TECH TALK

THERMAL STRESS BREAKAGE

VIRACON

"The Leader in Glass Fabrication"™

THERMAL STRESS BREAKAGE

This Tech Talk provides information on how to identify and minimize the causes of glass breakage. It is important to remember that neither glass manufacturers nor glass fabricators warrant glass against breakage.

thermal breakage

TENSILE STRESS

The complexity of today's commercial glass building designs increases the probability of unique shading patterns, which may elevate thermal stresses and breakage.

Glass breakage can occur for many reasons. Generally, thermal loads on glass occur as a result of the glass being exposed to sunlight and interior heating. If the glass is heated uniformly, the entire panel expands. If the glass is heated non-uniformly, temperature gradients occur within the glass, creating tensile stresses. The amount of tensile stress is a function of the extent of temperature differences within the glass. Thermal breakage occurs when the tensile stresses exceed the glass edge strength.

GLASS EDGES

In conventionally glazed windows, temperature gradients normally occur between the covered glass edge and the glass center due to the window framework. The glass edge is generally captured up to approximately 1/2" (13 mm), which insulates it slightly from the sun's rays. As a result, the glass edge temperature increases more slowly than the center of the glass when it is sunlit. This is a function of solar absorption by the glass panel.

When the glass edge is shaded, greater thermal stresses occur, because the shadows inhibit the temperature from increasing at the glass edge (see Figure 1). As a result of the "colder" glass edge or the greater temperature difference between the center and the glass edge, higher tensile stresses occur, increasing the risk of glass breakage.

It is important to note that a clean cut glass edge will resist a tensile stress of ~2,400 psi. Due to the coefficient of thermal expansion of soda lime glass, a 1°F (0.56°C) temperature differential across the glass area produces ~50 psi tensile stress. Consequently, for a glass edge temperature of 70°F (21°C) and a center pane temperature of 120°F (48°C) you will have a 50°F (27°C) differential. This results in a 2,500 psi tensile stress at the glass edge, which is sufficient to cause breakage in annealed glass.

GLASS TYPES

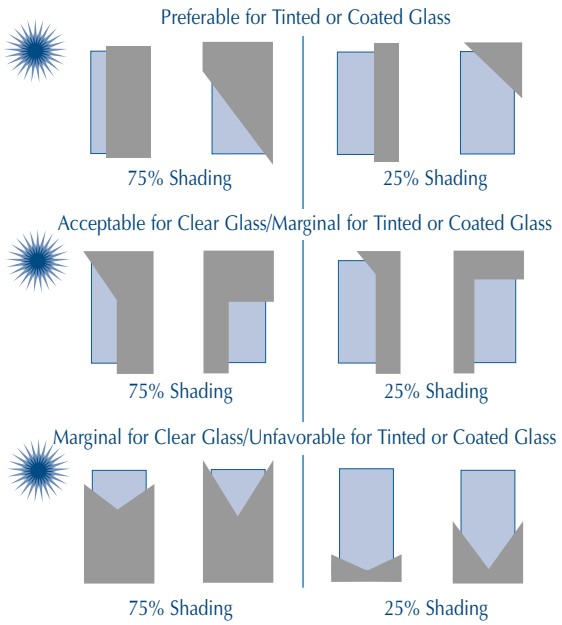
Certain types of tinted glass and coatings are inherently at risk of thermal stress breakage. This is because of the temperature imbalance that occurs in the glass due to solar absorption at the sunlit glass area versus the captured (covered) glass edge area. Some of these glass types include Viracon's standard reflective coated glass, as well as lower light transmitting "high-performance" Low-E coatings on tinted glass.

High-performance reflective coatings on tinted substrates have a solar absorption of 70 to 80 percent; whereas, Low-E coatings on tinted glass have a solar absorption between 55 and 80 percent. These products require the base glass substrate, on which the coating is applied, to be either heat-strengthened or tempered. Viracon recommends tempered glass for safety glazing applications only.

In some cases uncoated tinted glass products, such as Azuria™ and EverGreen™, may require heat treating due to the exterior wall design. Viracon evaluates these applications on request.

OUTDOOR SHADING PATTERNS

Varying outdoor shading patterns will have different effects on glass products. For example, under marginal shading conditions, uncoated tinted glass would require heat strengthening (refer to the following illustrations).



bid stage

BID STAGE

Viracon performs wind load and thermal stress analyses on its products for specific applications when information is made available at the bid stage. However, specific design loads and potential information regarding thermal stress are not always available at this stage. Consequently, if additional costs are incurred because of a heat-treated glass requirement, Viracon will qualify the quotation. It is important to have accurate information at the bid stage to determine glass requirements.

POST BID STAGE

After contract award, Viracon will provide the necessary submittals for a project. These submittals include a shop drawing review and glass strength analysis. The glass strength analysis validates the glass performance to design wind and snow load pressures, as well as a thermal stress analysis.

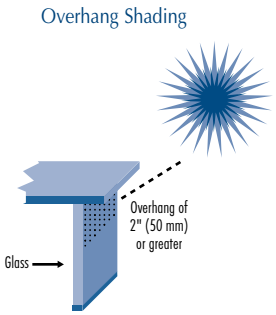


Figure 1

To evaluate the anticipated thermal stresses for a given project, Viracon requires drawings that accurately represent the conditions that will be present for each building design. The drawings need to indicate any horizontal or vertical building projection, which may cast shadows onto the glass. Window treatments, such as interior blinds should also be clearly marked on the shop drawings. Heat-treated glass may be required if interior blinds are positioned in such a way that the minimum clearances cannot be met. In addition, heating and cooling registers need to be located to the roomside of any shading device. Figure 2 illustrates the register located roomside of a venetian blind, drapery or roller shade.

storage guidelines

ON-SITE STORAGE

Annealed glass products are susceptible to thermal stress breakage while crated and after installation. To minimize the breakage during storage, please refer to Viracon's Glass Staining Tech Talk for further guidelines than those listed below.

It is important to properly store crated glass during the construction period, especially for high-performance coated insulating glass units. These types of coatings are heat reflective by nature, and the potential for thermal stress breakage in crates increases. As a result, avoid storing glass for any extended period of time. Crates containing high-performance coated glass products need to be stored in locations where partial and full-exposure to sunlight does not occur.

Glass strength is a function of surface and edge quality. If the glass is damaged prior to or during installation, its ability to resist thermal stresses is dramatically decreased and may result in breakage. Damage to the glass by other building trades during construction can also result in breakage after installation.

construction phase

JOB SITE CONDITIONS

During construction thermal stress breakage can occur from a result of jobsite conditions. Exterior scaffolding can create large shade patterns on the glass and elevate thermal stresses. Before a building is heated, it is subjected to large diurnal temperature fluctuations. Since the framing can cool down dramatically overnight, the glass edges remain cooler for longer periods. These high stresses can cause significant breakage.

Materials used to protect the glass from adjacent work by other trades may also elevate thermal stress in glass. Welding, painting and concrete work should be performed prior to glass installation. Any of these activities performed after glass installation increases the potential for glass surface damage.

Indoor Shading and Heat Duct Locations

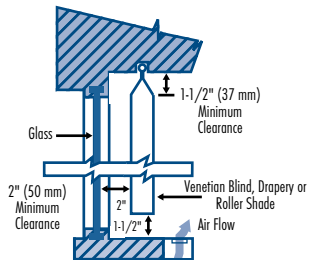


Figure 2

Low Stress <1,500 psi

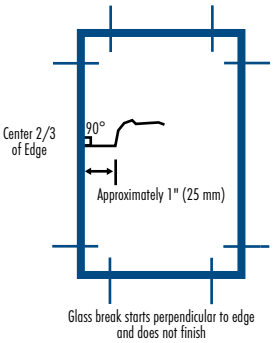


Figure 3

Low Stress ~1,500 psi

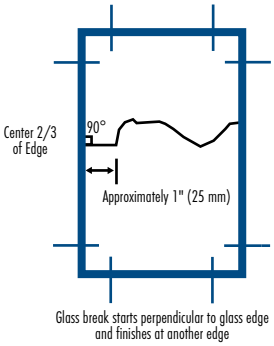


Figure 4

High Stress
Initial Fracture ~1,500 psi
Each Branch ~1,000 psi

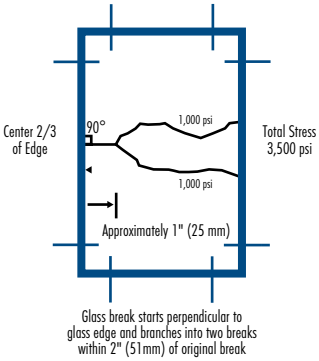


Figure 5

performance

IN-SERVICE PERFORMANCE

The potential for thermal stress breakage dramatically decreases once the glass is installed and interior building temperatures are stabilized. Proper clearances for interior shading devices help avoid thermal breakage after installation.

APPLIED FILMS

The application of films to interior glass surfaces needs to be approved by Viracon prior to installation. Viracon does not recommend applying decorative appliqués or any other materials to the interior glass surface of annealed glass products. The remodeling of interior office spaces can sometimes result in walls being too close to existing glass. As with any office wall partition, special evaluations are required to determine the thermal stress for specific applications to eliminate potential breakage. This evaluation is not a guarantee that breakage will not occur under these conditions. Viracon provides this service to assist our customers in proper glass selection for specific applications.

break patterns

THERMAL BREAK PATTERNS

Building designs that subject glass to stresses above their design strength require heat-treated glass. Thermally-initiated fractures at stress levels below their average design strength may result from glass edge damage, which lowers the in-service glass strength (see Figures 3 through 5).

High-stress thermal breakage is an indication that the glass is incapable of withstanding the ambient thermal stresses. To minimize the risk, heat-strengthened glass is required.

glass solutions

THE LEADER IN GLASS FABRICATION

As an international company, Viracon offers the most complete range of high-performance architectural glass products available worldwide. We're a company that not only fabricates glass, we're also a company that delivers design, aesthetic, budget and performance solutions for client projects. Our success is reflected in our long-lasting relationships that have given Viracon a visible presence on skylines around the world, including Asia, Australia, Europe, North America, South America and the Middle East.

Since 1970, Viracon has expanded its facilities to perform more glass fabricating processes at a single site than any other fabricator in the world. Our complete product line includes tempered, heat-strengthened, insulating, laminated, security, silkscreened, spandrel and high-performance coated glass. This single-source responsibility is evident in our complete line of product offerings, technical expertise, design assistance and responsive customer support.

The information contained in this publication is presented in good faith. It is believed to be accurate at the time of publication. Viracon reserves the right to change product specifications without notice and without incurring obligation.

VIRACON

"The Leader in Glass Fabrication"™

www.viracon.com

800 Park Drive
Owatonna, MN 55060
507.451.9555
800.533.2080 (Toll Free)
507.444.3555 (Within the U.S.A.)
507.451.2178 (Outside the U.S.A.)
E-Mail: glass@viracon.com

ISO 9002 SGS

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