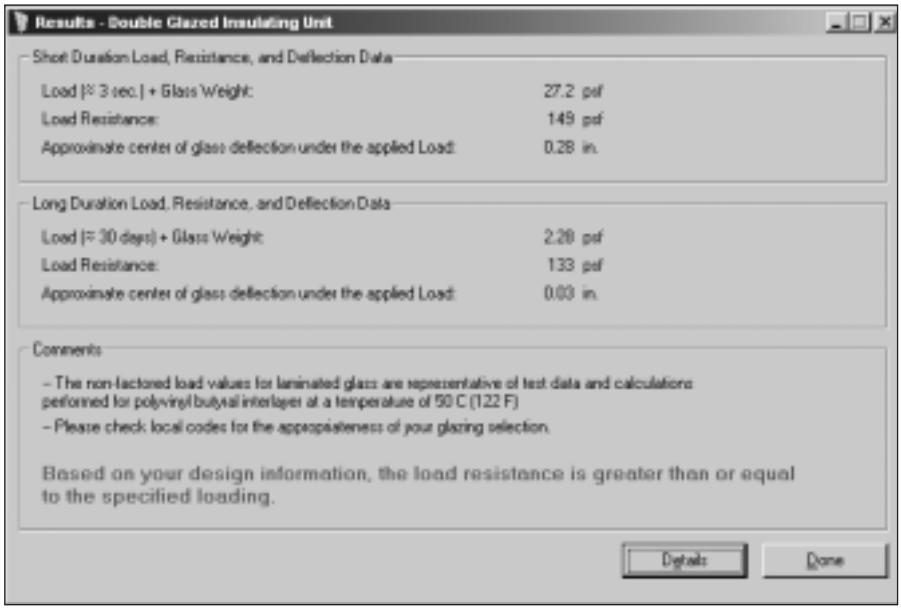


(continued on back)

Design Criteria

Deflection (continued)

Example of a Window Glass Design Results Screen



Design Criteria

Glass Design Loads

Prior to designing buildings and its components, it is necessary to have an understanding of requirements specified for every phase of the building. ASCE 7 is the standard that provides requirements for dead, live, soil, flood, wind, snow, rain, ice and earthquake loads, and their combinations that are suitable for inclusion in building codes and other documents.
The ASCE (American Society of Civil Engineers) 7 Standard assigns the minimum design loads for buildings and other structures, which are necessary for determining the type and thickness of glass required for an application.

Regional impact codes (which encompass building, hurricane, seismic and overhead glazing) also indicate design loads required for determining glass strength requirements.

Glass Thickness Selection (ASTM E1300)

Glass strength and deflection are discussed in detail in the ASTM E1300 *Standard Practice for Determining the Load Resistance of Glass in Buildings*. The model building codes contain requirements for wind, snow and dead loads on glass. The applicable state laws and local building codes must be checked to determine minimum glass strength requirements governing each project.

Currently, ASTM E1300 addresses monolithic, laminated and insulating glass constructions exposed to a uniform lateral load of a short or long duration for a specified probability of breakage. The standard does not apply to glass with surface and edge treatments that alter the glass's strength, such as wired, patterned, etched, sandblasted, drilled, notched or grooved glass. While ASTM E1300 is based on a determination of a glass's resistance to uniform lateral loads, the standard clearly notes that the final glass thickness and the type of glass used will depend on a variety of factors, including thermal stresses, spontaneous breakage of tempered glass, effects of windborne debris, excessive deflections, considerations set forth in building codes, safety glazing requirements and other site-specific concerns. Design professionals use this standard to show compliance to building code regulations. Building code officials use the standard to verify compliance with applicable codes. And glass manufacturers, fabricators and installers use it to assist their customers in selecting a proper glass thickness and type.

Design Criteria

Spontaneous Breakage of Tempered Glass

All float glass contains some level of blemishes, including stones, seeds and bubbles, which are an unavoidable part of the glass manufacturing process. ASTM C1036, *Standard Specification for Flat Glass,* is the industry standard that provides the specific requirements for size, intensity and frequency of blemishes that are allowed.

One type of stone (crystalline blemish) is nickel sulfide (NiS). Nickel can be present in any particular batch of glass, derived from trace amounts of nickel in the sand, the fuel, the fire-brick, or even the machinery used to mix the batch. Sulfur can come from the fuel or from sodium sulfate, one of the glass batch's ingredients. When NiS is present, the quantity is typically extremely small.

Most NiS stones are stable and cause no problems. However, there is a small quantity of very rare NiS stones formed, which, when cooled slowly from about 750°F down to room temperature, undergo a change in crystalline structure (a phase change) that results in an increase in volume. In annealed glass (standard float glass), this expansion takes place while the glass is at annealing temperatures, and so stress relaxation eliminates the tensile stress caused by the phase change.

NiS inclusions may undergo a phase transformation (shrinkage) in tempered glass due to the reheat/quench operations required to fabricate tempered glass. The rapid quench of the tempering process traps the inclusion in its small (Alpha) phase. Over a period of time, these inclusions may revert back (expand) to their original (Beta) phase state. When the inclusion is located in the center tension area of tempered glass, this increase in volume may cause a localized stress increase sufficient to break the glass.

Such inclusions can cause spontaneous breakage in tempered glass, without any load being applied, at any time, even five or ten years after the tempered glass has been fabricated. These inclusions are typically so small (about 0.010" in diameter) that they are virtually impossible to locate and identify in an individual unbroken lite of glass.

Glass manufacturers have recognized these details and have instituted programs of batch quality control, along with the elimination of any nickel-containing materials from their raw material and glass handling systems. Automatic inspection of 100% of the float ribbon has also contributed to the reduction in the number of inclusions of all types present in float glass. Even though these improved quality measures are not capable of eliminating all such inclusions, the success of these programs is evident in the near elimination of spontaneous breakage reports related to current production float glass.

Heat soaking is a process that can uncover some NiS inclusions present in an individual lite of glass. But it is not 100% effective, and carries the risk of reducing the compressive stress in tempered glass.

Heat-strengthened glass is the preferred product of choice, rather than tempered glass, for applications where additional glass strength, compared to annealed glass, is required. The current low stress levels specified for heat-strengthened glass in the industry standard for heat-treated glass products, ASTM C1048, has been very successful in reducing the possibility of NiS spontaneous breakage in heat-strengthened glass.

Given the conditions listed above, the complete absence of NiS in glass cannot be guaranteed. Good design and engineering practices recognize this fact and accordingly only specify the use of tempered glass in applications where spontaneous breakage will not cause major problems. Suspended glazing, and all-glass walls using tempered glass, should be designed with redundant load paths so that the breakage of one individual lite will not lead to a progressive collapse.

(continued on back)

Design Criteria

Spontaneous Breakage of Tempered Glass (continued)

Spandrel lites, which have to withstand high thermal stresses, should be specified as heat-strengthened glass to reduce the potential for NiS breakage.

Architects and engineers can minimize the chance of serious problems from NiS breakage by using heat-strengthened and laminated glass in critical applications.

Roller Wave Distortion in Heat-treated Glass

Annealed glass that is processed through a horizontal oscillating tempering furnace will contain surface waves creating waviness or roller wave distortion, when viewing reflected images from a distance. The industry standard for heat-treated glass, ASTM C1048 *Standard Specification for Heat-Treated Flat Glass-Kind HS, Kind FT Coated and Uncoated Glass,* specifically addresses distortion in paragraph 7.4.1, as follows:

"Thermally tempered and heat-strengthened glass is made by heating glass in a furnace to a temperature at which the glass becomes slightly plastic. Immediately after heating, the glass surfaces are rapidly cooled by quenching with air from a series of nozzles. The original flatness of the glass is slightly modified by the heat treatment, causing reflected images to be distorted. When viewing images through the glass, the distortion, in most glazing applications, is less than that of the reflected images and is not as noticeable."

Paragraph 7.4.5 states further that regardless of the flatness achieved, the perceived reflective distortion is primarily due to the symmetry of the object being reflected. For instance, linear objects (telephone poles and building curtain walls) and moving objects (such as cars, etc.) may appear distorted, whereas irregular free-form objects (such as trees, clouds) may have little perceived distortion. Roller wave distortion is inherent in all heat-treated glass.

Currently, there is no ASTM or industry standard for maximum allowable roller wave distortion in heat-treated glass.

Design Criteria

Mock-ups

The color, reflectivity, distortion and overall visual appearance of glass products may vary greatly, depending on glass type, size, and thickness, heat-treating, manufacturing conditions and surroundings.

Glass samples viewed in an office in artificial light may not produce the same visual effect as the same product at the project site. Oldcastle Glass® recommends that architects and owners consider viewing a full-size mock-up in surroundings similar to those at the job site, prior to finalizing specifications.

Warranty Information

All Oldcastle Glass® products are subject to written warranties that are available by calling 1-866-OLDCASTLE(653-2278) or by logging on to www.oldcastleglass.com, and clicking on "Need Assistance with a Project," clicking on "General Inquiry," and entering your request.

Product warranties depend on strict adherence to Oldcastle Glass® glazing instructions, which are based on publications available from the Glass Association of North America, the American Architectural Manufacturers Association (AAMA) and the Insulating Glass Manufacturers Alliance (IGMA). Recommendations must be followed for glass handling, storage, weep systems, setting blocks, edge and face clearance, and bite and cleaning procedures. Installation considerations that must be addressed include structural glazing, sloped conditions, exterior and interior shading and protecting the glass to avoid irreversible damage from welding sparks or other materials during construction.

A product's limited liability warranty should be carefully reviewed because it will contain the specific product qualities that Oldcastle Glass® warrants, as well as the terms, exclusions, remedial action taken and glazing requirements for specific products. Oldcastle Glass® exclusions from warranty liability include, but are not limited to, breakage, replacement costs and costs for incidental, special or consequential damages.