

Expert Series: Bent Glass



**GUARDIAN®
GLASS**

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Overview

Flat glazing panels can be mounted at varying angles to achieve a wide variety of visual effects. However, individual insulating glass units (IGUs) can also be bent by experienced glass fabricators, creating even more design flexibility and stunning aesthetics. It takes skill, experience and the proper equipment and techniques to bend glass well, especially coated glass. For example, contact with the low-E coating can damage the surface and should be avoided. Guardian provides detailed bending technical support and guidance to Guardian Select® Fabricators to help project teams achieve the desired aesthetic and energy performance objectives of bent glazing applications.

Hot bending refers to the process of curving a piece of glass in a furnace and then allowing the glass to cool into a permanently self-sustaining, out-of-plane shape. **Cold bending**, on the other hand, refers to the process of externally stressing an otherwise flat piece of glass into an out-of-plane geometry, and constraining it in that state permanently using the framing system.

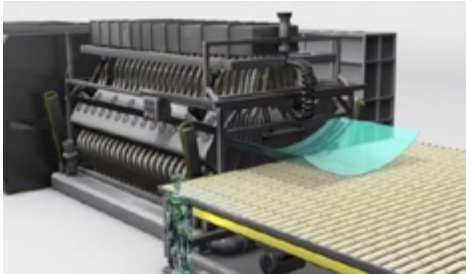
Hot Bending

The most common method of hot bending architectural glass is to mechanically establish a constant-radius form within a specially configured quench section of a heat treatment (heat-strengthened or fully tempered) production line.

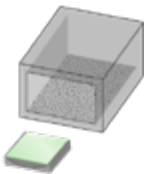
The principal alternative is to slump bend the glass, that is to gradually heat the glass within a kiln, allowing it to deform onto the shape of a mold. Slump bending is more time-consuming than is heat treatment bending, as it is a non-continuous, custom process. One advantage of slump bending is that the process facilitates a broader range of out-of-plane geometries.

Smaller radii represent more extreme out-of-plane forms than do larger radii. When SunGuard® coated glass is to be bent to a radius tighter than 6'-8" (80"), Guardian should be contacted for review and approval.

Heat Treatment Bending Quench



Slump Process of Hot Bending



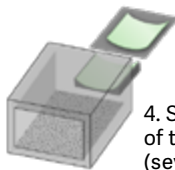
1. Construction of a bending mould and placement of the flat glass substrate



2. Heating of the glass substrate 1000 - 1150 F°



3. The glass sinks into the bending mould



4. Slow cooling of the float glass (several hours)

Hot Bending: Heat Treatment vs. Slumping		
Process	Heat Treatment	Slumping
Supported Geometries	Constant-Radius Cylindrical Arcs that are Generally Supportive of Externally-Convex Building Skins	Freeform Surfaces
Readily-Supported Glass Types	Heat-Strengthened and Fully Tempered	Annealed and Laminated
Distortion	Limited	Minimal
Anisotropy	Some	Limited
Processing Time	< 1 hour	> 1 Hour

Cold Bending

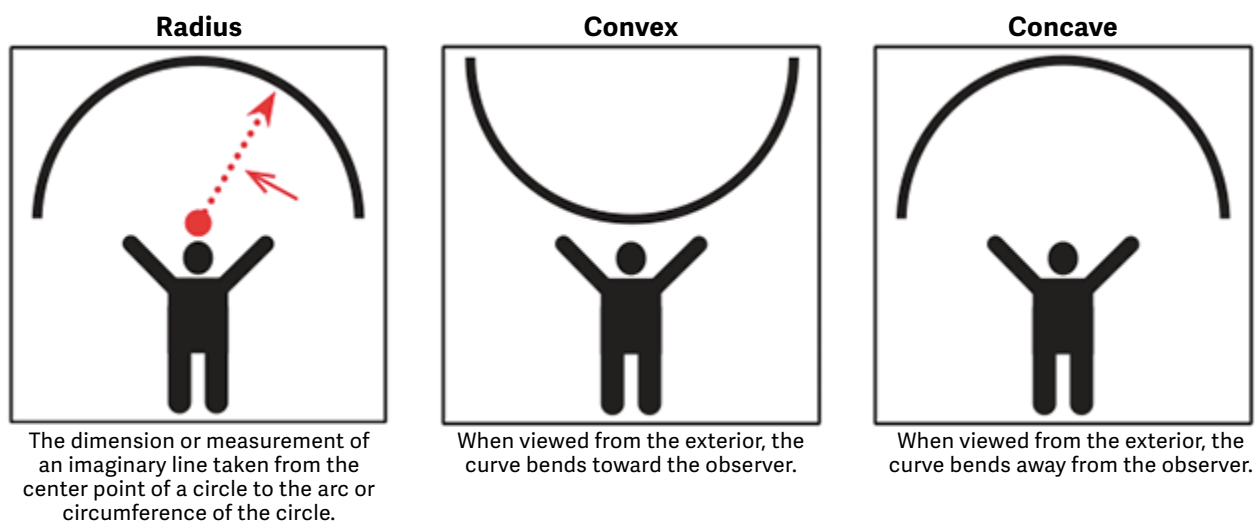
IGUs can be cold bent by mechanically capturing an otherwise flat panel within a bent frame or, in close coordination with a structural silicone sealant supplier, structurally bonding the panel to the outside face of the frame.

When the flat panel is forced into an out-of-plane state, the resulting stresses diminish the capacity remaining to resist wind and other service loads. Heat-treated glass is commonly selected for cold bent applications in order to help compensate for this reduction. Nonetheless, cold bending is generally only utilized for mildly out-of-plane geometries, such as those with radii greater than 10'-0" (120"). Glass, sealant and framing manufacturers should review and approve each application.

Important Considerations

Whether hot or cold bent, meticulous designation of the glazing panel geometry is crucial, particularly for complex shapes. Finite element analyses are critical in establishing the glazing panel strength. To facilitate alignment on the architectural vision and the consistency of the low-e coating with the intended aesthetic, full-size visual mockups encompassing all crucial glazing panels and geometric transitions should be carefully reviewed in representative outdoor conditions, and should be approved in writing by all key members of the project team.

Glass that is bent in a heat treatment process may exhibit more visually noticeable anisotropy (strain pattern) than flat heat-treated glass in association with the closer proximity of the quench nozzles to the glass surface during the bending process. Outdoor mockup viewings should include evaluation of anisotropy.



Concentration of Solar Energy

When an individual glazing panel or facade feature (even if comprised of segmented flat glazing panels) exhibits a concave geometry as viewed by those located outside of the building, an application- and location-specific evaluation should be conducted to ensure that the energy reflected from the panels (both in the visual and infrared ranges) does not concentrate in a manner that causes safety, discomfort, or property damage issues.

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Coating Location

Most low-e coatings are consistent with placement on the #2 surface of a double-pane non-laminated IGU. This generally aligns with their available use on convex designs, because hot bending of the coated glass within the quench section of a heat treatment line does not involve equipment contact with the coated surface.

For concave facades comprised of IGUs, the critical design options include the selection of a coating that may be implemented on the #3 surface successfully through the heat treatment bending process, or the use of a different bending process, such as slump bending or cold bending.

Learn More About Bent Glass

If you need more information, Guardian's Technical Services group is available to assist with the evaluation of bent SunGuard® glazing options. Please contact Guardian at <https://www.guardianglass.com/us/en/contact> or call [855-58-GLASS \(45277\)](tel:855-58-GLASS).

Please note: This information is provided as a convenience and is not to be construed as an assumption of responsibility or liability for design and application choices, which remain the responsibility of the design professionals involved in any project. It does not constitute legal advice, a modification of Guardian's standard warranties, or an additional warranty of any kind.