

Heat-Treated Glass

Introduction

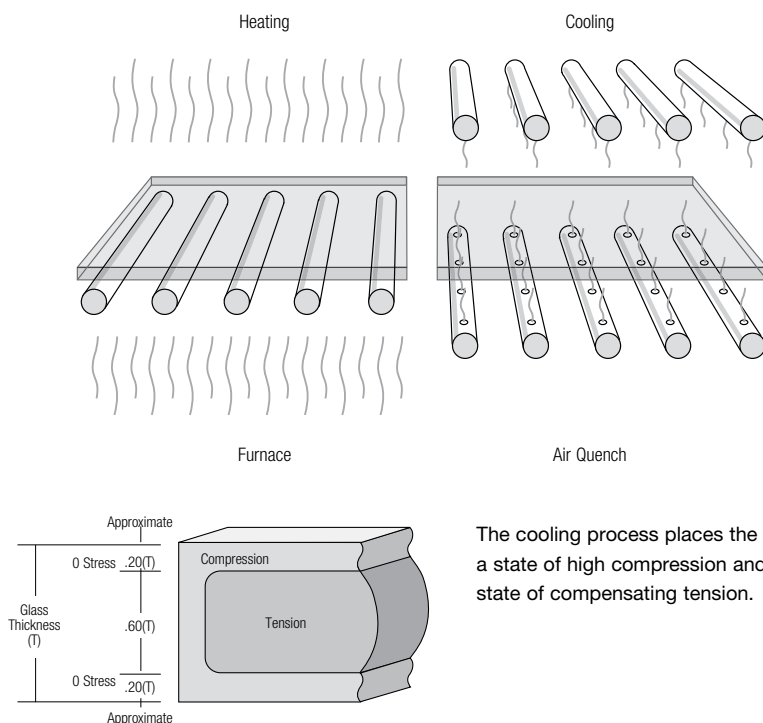
“Heat-treated glass” is a general term used in the glass fabrication industry to describe glass that has been processed through a tempering oven to change its strength and breakage characteristics (i.e., the size and/or shape of the glass pieces after breakage). There are two distinct heat-treated products, heat-strengthened glass and fully tempered glass, as defined in ASTM C1048 Standard Specification for Heat-treated Flat Glass—Kind HS, Kind FT Coated and Uncoated

Glass. Compared to annealed glass (non-heat-treated glass), both have increased strength to resist higher levels of impact, mechanical load and thermal stress. Heat-strengthening adds strength to the glass while limiting the change in its breakage characteristics. Tempered glass is stronger than heat-strengthened glass and significantly reduces the broken piece sizes to meet the safety glazing standards.

Description

Glass is heat-treated by heating annealed glass to a temperature of approximately 1,150°F (621°C), then rapidly cooling it. The glass is cooled by a carefully controlled airflow (also known as

quenching), which uniformly cools all glass surfaces simultaneously. High airflow rates produce tempered glass and much lower airflow rates produce heat-strengthened glass.



The cooling process places the surfaces of the glass in a state of high compression and the central core in a state of compensating tension.

Cross-section of the compression and tension zones in tempered glass.



Heat-Treated Glass

Description (continued)

Fully Tempered Glass

Fully tempered glass, normally referred to as just “tempered glass,” is approximately four times stronger than annealed glass of the same thickness and configuration. When it is broken, tempered glass fractures into small fragments that reduce the probability of serious injury as compared to annealed glass. Tempered glass meets all safety glazing standards including the federal safety glazing standard, CPSC 16 CFR 1201. Because tempered glass fractures into many small pieces, it tends to vacate the opening, when broken, more than heat-strengthened and annealed glass does.

Heat-Strengthened Glass

Heat-strengthened glass is approximately twice as strong as annealed glass of similar thickness and configuration. Heat-strengthened glass generally fractures in a manner similar to annealed glass and tends to remain in the opening when broken. It is intended for general glazing where additional strength and/or resistance to mechanical and/or thermal stress are desired. Heat-strengthened glass is NOT a safety-glazing product and therefore should not be used where safety glazing is required.

Capabilities

Glass Options

Most architectural glass products can be heat-treated. Some patterned glass and decorative glass with a deep surface pattern may not be heat-treatable. Silk-screened and ceramic spandrel glass are always either heat-strengthened or tempered as part of their fabrication process. When spandrel glass is incorporated into insulating glass units, both lites must be heat-treated. Heat-absorbing glasses, such as tints, reflective glasses and some Low-E glass, may require heat treatment to reduce the probability of thermal-stress breakage, especially when used as part of an insulating glass unit.

For a list of available glass products/colors, go to the Glass Options Tab.

For more information on silk-screened, spandrel glass and insulating glass products, go to their respective Product Information Tabs.

For monolithic glass performance data, log on to www.oldcastlebe.com and choose GlasSelect™.

Thickness

Glass thicknesses from 1/8" through 3/4" can be tempered. Glass thicknesses from 1/8" through 1/4" are commonly heat-strengthened. And 3/8" can be heat-strengthened on a limited and project-specific basis.

Size

The minimum and maximum heat-treated glass sizes are restricted by the thickness of the glass and production equipment capabilities. Generally, the minimum size is 12" in width and length, and the maximum width and length are 84" x 144", respectively. Specific oversize ovens are able to process some glass types up to 98" in width and 200" in length.



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Applications

Heat-Strengthened

Due to its superior glass retention properties, heat-strengthened glass is the preferred heat-treated glass product for applications where additional strength is needed to meet mechanical loads (wind or snow) or thermal loads caused by certain tinted or coated glasses. Heat-strengthened glass is widely used in laminated glass for additional strength, such as in overhead and sloped glazing. Heat-strengthened glass cannot be used in any safety glazing applications.

See the Glass Selector Tab for some typical applications.

Tempered

Tempered glass is used when the strength requirements exceed the capabilities of heat-strengthened glass, and for all safety glazing applications. Tempered glass is commonly used in sliding doors, storm doors, atriums, partitions, windows, storefronts, display cases, bath and shower enclosures and all-glass doors and entrances. Tempered glass should not be installed in areas where it is exposed to temperatures greater than approximately 400°F because it will begin to lose its degree of temper (reverting back to annealed glass).

Characteristics

Properties Unaffected by Heat-Treating

The color, chemical composition and light transmission characteristics of glass remain unchanged after the heat-treating process. The physical properties of glass, such as the compressive strength, hardness, specific gravity, the softening point, thermal conductivity, solar transmittance, stiffness and expansion coefficient, also remain unchanged.

Deflection

It is important to note that heat-treating does not change the deflection characteristics of glass. In many cases, even though thinner heat-treated glass may be strong enough for a specific application, thicker glass may need to be specified in order to reduce the amount of glass deflection. The project design professional establishes the maximum allowable deflection, as well as the design loads, on a project. Given a specific glass size and the design load, Oldcastle BuildingEnvelope™ can determine if the glass will meet the specified maximum deflection requirement.

Breakage Characteristics

The higher the amount of residual stress in a piece of glass, the smaller the particle size will be when the glass fractures. When annealed glass

fractures, the cracks are far apart and the pieces are normally quite large with sharp edges. As a result of the heat-treating process, tempered glass fractures into small particles when broken, thus meeting the safety glazing requirements of the federal safety glazing standard, CPSC 16 CFR 1201, the Canadian safety glazing standard CAN/CGSB-12.1 and the American National Standard, ANSI Z97.1. These safety glazing standards require the ten largest particles of the test specimen to weigh no more than the equivalent weight of 10 sq. in. of glass thickness. The breakage characteristics of heat-strengthened glass can vary within the allowable stress range of the product (3,500 to 7,500 psi surface compression). Heat-strengthened glass typically fractures into large pieces that are more similar to annealed glass than to tempered glass.

Fabrication

Fabrication work such as cutting, polishing, grinding, drilling, notching, sandblasting, etching or any other process that modifies the glass must be completed prior to heat-treating the glass. ASTM C1048 provides specific limitations and requirements for the size and location of holes and notches. Any fabrication process completed after the glass is heat-treated, such as sandblasting or V-grooving, will reduce the strength of the glass.



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Characteristics (continued)

Roller Wave Distortion in Heat-Treated Glass

Since the glass is heat-treated in a horizontal oven, it contains waves created by contact with ceramic rolls during the heating process. This waviness, or roller wave distortion, can be detected when viewing reflected images from a distance. To minimize the appearance of roller wave distortion, the glass orientation in the oven becomes critical. When the direction of roller waves is critical, roller waves are typically specified and ordered parallel to the horizontal (sill) or base dimension.

Flatness

Due to the nature of the heat-treating process, heat-strengthened and tempered glass is not as flat as annealed glass. The deviation for flatness depends on glass thickness, width and length and other factors. ASTM C1048 contains information on the permissible overall bow and warp, and on localized warp.

Strain Pattern

Heat-treated glass may display visible strain patterns, also known as quench marks. These

appear as geometric patterns of iridescence or darkish shadows. The strain pattern may appear under certain lighting conditions, particularly in the presence of polarized light. This phenomenon is a result of localized stresses imparted by the rapid air-cooling (quenching) of the heat-treating process. This strain pattern is an inherent characteristic of heat-treated glass and is not considered a defect.

Thermal Shock Resistance

Heat-treated glass will withstand greater thermal shock than the same thickness and configuration of annealed glass. Thermal shock results when a rapid temperature change between the surface and core of the glass occurs. When this temperature differential is of sufficient magnitude, the glass will fracture. To fracture 1/4" (6 mm) annealed glass, the average temperature differential would be approximately 100°F (38°C). To fracture 1/4" (6 mm) heat-strengthened and tempered glass, the average temperature differential would be about 250°F (121°C) and 400°F (204°C), respectively. The resistance to thermal shock also decreases with increased glass thickness.

Additional Important Information

Specifications

A sample Section 08 81 00 Specification for North America can be found in the last section of this binder titled: Sample Architectural Glass Specifications.

Contact Us

For any additional information, including details, technical data, specifications, technical assistance and samples, call 1-866-OLDCASTLE (653-2278).

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